Kern County Water Agency

Water Supply Report 1991

December 1992

Kern County Water Agency
WATER SUPPLY REPORT
1991

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December 1992

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Definitions

Acre-Foot (AF) The quantity of water required to cover one acre of land to a depth of one foot (325,872 gallons). This amount of water is normally used by a family of five during a one-year period for residential use.

Agency Kern County Water Agency (KCWA).

Aquifer Geologic formations or parts of formations containing sufficient saturated permeable material able to yield sufficient quantities of water.

cfs Cubic feet per second, a rate of flow.

1 cfs = 450 gallons per minute
= 646,360 gallons per day
= 1.983 acre-feet per day

Change in Groundwater Storage The change in volume of water retained by subsurface aquifers within the groundwater basin. A negative change reflects the fact that extractions have exceeded recharge.

Confined Aquifer A groundwater bearing strata constrained at its upper surface by an impervious unit, such as a regional clay.

Corcoran Clay A thick, impermeable layer of clay which lies under much of the San Joaquin Valley. This clay layer separates the groundwater basin into two distinct aquifers. One region, referred to as the "unconfined" aquifer, lies above the Corcoran Clay. The other region, referred to as the "confined" aquifer, lies entirely below the Corcoran Clay.

CVC The Cross Valley Canal.

CVP The federal Central Valley Project. The Friant-Kern Canal is its major feature in Kern County.

DWR California Department of Water Resources. The operators of the State Water Project (California Aqueduct).

Electrical Conductance (EC) A measure of the ability of water to conduct an electrical current, which can be related to the concentration of total dissolved solids. The normal unit of measurement is micromhos per centimeter.

Groundwater Basin An area underlain by one or more permeable formations (aquifers) capable of furnishing a substantial and beneficial water supply. The basin referred to in this report is within the San Joaquin Valley portion of Kern County but is connected hydrologically and geologically to a larger basin.

Groundwater Recharge Any act of nature or man which replenishes or adds water to that supply which is stored within the natural subsurface aquifer system.

In-lieu Recharge The process of recharging groundwater supplies by substituting surface water for groundwater.

Irrigation Efficiency The amount of applied irrigation water that actually goes to satisfy net crop water demands, expressed as a percent.

Metric Conversions Acre-feet (x) 1233.5 = cubic meters
Acre-feet (x) .0012335 = cubic hectometers
Feet (x) .0348 = meters
Inches (x) 2.54 = centimeters
Million gallons per day (x) .043813 = cubic meters per second

Overdraft A long-term condition in which groundwater extractions exceed groundwater recharge.

Sacramento Index An index used by the California Department of Water Resources to forecast available water supplies and SWP delivery capabilities. The index consists of the forecasted or computed unimpaired flows of the Sacramento River near Red Bluff, Feather River at Oroville Reservoir, Yuba River at Smartville and American River at Folsum Reservoir.

SWP The State Water Project. In Kern County, its major feature is the Edmund G. Brown California Aqueduct.

TDS Total dissolved solids. A measurement of the dissolved matter in water, consisting mainly of inorganic salts, and small amounts of organic matter and gases. Usually measured in parts per million (PPM).

Unconfined Aquifer A groundwater bearing strata that is not constrained at its upper surface by an impervious or semi-impervious unit, such as a regional clay.

USBR United States Bureau of Reclamation. The operators of the Federal Central Valley Project.

Introduction

The Kern County Water Agency was created by the California Legislature in July, 1961 and ratified by the electorate of Kern County in September, 1961. The Agency was granted the primary power to acquire and contract for water supplies for Kern County, with additional powers to control flood and storm waters, to drain and reclaim land, to store and reclaim water, to protect the quality of underground waters, and to conduct investigations relative to water resources. The primary focus of the Agency, working with other water entities, is to coordinate management of the water supplies of Kern County, with particular emphasis on State Water Project supplies, in order to enhance our local economy.

Since its beginning in 1961, the Agency has been building a base of information on the water supply and demand characteristics of the San Joaquin Valley portion of Kern County. Since 1977, the Agency has published the annual Water Supply Report in order to present these statistics in one document and to assist water leaders and users in making water management decisions.

The Water Supply Report attempts to identify and quantify the interrelationships of the hydrologic cycle (see Figure 1) with man's activities in Kern County. For instance, the natural pattern of evapotranspiration has been altered by the planting and harvesting of crops. Groundwater storage has been affected by groundwater pumping and spreading, as the agricultural, municipal and industrial sectors attempt to meet their expanding needs. Local surface storage facilities and contracts for imported surface supplies have lessened our dependence upon groundwater supplies. Also, coordinated groundwater recharge efforts have had a positive effect upon groundwater storage.

The net result of the interactions between the available water supplies and the various demands for that water is a change in groundwater storage and groundwater quality. The Water Supply Report documents these changes and their causes.

All supporting data and calculations used to prepare this report are on file at the Agency and are open to public review.

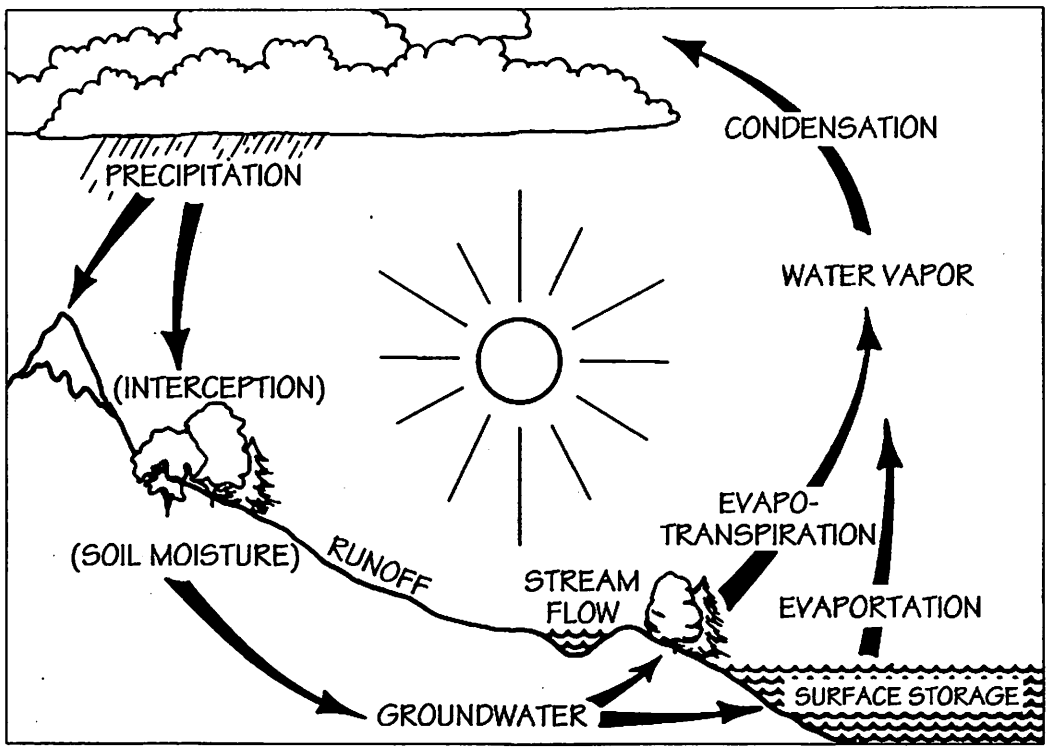


Figure 1. The Hydrologic Cycle

1991: The Drought Gets Worse

The year 1991 was conspicuous by the fact that the impacts of the present, lingering drought got worse. On the heels of a critically dry 1990 (when Kern County was strapped with a 50 percent reduction in State Water Project agricultural entitlement, and local Kern River supplies were 29 percent of average) the year 1991 proved also to be even more critically dry than the previous year. The resultant impacts of the ongoing drought during 1991 were substantial, caused primarily by a 100 percent reduction in SWP agricultural supplies and a 70 percent cut in SWP urban supplies. Since the SWPs inception, 1991 is the only year that a 100 percent reduction in SWP supplies was necessary, and the second time that urban SWP supplies have suffered a reduction. This is an event that seemed extremely unlikely when the State Water Project was approved by voters in 1960.

Curiously, there seems to be a persistence effect in the weather. The last drought cycle spanned the years 1976-77. The 1978-83 period was the wettest on record. Conversely, the year 1991 marks the fifth (and worst) year in the present, persistent drought, as shown below:

Year	Sacramento River Index
1991	8.4
1990	9.2
1989	14.8
1988	9.2
1987	9.2

The Sacramento River Index is routinely used to reflect statewide water supply conditions. The average index over 86 years of record is 17.8. Any year with an index less than 10.2 is classified as critically dry. Thus, four out of the last five years were critically dry, a period unmatched over the 86 years of historical record, dating back to 1906. Indeed, since 1906, never before has four critically dry years occurred back-to-back. One bright anomaly in the dismal year was the month of March, 1991. Going into March, precipitation was only 35 percent of normal in the Sierra watershed. Some cities were poised to impose near-draconian water rationing due to the severe water shortage. Marin County residents were faced with rationing cutbacks of 50 percent. Los Angeles residents were faced with up to a 30 percent water conservation target. Three times normal precipitation during March provided a much-needed boost to the State's water supply picture, but not enough to overcome the effects of six consecutive years of drought. Overall precipitation in the Sierra watershed was boosted to 75 percent of normal as a result of the March rains. Many areas of the state, including San Diego, Ventura and Fresno, surpassed their normal rainfall amounts for the year during March alone. Most urban areas were able to scale back their water rationing and conservation programs. While the month came to be called Miracle March , the rains came too late to be of much help to agricultural water users. Storage in the states reservoirs was too severely depleted from the previous years of drought.

In response to the serious water supply shortage, the state developed the State Emergency Bank. The Bank bought water from Delta and northern California water right holders, as well as paid farmers to fallow lands in return for the water that would have been used to irrigate the crop. A total of 820,000 acre-feet of water was made available by the Bank, from the following sources:

Source	**Acre-Feet**
Land fallowing	414,000
Groundwater purchases	276,000
Surface water purchases	142,000
Subtotal	**832,000**
Less carriage losses	(168,000)
Total available for sale	**664,000**

The cost for water from the Bank was about $175 per acre-foot at the Delta pumps. Power costs to convey the water to Kern County was an additional $20 per acre-foot. Urban interests accounted for the bulk of State Bank purchases, about 307,000 acre-feet. The water was simply too expensive for most agricultural interests to afford, when added to their already large fixed costs for SWP water. Statewide, agricultural interests purchased about 83,000 acre-feet from the Bank. Of this amount, about 54,000 acre-feet was purchased by Kern County agricultural interests, and was used to sustain high-value permanent crops on the west side of the County. These west side areas were especially hard-hit by the zero allocation, since they have no usable groundwater to turn to when surface supplies are scarce.

Two important studies of drought impacts have been completed by Northwest Economics Associates (Economic Impacts of the 1991 Drought on Kern County Agriculture, Economic Impacts of the 1991 California Drought on San Joaquin Valley Agriculture and Related Industries). The worst impacts on San Joaquin Valley and Kern County agriculture were:

A) Severely reduced surface supplies resulted in idling of about 237,000 acres in the San Joaquin Valley, with about 101,400 acres idled in Kern County as a result of the drought. An additional 16,200 acres were abandoned after planting due to lack of water, with about 9,700 acres abandoned in Kern County. Another 124,900 acres suffered reduced yields, with about 110,700 acres in Kern County. Loss of farm revenue due to reduced acreage or reduced yields amounted to about $281.5 million, with about $170.8 million occurring in Kern County. When considering the impacts upon related businesses and industries, the total revenue losses were estimated to be $545.8 million, with $332.6 million occurring in Kern County. A total of about 5,000 direct jobs were lost in agriculture (about 3,800 in Kern County), with an additional 4,000 jobs lost in related agricultural support industries (about 3,100 in Kern County). In terms of economic impacts, the drought impacted Kern County the worst.

B) Repayment of fixed costs for State Water Project storage and delivery facilities, payable regardless of water deliveries. For Kern County, these fixed costs for agricultural water users were $34.5 million in 1991. Such a repayment without receiving any water placed a tremendous financial burden upon the farming industry. Higher water costs related to the present drought have had a severe impact on San Joaquin Valley farmers' net income and financial reserves. In some areas, unit water costs have more than doubled since 1987 due to price increases for both surface and groundwater.

C) Cost of purchasing alternative water supplies, such as from the State Emergency Bank, drilling new groundwater wells or rehabilitating existing wells. For the San Joaquin Valley, costs for these activities amounted to nearly $230 million in 1991. Notably, about 2,400 new groundwater wells were drilled from 1989-91 in the San Joaquin Valley, with about 1,300 new wells being drilled in 1991 alone. With average construction costs of $95,000 per well, some $228 million has been spent to drill new wells since 1989; about $124 million was spent in 1991 alone.

D) Increased groundwater pumping lifts due to groundwater level increases. More energy is required to pump from greater depths. The average increase in groundwater depth in the San Joaquin Valley from 1985 (pre-drought) to 1991 was about 54 feet. For Kern County, the average increase was 57 feet. The combination of increased pumping lifts and greater use of groundwater increased San Joaquin Valley farmers pumping costs by $219 million in 1991 alone, with $62.3 million in Kern County. Some of these cost increases will continue into future years, creating a long-term increase in farm production costs.

The seriousness of the water supply situation is reflected by the fact that a total of only 34,865 acre-feet of SWP water was imported into Kern County. Total deliveries through the SWP facilities were 34,865 acre-feet of SWP entitlement water, 47,670 acre-feet of State Bank water, 7,000 acre-feet of water delivered via an inter-county exchange by a landowner. An additional 143,310 acre-feet of local groundwater supplies were delivered via SWP facilities as part of the 1991 emergency programs. Kern River supplies were only 335,913 acre-feet, or 45 percent of average. Central Valley Project deliveries were 204,400, or 54 percent of the 1975-91 average. Overall, surface water supplies were only about 655,000 acre-feet during 1991. Total irrigated acreage was 767,600 acres. As a result of the reduction in irrigated acreage, total agricultural water use was correspondingly reduced, with a total gross water requirement of about 2,489,400 acre-feet. Total groundwater pumping was sharply increased during 1991 to 2,002,400 acre-feet, about 205,400 acre-feet more than 1990 and 414,000 acre-feet more than 1989. The change in groundwater storage in 1991 was a withdrawal of about 1,484,400 acre-feet, the ninth time since the 1976-77 drought that a withdrawal has occurred. The total extractions since 1970 (when SWP water was first delivered over the Kern County groundwater basin) have been about 10,871,000 acre-feet. The total additions to storage over the same period have been about 4,614,000 acre-feet. Hence, the net change in storage since 1970 has been a reduction of about 6,257,000 acre-feet, or about 285,000 acre-feet per year. In terms of volume of water stored, the groundwater basin is now at 1977 levels, erasing the gains made since the 1976-77 drought. During the last five years of drought, about 4,258,000 acre-feet has been mined, or about 852,000 acre-feet per year.

Water Supplies

State Water Project

The drought patterns which have persisted since 1987 continued through 1991. The Sacramento River Index, used to reflect statewide water supply conditions, was 8.4, the lowest since the drought began. The average index over 86 years of record is 17.8. Generally, when the index is above 19.6 the year is classified as wet. When the index is between 15.7 and 19.6 the year is above normal. Between 12.5 and 15.7 is below normal. From 10.2 to 12.5 is considered dry. Any year with an index less than 10.2 is classified as "critically dry". Table 1 shows the historic record of the Sacramento River Index (SRI), both in natural order and sorted by size. Figure 2 is a histograph of the historic index.

Kern County Water Agency's initial 1991 allocations of State Water Project entitlement (made in December, 1990) provided only 356,600 acre-feet for agricultural use (a 75 percent reduction) and 106,900 acre-feet for urban or M&I uses (a 20 percent reduction). As the year progressed, it became obvious that the drought weather pattern was still with us, and even worse than expected. Final allocations of SWP agricultural water resulted in NO water being available for agricultural uses (a 100 percent reduction), and only 35,900 acre-feet for M&I uses (a 70 percent reduction). This marked the first time ever that a zero allocation was declared. Following on the heels of a 50 percent agricultural entitlement reduction received in 1990, the potential impacts of such a water supply shortage were nothing short of catastrophic. KCWA recognized the catastrophic nature of the drought early on, and took a number of important drought-related actions early in the year:

A) Staff developed a 1991 Emergency Drought Relief Plan, which outlined many possible actions, both structural and administrative, which could be taken to lessen the local impacts of the drought.

B) KCWA's Board of Directors declared a drought emergency in February, 1992. The intent of a drought emergency declaration is to facilitate emergency financing for drought relief and to allow KCWA to undertake other emergency measures.

C) KCWA petitioned the state Department of Water Resources to allow carryover of unused 1990 entitlement. This was done to maximize the amount of surface water available during 1991.

D) Approval was given KCWA's General Manager to approve inter- or intra-district water transfers, subject to appropriate conditions.

E) KCWA petitioned the DWR to apply about $14 million in prior-year overcharges to the Agency's 1991 bill, in order to minimize the financial impacts of paying for the SWP supply without receiving any water. (KCWA requested these funds to be returned earlier than provided by contract). Additionally, a five-year deferment of $21.4 million of KCWA's fixed charges for 1991 SWP agricultural entitlement was approved.

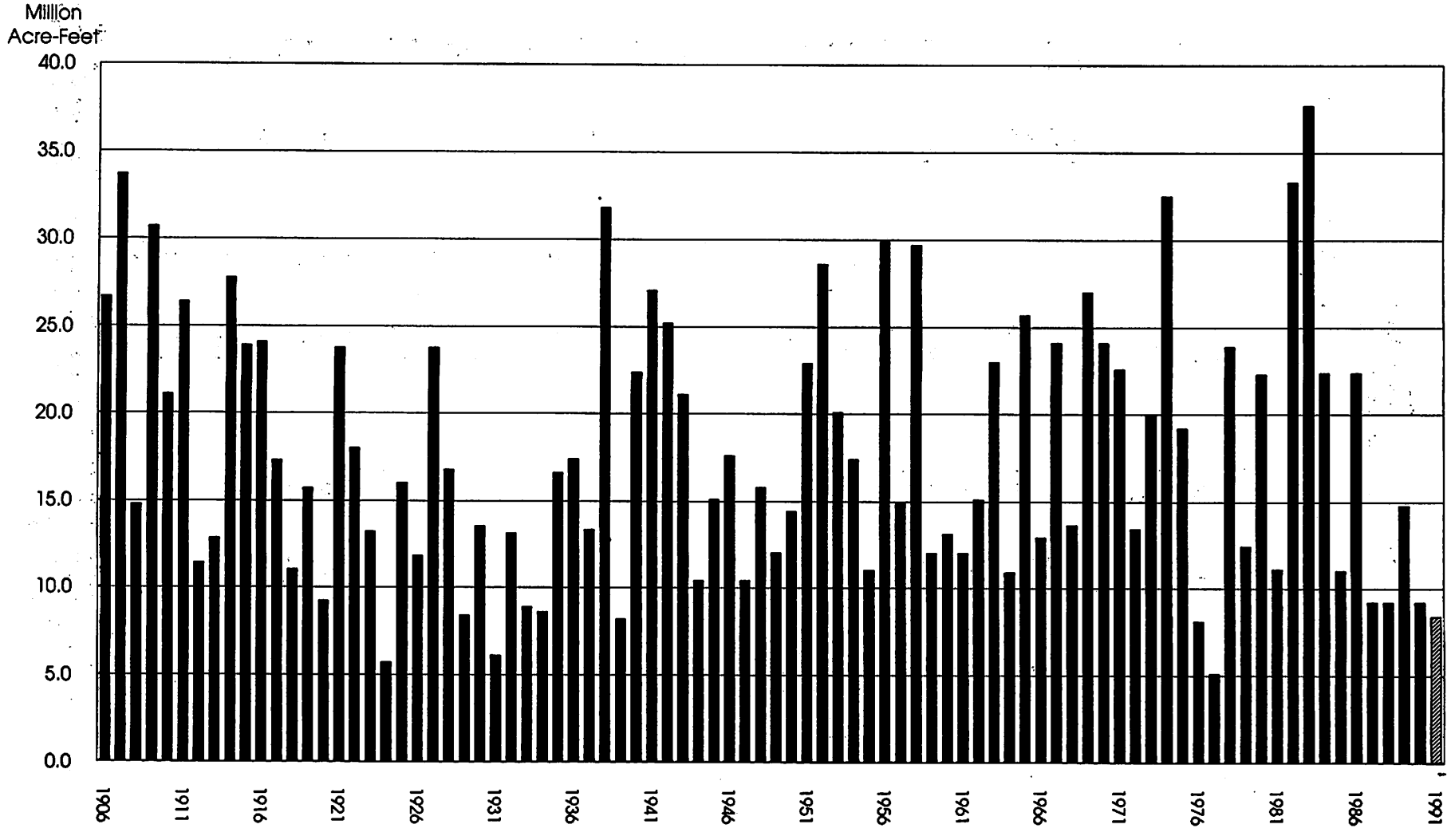
The centerpiece of KCWA's efforts to combat the drought was the 1991 Emergency Groundwater Recovery Program. This program was designed to extract 100,000 acre-feet of previously banked water from groundwater storage and deliver it via local canals to the California Aqueduct. From there it could be distributed to four west side water districts that were entirely without an alternative supply. While simple in principle, implementation of the program required construction of 14 new groundwater wells, in addition to the use of five wells already in place, and leasing of 25 other wells from private landowners. This effort required execution of numerous agreements between Kern County Water Agency and the Department of Water Resources, City of Bakersfield, local water districts and private landowners. The maximum extraction capacity of all the wells was about 6,800 acre-feet per month, which was insufficient to provide for peak irrigation needs. To overcome such pumping limitations, agreements with DWR provided for regulation of the local groundwater supply using SWP facilities. These agreements provided for advance delivery of water from SWP reservoir storage via the California Aqueduct on an agricultural demand schedule, with the bulk of the deliveries made during the peak summer months. KCWA would pump a steady stream of water into the California Aqueduct until the water was repaid to DWR. KCWA began groundwater production to repay the regulated water to DWR in January, 1991 and

Table 1
Historic Sacramento River Indexes *
(in million acre-feet)

Decending Order by Year				Ascending Order by Index			
Year	Index	Year	Index	Year	Index	Year	Index
1991	8.4						
1990	9.2	1945	15.1	1977	5.1	1928	16.8
1989	14.8	1944	10.4	1924	5.7	1917	17.3
1988	9.2	1943	21.1	1931	6.1	1954	17.4
1987	9.2	1942	25.2	1976	8.1	1936	17.4
1986	22.4	1941	27.1	1939	8.2	1922	18.0
1985	11.0	1940	22.4	1929	8.4	1975	19.2
1984	22.4	1939	8.2	1991	8.4	1973	20.0
1983	37.7	1938	31.8	1934	8.6	1953	20.1
1982	33.3	1937	13.3	1933	8.9	1943	21.1
1981	11.1	1936	17.4	1990	9.2	1946	17.6
1980	22.3	1935	16.6	1988	9.2	1910	21.1
1979	12.4	1934	8.6	1987	9.2	1980	22.3
1978	23.9	1933	8.9	1920	9.2	1984	22.4
1977	5.1	1932	13.1	1947	10.4	1940	22.4
1976	8.1	1931	6.1	1944	10.4	1986	22.4
1975	19.2	1930	13.5	1964	10.9	1971	22.6
1974	32.5	1929	8.4	1985	11.0	1951	22.9
1973	20.0	1928	16.8	1955	11.0	1963	23.0
1972	13.4	1927	23.8	1918	11.0	1927	23.8
1971	22.6	1926	11.8	1981	11.1	1921	23.8
1970	24.1	1925	16.0	1912	11.4	1978	23.9
1969	27.0	1924	5.7	1926	11.8	1915	23.9
1968	13.6	1923	13.2	1961	12.0	1970	24.1
1967	24.1	1922	18.0	1959	12.0	1967	24.1
1966	12.9	1921	23.8	1949	12.0	1916	24.1
1965	25.7	1920	9.2	1979	12.4	1942	25.2
1964	10.9	1919	15.7	1913	12.8	1965	25.7
1963	23.0	1918	11.0	1966	12.9	1911	26.4
1962	15.1	1917	17.3	1960	13.1	1906	26.7
1961	12.0	1916	24.1	1932	13.1	1969	27.0
1960	13.1	1915	23.9	1923	13.2	1941	27.1
1959	12.0	1914	27.8	1937	13.3	1914	27.8
1958	29.7	1913	12.8	1972	13.4	1952	28.6
1957	14.9	1912	11.4	1930	13.5	1958	29.7
1956	29.9	1911	26.4	1968	13.6	1956	29.9
1955	11.0	1910	21.1	1950	14.4	1909	30.7
1954	17.4	1909	30.7	1989	14.8	1938	31.8
1953	20.1	1908	14.8	1908	14.8	1974	32.5
1952	28.6	1907	33.7	1957	14.9	1982	33.3
1951	22.9	1906	26.7	1962	15.1	1907	33.7
1950	14.4			1945	15.1	1983	37.7
1949	12.0			1919	15.7		
1948	15.8			1948	15.8		
1947	10.4			1925	16.0		
1946	17.6			1935	16.6		

* An index used by the California Department of Water Resources to forecast available water supplies and SWP delivery capabilities. The index consists of the forecasted or computed unimpaired flows of the Sacramento River near Red Bluff, Feather River at Oroville Reservoir, Yuba River at Smartville and American River at Folsum Reservoir. Formerly called Four-basin Index.

Figure 2
Historic Sacramento River Indexes



continued until mid-1992. Total cost of the program was about $12 million, which was entirely paid during 1991 by the west side participants in the program. Total water delivered to these participants during 1991 was 97,013 acre-feet; the remaining 2,987 acre-feet was delivered during January-February, 1992.

* * *

In addition to KCWA's program, local water districts developed their own programs to cope with the drought. Numerous water exchanges and purchases were made under these district programs. (As a regional body, KCWA serves as an administrator for the transfer of local SWP water). Also, local landowners without alternative groundwater supplies developed their own individual emergency programs. (See Table 4 for a list of these programs and their deliveries). These programs allowed west side permanent crops to avoid disaster — dying from lack of water. Had such an occurrence happened, the impacts on the local economy would have been catastrophic. The major local programs were developed by Wheeler Ridge-Maricopa Water Storage District, Belridge Water Storage District, Berrenda Mesa Water District, Lost Hills Water District, Buena Vista Water Storage District and Henry Miller Water District. Crucial to the success of these district's programs was an agreement between KCWA and the State Department of Water Resources to make use of San Luis Reservoir storage for regulation of local water on an irrigation demand schedule.

Wheeler Ridge-Maricopa Water Storage District

Due to the zero State Water Project allocation in 1991, Wheeler Ridge-Maricopa WSD allowed farmers to connect 43 private wells to the District's delivery system or the California Aqueduct. Farmers could then grow crops on fields without wells by utilizing the District's delivery system, or could place water into the California Aqueduct for regulation on an irrigation demand schedule. A total of 14 pipeline interties were constructed across the California Aqueduct right-of-way to discharge directly into the Aqueduct. A total of 26,650 acre-feet of groundwater was produced in 1991 as part of the District's program, at a cost of about $143,000.

Belridge Water Storage District

Several industrial water users within Belridge WSD entered into an agreement with West Kern WD to purchase banked water belonging to West Kern. A pipeline was constructed by these industrial users to convey the extracted groundwater from West Kern's well field to the California Aqueduct. Belridge WSD then diverted a like amount of water into their distribution system from further north on the California Aqueduct for these industrial users. A total of 6,580 acre-feet was delivered under this program, at a cost of about $2.5 million.

Berrenda Mesa Water District

Berrenda Mesa WD owns about 400 acres of land adjacent to the Kern River, which has been developed into a groundwater recharge area. The District owns two groundwater wells which are on the property. As part of its program to survive the drought, Berrenda Mesa pumped 4,000 acre-feet of groundwater, transferred from KCWA, which had previously been recharged into the Berrenda Mesa Spreading Grounds. This water was extracted via the two district-owned wells and discharged into the Cross Valley Canal (CVC). The CVC was used to convey the well water into the California Aqueduct, and the District simultaneously diverted a like amount of water into its delivery system from further north on the California Aqueduct.

Additionally, Berrenda Mesa entered into an agreement with a landowner in the Devils Den WD and Green Valley WD to buy groundwater and import it into Berrenda Mesa. The landowner farmed in both the Devils Den and Green Valley WDs. This agreement called for the landowner to pump groundwater into the California Aqueduct during times when his wells weren't being used to irrigated his own crops. The water was then diverted into Berrenda Mesa's facilities via the Coastal Branch of the California Aqueduct. A total of 1,500 acre-feet was delivered as part of this agreement.

Total costs for Berrenda Mesa WD's programs were between $500,000 and $600,000.

Lost Hills Water District

Lost Hills WD facilitated the maximum use of water in-district by simplifying rules and regulations regarding water transfers. Lost Hills WD landowners with water allocations in other districts were allowed to transfer such water into Lost Hills WD for use on lands within the District. About 10,000 acre-feet of water was transferred into Lost Hills WD during 1991. These emergency transfers were necessary for the protection of permanent crops within Lost Hills WD.

Also, some landowners in Lost Hills WD drilled shallow groundwater wells and blended the poorer-quality groundwater with the district's higher-quality canal water.

Henry Miller Water District/Buena Vista Water Storage District

Buena Vista WSD and Henry Miller WD operated a joint program to help both districts meet peak summer irrigation demands. Buena Vista WSD delivered pumped groundwater and Lake Isabella power flows (Kern River water which must be released from Lake Isabella for power generation) into the California Aqueduct on an as-available basis. In return, Buena Vista delivered California Aqueduct water on an agricultural irrigation demand schedule.

Henry Miller WD faced a similar problem as Buena Vista WD. Henry Miller has insufficient well pumping capacity to meet its full irrigation demands. The District normally uses a combination of surface and groundwater together to meet its peak needs. With no surface water available in 1991, 5,000 acres of land was fallowed in the district. To cope with the lack of surface water and limited well pumping capacity, Henry Miller used District-owned wells to pump groundwater into surface storage when irrigation demand were low. Water from seven District wells was discharged into Lake Webb (Buena Vista Aquatic Recreation Area) and into the California Aqueduct via a pump station at the Outlet Channel of the lake. The District then delivered California Aqueduct water on an irrigation demand schedule. The success of Henry Miller's program is evidenced by the fact that about 3,000 acres were kept in production that would otherwise have been fallowed, due to inability of the District to meet peak irrigation demands via groundwater alone.

It should be noted that these programs and their costs were in addition to normal district costs for water supplies. The critical situation created by the drought required extreme emergency measures. The local programs developed by the districts to cope with the drought emergency are a tribute to the ingenuity of local water managers.

* * *

The potential economic impacts of the drought could have been devastating to the local economy. Northwest Economics Associates (NEA) was engaged to analyze the economic impacts of the drought on Kern County. NEA's studies show that the potential drought impacts could have reached $8.4 billion had west side permanent crops died from lack of water. The emergency programs reduced the economic impacts to about $800 million. While this may seem to be a much smaller economic impact compared to a potential $8.4 billion impact, it still represents a substantial negative effect upon the local economy. With less farmed acreage and less water, there is an associated reduction in farm labor requirements. NEA estimated that about 3,800 farm jobs were lost as a direct result of the drought. Perhaps another 3,100 jobs were lost in support and related industries, for a total job loss of 6,900. Total revenue losses from all sectors as a result of the drought were estimated to be about $384 million. This money was not circulated through the local economy. Also, one must not lose sight of the suffering endured by nearly 7,000 people, and their families, who lost their means of livelihood because of the drought. The human aspects of these drought impacts must not be lost in a focus upon merely economic values.

On a state level, Governor Pete Wilson set up a drought team to assess and cope with the situation. Mother nature provided some respite by granting a very rainy March, but the long drought was too entrenched for the precipitation to make a major difference in SWP allocations. At the recommendation of the drought team, a State Emergency Bank was set up by the Department of Water Resources early in 1991. In northern California, the DWR paid growers to pump groundwater and release their surface water to DWR's drought pool. DWR also purchased stored surface water from some districts, and paid landown-

ers to fallow their land and thereby release their surface water rights for resale in the Bank. Potential buyers were required to demonstrate a critical need for the water. Kern County purchased 47,670 acre-feet from the Bank, for use on west side, high-value permanent crops.

The year 1991 was indeed a complicated year, with many water management programs not anticipated by the master water supply contracts for SWP water. Table 4 shows SWP water deliveries to each member unit in 1991, and reflects this complexity.

Article 12(d) of the master contract between DWR and KCWA provides for future repayment of entitlement water which DWR is unable to deliver as a result of causes beyond its control. Such 12(d) water is delivered on an as-available basis. (By design, 12(d) water is unreliable, and when it is available, it can only be delivered after entitlement deliveries). The 50 percent agricultural entitlement reduction in 1990 caused Article 12(d) to apply. At the end of 1990, KCWA had a 12(d) account of 516,900 acre-feet. The 100 percent agricultural entitlement cut in 1991, combined with the 75 percent M&I entitlement cut, added another 1,117,520 acre-feet to the account, for a total 12(d) account of 1,634,420 acre-feet. A breakdown of 12(d) water by Agency member unit is shown in Table 2a.

The Agency's annual entitlement to SWP water is according to a build-up schedule in the master contract. The build-up provides for increasing amounts of water beginning in 1968, which reached a maximum in 1990. Contracts between the Agency and its member units provided for additional decreasing amounts of surplus water, reaching a minimum of 100,000 acre-feet in 1990. The surplus water would be delivered on an as-available basis. Agency member units' contract entitlements for 1990 and thereafter are shown on Table 2b. The Agency's actual contracted entitlement with DWR is the total firm entitlement shown on Table 2b. The table also breaks down entitlement between M&I and agricultural uses. While the M&I entitlement is relatively small compared to the agricultural, KCWA is the third-largest M&I contractor with the SWP, and is the largest agricultural contractor.

Since the first deliveries in 1968, a total of over 17 million acre-feet of SWP water has been imported into the San Joaquin Valley portion of Kern County. A histogram of historic SWP deliveries is provided in Figure 3. Table 3 provides a history of SWP deliveries, with annual and cumulative deliveries and imports shown. Table 4 shows 1991 SWP deliveries by contract type.

Kern River

Total Kern River flows contributed 335,913 acre-feet to the valley portion of Kern County in 1991, consisting of First Point Regulated flows of 333,494 acre-feet and 2,419 acre-feet diverted above First Point. The total was about 46 percent of the 98-year mean flow of 724,627 acre-feet, and about 45 percent of the mean regulated flow (1954 to present) of 749,397 acre-feet. Kern River runoff during the 1991 April-July snow melt period was 55 percent of the 98-year average flow. During the rainy season from October, 1990 through February, 1991 the Kern River watersheds rainfall was only 28 percent of normal. Early predictions were for the driest water year of the century on the Kern River. Then the March Miracle occurred, and record-breaking precipitation fell. The town of Isabella at the north end of Lake Isabella received 6.43 inches of rain in March, the greatest amount for that month ever recorded. Then the precipitation window slammed shut and the drought resumed, with the remainder of the season producing less than 10 percent of normal.

A comparison of the April 1 snowpack for the snow sensors in the Kern River watershed during 1991 with the historic average is shown as follows (inches of water content):

	Apr. 1 1990	Apr. 1 1991	Apr. 1 Avg.	1991 % of Avg.
Upper Tyndall Creek	12.7	16.0	27.7	58
Crabtree Meadow	7.1	13.1	19.8	66
Chagoopa	11.3	21.6	21.8	99
Pascoe	12.0	27.7	24.9	111
Wet Meadow	6.6	23.2	30.3	77
Tunnel Guard	0.0	13.2	15.6	85
Casa Vieja Meadows	10.5	19.0	20.9	91
Beach Meadows	0.0	9.0	11.0	82

Table 5 gives historic Kern River First Point runoff and cumulative runoff for the 98 years of complete record. During the last 98 years, over 71 million acre-feet of Kern River runoff have occurred. Since Isabella Dam began regulating flows in 1954, nearly 28.5 million acre-feet of Kern River runoff has occurred.

Table 2a
Kern County Water Agency
State Water Project
Article 12(d) Account
(in acre-feet)

Member Unit	Article 12(d) Acquired			Article 12(d) Delivered	Available Balance
	1990	1991	Total		
Berrenda Mesa WD	77,505	155,073	232,578	0	232,578
Lost Hills WD	70,159	140,376	210,535	0	210,535
Belridge WSD	81,453	162,972	244,425	0	244,425
Buttonwillow ID	41,476	82,986	124,462	0	124,462
Pond Poso ID	33,480	66,988	100,468	0	100,468
Semitropic WSD	3,998	7,999	11,997	0	11,997
Cawelo WD	19,089	38,193	57,282	0	57,282
Improvement District No. 4 (Ag)	5,135	10,274	15,409	0	15,409
Improvement District No. 4 (M&I)	0	53,900	53,900	0	53,900
Rosedale-Rio Bravo WSD	14,941	29,895	44,836	0	44,836
Buena Vista WSD	10,644	21,296	31,940	0	31,940
Kern Delta WD	12,742	25,495	38,237	0	38,237
Henry Miller WD	17,740	35,494	53,234	0	53,234
West Kern WD (M&I)	0	17,500	17,500	0	17,500
Wheeler Ridge-Maricopa WSD	126,389	252,880	379,269	0	379,269
Tehachapi Cummings CWD (Ag)	2,149	4,299	6,448	0	6,448
Tehachapi Cummings CWD (M&I)	0	10,500	10,500	0	10,500
Tejon-Castac WD (M&I)	0	1,400	1,400	0	1,400
Total	**516,900**	**1,117,520**	**1,634,420**	**0**	**1,634,420**

Table 2b
Kern County Water Agency
Member Unit Contract Entitlements
for 1990*-2035

Member Unit	Table 1 Entitlements (in acre-feet)					
	Firm	Surplus	Total	M&I	Ag	Total
Berrenda Mesa WD	155,100	8,100	163,200		163,200	163,200
Lost Hills WD	140,400	0	140,400		140,400	140,400
Belridge WSD	163,000	0	163,000	15,000 **	148,000	163,000
Buttonwillow ID	83,000	13,100	96,100		96,100	96,100
Pond Poso ID	67,000	11,100	78,100		78,100	78,100
Semitropic WSD	8,000	900	8,900		8,900	8,900
Cawelo WD	38,200	6,800	45,000		45,000	45,000
Improvement District No. 4	87,276	1,554	88,830	77,000	11,830	88,830
Rosedale-Rio Bravo WSD	29,900	5,100	35,000		35,000	35,000
Buena Vista WSD	21,300	3,750	25,050		25,050	25,050
Kern Delta WD	25,500	4,500	30,000		30,000	30,000
Henry Miller WD	35,500	6,250	41,750		41,750	41,750
West Kern WD	25,000	0	25,000	25,000		25,000
Wheeler Ridge-Maricopa WSD	252,924	38,146	291,070		291,070	291,070
Tehachapi-Cummings CWD	19,300	700	20,000	15,000	5,000	20,000
Tejon-Castac WD	2,000	0	2,000	2,000		2,000
Total	**1,153,400**	**100,000**	**1,253,400**	**134,000**	**1,119,400**	**1,253,400**

* Maximum annual entitlement is reached in 1990.
** Subject to agricultural water shortage provisions.

Figure 3
California State Water Project Deliveries
to Kern County Water Agency

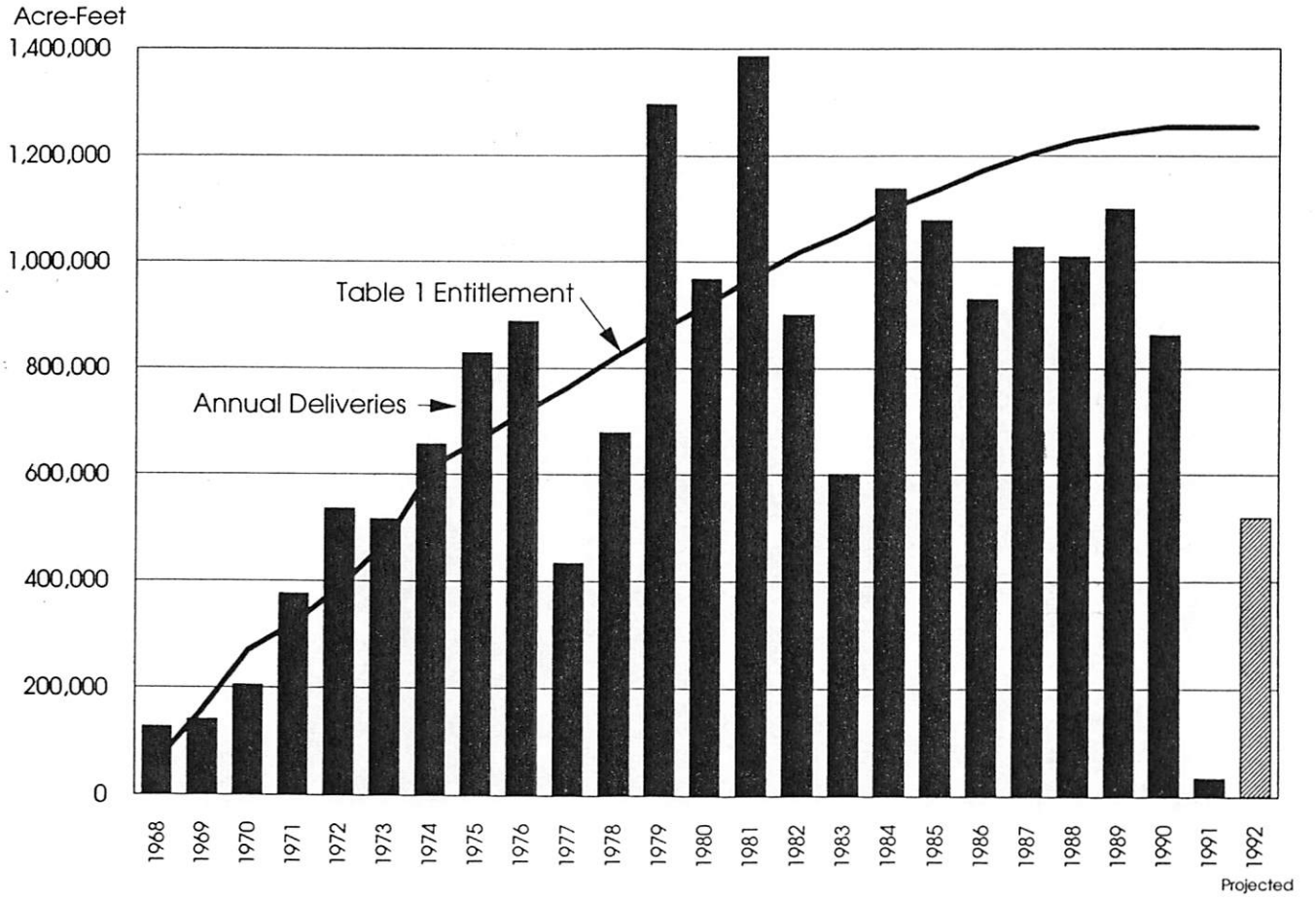


Table 3
SWP Water Deliveries to the
San Joaquin Valley Portion of Kern County
(in acre-feet)

Year	Annual (1) Deliveries	Cumulative Deliveries	Intertie Deliveries	Deliveries (2) Outside SJV	Annual Importations	Cumulative Importations
1968	127,384	127,384			127,384	127,384
1969	141,265	268,649			141,265	268,649
1970	204,634	473,283			204,634	473,283
1971	375,505	848,788			375,505	848,788
1972	535,573	1,384,361			535,573	1,384,361
1973	515,546	1,899,907		25	515,521	1,899,882
1974	656,773	2,556,680		4,992	651,781	2,551,663
1975	828,437	3,385,117		6,699	821,738	3,373,401
1976	888,112	4,273,229		4,755	883,357	4,256,758
1977	432,837	4,706,066		3,424	429,413	4,686,171
1978	678,400	5,384,466	64,100	2,826	611,474	5,297,645
1979	1,295,388	6,679,854		3,630	1,291,758	6,589,403
1980	968,092	7,647,946	64,792	3,041	900,259	7,489,662
1981	1,386,641	9,034,587		1,897	1,384,744	8,874,406
1982	900,973	9,935,560	13,679	2,791	884,503	9,758,909
1983	601,183	10,536,743	362,292	724	238,167	9,997,076
1984	1,138,040	11,674,783	13,639	1,360	1,123,041	11,120,117
1985	1,078,147	12,752,930		4,015	1,074,132	12,194,249
1986	929,178	13,682,108	12,701	2,916	913,561	13,107,810
1987	1,028,124	14,710,232		2,217	1,025,907	14,133,717
1988	1,009,520	15,719,752		3,307	1,006,213	15,139,930
1989	1,146,062	16,865,814		48,833	1,097,229	16,237,159
1990	862,448	17,728,262		5,112	857,336	17,094,495
1991	34,865 (3)	17,763,127		2,213	32,652	17,127,147

Mean Deliveries	729,444 AF
Median Deliveries	828,437 AF
Mean Importations	705,754 AF
Median Importations	821,738 AF

(1) Includes Pre-consolidation water deliveries.
(2) Includes Tehachapi-Cummings CWD and other deliveries outside the San Joaquin Valley portion of Kern County.
(3) From Table 4.

Table 4
1991 State Water Project Deliveries by Contract
(in acre-feet)

	SWP Entitlement Supplies						State Bank	Other Supplies	Local Groundwater Supplies			Total Deliveries				
		1990	Entitlement Transfers and Exchanges				State	District/	1991	Member					Local	
	Table 1	Entitlement	Landowner	Long-Term	ID4	Misc.	Bank	Landowner	Emergency	Unit	Landowner	SWP (21)	State (22)	Other	Ground	Grand
Member Unit	Entitlement	Carryover	Transfers	M&I Pool	Transfers	Exchanges	Purchases	Transfers	Pool (11)	Programs	Programs	Water	Bank	Supplies	Water	Total
Berrenda Mesa WD		780					43,021		22,243	6,283 (12)		780	43,021		28,514	72,315
Lost Hills WD					3,672 (3)		3,649	7,000 (10)	20,088		2,000 (18)	3,669	3,649	7,000	22,088	36,406
Belridge WSD		118		1,116 (2)	400 (4)		1,000		22,811	4,425 (13)	590 (19)	1,628	1,000		27,813	30,441
Buttonwillow ID		2,886				89 (7)						2,975				2,975
Pond Poso ID		2,329				72 (7)						2,401				2,401
Semitropic WSD		278										278				278
Cawelo WD					207 (5)							202				202
Improvement District No. 4 Ag																
M&I	7,467	635		1,116						1,864 (14)		9,218			1,850	11,068
Rosedale-Rio Bravo WSD																
Buena Vista WSD		1,288			34 (6)	6,700 (8)				15,001 (15)		8,016			14,986	23,002
Kern Delta WD																
Henry Miller WD										2,132 (16)					2,116	2,116
West Kern WD	768											768				768
Wheeler Ridge-Maricopa WSD			718 (1)			2,000 (9)			31,871	8,670 (17)	5,419 (20)	2,717			45,943	48,660
Tehachapi-Cummings CWD Ag		25										25				25
M&I	2,188											2,188				2,188
Tejon-Castac WD																
Total	**10,423**	**8,339**	**718**	**2,232**	**4,313**	**8,861**	**47,670**	**7,000**	**97,013**	**38,375**	**8,009**	**34,865**	**47,670**	**7,000**	**143,310**	**232,845**

This table shows contracted deliveries for calendar year 1991. For each district, deliveries may vary from amounts shown, due to: a) current year SWP/Kern river exchanges, b) payback of SWP water from prior year exchanges, c) conjunctive use agreements.

(1) Includes 318 AF of 1990 entitlement carryover and 400 AF of 1991 entitlement from Tejon-Castac WD transferred to a common landowner in Wheeler Ridge-Maricopa WSD.

(2) This water, which is normally delivered to Buena Vista WSD via a long-term exchange with West Kern WD, was delivered to Belridge WSD for M&I purposes.

(3) Includes 2,500 AF of ID4 exchange payback to Kern-Tulare WD/Lost Hills WD; includes 1,100 AF of Nickel water sold to Lost Hills WD (Ritchie & Westfarmers) and delivered via Nickel/ID4 exchange; includes 72 AF of a 100 AF ID4 sale to Munger (LHWD).

(4) Includes 300 AF of Hacienda water sold to Belridge WSD (Starrh) and delivered via the Hacienda/ID4 exchange; includes 100 AF of Nickel water sold to Belridge WSD (Ritchie) and delivered via the Nickel/ID4 exchange.

(5) Cawelo WD's January SWP delivery prior to the 0% agricultural allocation. Accomodated through an exchange with ID4 for a like amount of Kern River water.

(6) Completion of 1990 ID4 exchange payback to Buena Vista WSD.

(7) Exchange payback from Dudley Ridge WD to Semitropic WSD for water delivered to Dudley Ridge WD in 1990 via exchange agreement dated December 6, 1990.

(8) West Kern WD's 1991 entitlement delivered to Buena Vista WSD via long-term exchange agreement.

(9) Imported supply of Antelope Valley-East Kern WA's (AVEK) 1991 SWP entitlement delivered to Wheeler Ridge-Maricopa WSD via exchange agreement between Tejon-Castac WD, Wheeler Ridge-Maricopa WSD and AVEK (future payback required).

(10) Imported supply of CVP water delivered to Lost Hills WD (Paramount) via Kern-Tulare WD/ID4 exchange date July 25, 1991 (Exhibit A to agreement between Lost Hills WD, Paramount and KCWA dated August 26, 1991).

(11) Includes 97,013 AF out of a 100,000 AF production target; remaining 2,987 AF delivered in 1992.

(12) Includes 2,333 AF of groundwater introduced into the Coastal Branch of the California Aqueduct, and 3,950 AF of groundwater from the Berrenda Mesa Spreading Grounds introduced into the California Aqueduct and/or exchanged in the Cross Valley Canal.

(13) Groundwater produced by West Kern WD and introduced into the California Aqueduct at Mile Post 240.20 and delivered to Belridge WSD Turnout No. 5 at Mile Post 217.13 of the California Aqueduct per agreement dated July 12, 1991.

(14) Groundwater produced by ID4 and by private parties (Bartell and Castle & Cook) in excess of consumptive use limit; all for use by ID4.

(15) Kern River water and groundwater produced by Buena Vista WSD and introduced into the California Aqueduct for delivery by district later in the year; as per draft agreement dated April 22, 1991.

(16) Groundwater produced by Henry Miller WD and introduced into the California Aqueduct for delivery by district later in the year; as per draft agreement dated April 22, 1991.

(17) Groundwater produced by Wheeler-Ridge-Maricopa WSD and introduced into the California Aqueduct for instantaneous delivery to various users with the district; as per agreement dated April 18, 1991.

(18) Groundwater account transferred from North Kern WSD to the 2,800 Acre Spreading Facility for extraction and delivery to Paramount (LHWD); to be extracted by KCWA wells; pursuant to agreement dated September 19, 1991.

(19) Groundwater produced by private party (Bartell) and sold to Belridge WSD (Starrh) via agreement dated July 26, 1991.

(20) Includes 1,896 AF of groundwater produced by private party (Strand) and sold to Wheeler Ridge-Maricopa WSD (MJB Ranch) via agreement March 28, 1991; includes 3,523 AF of groundwater produced by Castle & Cooke for private use in Wheeler-Ridge-Maricopa WSD via agreement dated March 31, 1992.

(21) Excludes 2,758 AF of 1991 entitlement delivered during 1992. Excludes 9,054 AF of ID4 1991 entitlement exchanged for 1991 Emergency Pool groundwater. Excludes 308 AF of Buena Vista WSD's 1990 entitlement carryover sold to the 1991 Emergency Pool.

Table 5
Historic Kern River Flows *
(in acre-feet)

Calendar Year	Annual Flows	Cumulative Unregulated Flows	Calendar Year	Annual Flows	Cumulative Flows Unregulated	Cumulative Flows Regulated
1894	533,326	533,326				
1895	1,023,052	1,556,378				
1896	619,692	2,176,070	1931	185,645	26,249,601	
1897	893,434	3,069,504	1932	737,727	26,987,328	
1898	251,827	3,321,331	1933	441,086	27,428,414	
1899	338,872	3,660,203	1934	227,665	27,656,079	
1900	332,373	3,992,576	1935	474,128	28,130,207	
1901	880,089	4,872,665	1936	796,447	28,926,654	
1902	552,539	5,425,204	1937	1,260,182	30,186,836	
1903	546,395	5,971,599	1938	1,358,685	31,545,521	
1904	492,949	6,464,548	1939	461,073	32,006,594	
1905	531,809	6,996,357	1940	789,098	32,795,692	
1906	1,900,540	8,896,897	1941	1,401,076	34,196,768	
1907	990,900 **	9,887,797	1942	771,966	34,968,734	
1908	498,503 **	10,386,300	1943	1,220,827	36,189,561	
1909	1,838,643	12,224,943	1944	625,537	36,815,098	
1910	658,911	12,883,854	1945	938,055	37,753,153	
1911	1,013,384	13,897,238	1946	650,683	38,403,836	
1912	387,432	14,284,670	1947	406,698	38,810,534	
1913	367,840	14,652,510	1948	329,506	39,140,040	
1914	1,113,513	15,766,023	1949	302,870	39,442,910	
1915	646,287	16,412,310	1950	601,360	40,044,270	
1916	2,520,149	18,932,459	1951	442,222	40,486,492	
1917	823,082	19,755,541	1952	1,500,999	41,987,491	
1918	538,503	20,294,044	1953	548,833	42,536,324	
1919	499,124	20,793,168	1954	528,357 ***	43,064,681	528,357
1920	600,643	21,393,811	1955	444,300	43,508,981	972,657
1921	509,519	21,903,330	1956	840,862	44,349,843	1,813,519
1922	861,426	22,764,756	1957	444,338	44,794,181	2,257,857
1923	500,515	23,265,271	1958	1,104,730	45,898,911	3,362,587
1924	187,727	23,452,998	1959	257,978	46,156,889	3,620,565
1925	465,913	23,918,911	1960	300,037	46,456,926	3,920,602
1926	366,706	24,285,617	1961	177,642	46,634,568	4,098,244
1927	792,580	25,078,197	1962	697,704	47,332,272	4,795,948
1928	312,828	25,391,025	1963	801,450	48,133,722	5,597,398
1929	322,958	25,713,983	1964	339,266	48,472,988	5,936,664
1930	349,973	26,063,956	1965	720,362	49,193,350	6,657,026

* Includes deliveries above First Point.
** Data incomplete. Flow extrapolated from available data.
*** Isabella Dam in operation. All subsequent flows are controlled releases.

Table 5 (continued)
Historic Kern River Flows *
(in acre-feet)

Calendar Year	Annual Flows	Cumulative Flows Unregulated	Cumulative Flows Regulated
1966	678,595	49,871,945	7,335,621
1967	1,396,227	51,268,172	8,731,848
1968	453,760	51,721,932	9,185,608
1969	2,461,370	54,183,302	11,646,978
1970	589,474	54,772,776	12,236,452
1971	427,454	55,200,230	12,663,906
1972	268,427	55,468,657	12,932,333
1973	979,652	56,448,309	13,911,985
1974	818,608	57,266,917	14,730,593
1975	564,567	57,831,484	15,295,160
1976	249,468	58,080,952	15,544,628
1977	196,998	58,277,950	15,741,626
1978	1,653,505	59,931,455	17,395,131
1979	672,661	60,604,116	18,067,792
1980	1,639,957	62,244,073	19,707,749
1981	449,263	62,693,336	20,157,012
1982	1,271,139	63,964,475	21,428,151
1983	2,489,128	66,453,603	23,917,279
1984	821,797	67,275,400	24,739,076
1985	672,431	67,947,831	25,411,507
1986	1,444,939	69,392,770	26,856,446
1987	375,935	69,768,705	27,232,381
1988	294,685	70,063,390	27,527,066
1989	397,038	70,460,428	27,924,104
1990	219,501	70,679,929	28,143,605
1991	335,913	71,015,842	28,479,518

98 Year Mean First Point Flow	724,651 AF
98 Year Median First Point Flow	558,553 AF
Regulated Mean First Point Flow	749,461 AF
Regulated Median First Point Flow	577,021 AF

Figure 4 is a histograph of annual Kern River flows at First Point.

Entitlements to Kern River water are determined according to formulae established in the Miller-Haggin Agreement of 1888 and the Shaw Decree, a judicial decree set in 1900 by Judge Lucien Shaw. Later amendments to these agreements have been adopted as circumstances warranted. Essentially, these agreements establish diversion rights to Kern River water based on unimpaired flows at First Point of Measurement. Most of these diversion rights are now held by public water districts. Hence, entitlements to Kern River water are diverted into district delivery facilities, and subsequently to farmers within the district. Table 6 gives a summary of Kern River deliveries in 1991. Plate 10 at the end of this report shows the major canal distribution facilities operated by the Kern River group.

Central Valley Project (CVP)

Deliveries of federal CVP water to Kern County in 1991 were 204,396 acre-feet. Comparatively, 1990 deliveries of CVP water were 200,141 acre-feet. Supplies in 1991 were about 54 percent of the 1975-1991 average, and about 57 percent of the 1975-1991 median. For the fifth consecutive year no Class 2 entitlement was available. Since 1966, Class 2 entitlements have been unavailable in only seven years (1976-77 and 1987-91). Table 7 shows 1991 deliveries of CVP water by entity. As shown, 191,996 acre-feet of Class 1 entitlement and 12,400 acre-feet of other CVP water was delivered. Table 8 gives annual and cumulative deliveries of CVP water since 1950, when the first importations were made to Kern County. Figure 5 is a histograph of CVP deliveries since 1950. At the end of 1991, over 11.7 million acre-feet of CVP water have been imported into Kern County.

Minor Streams

Secondary to the Kern River water supply is runoff from local minor stream watersheds. Streams which yield measurable runoff are grouped into four watershed groups; the Poso group (most significant of which is Poso Creek), the Caliente group (most significant of which are Caliente and Tehachapi Creeks), the El Paso group (most significant of which is El Paso Creek), and the San Emigdio group (most significant of which is San Emigdio Creek). Grouping of minor streams is based upon hydrologic similarity of watersheds, and representative gauging records. Total yields from minor streams can be substantial during above-average precipitation years, such as 1978, 1982 and 1983. Runoff for un-gaged streams is estimated by statistical methods based on historic relationships of area, precipitation and runoff for gaged streams. Gages on Poso and Tehachapi Creeks are still operating, and therefore actual measurements of runoff can be used for these watersheds. (An exception is Tehachapi Creek in very dry years, when the flow is too small for the gage to record, as occurred in 1990). Total minor stream volumes in 1991 were estimated to be about 34,600 acre-feet as follows:

Group	Acre-Feet
Poso	9,000
Caliente	7,700
El Paso	6,300
San Emigdio	11,600
Total	**34,600**

During most years, some minor stream water is used for irrigation by farmers in the North Kern Water Storage District and Pond-Poso Improvement District. Much of the water percolates to the underlying aquifers. Some of this recharge probably contributes to perched water in the Kern Lake Bed area and near the Kern National Wildlife Refuge. The Agency estimated that about 32,900 acre-feet of the minor stream flows during 1991 contributed to groundwater recharge. Table 9 shows annual minor stream runoff by stream group, along with cumulative runoff. The variability of minor stream flows is shown by the accompanying statistics, and can be seen graphically in Figure 6.

The Agency, in cooperation with local water districts, monitors stream flows on Poso and Tehachapi Creeks. Figures 7a and 7b are hydrographs for Poso Creek, showing runoff during 1991.

Effective Precipitation

Rainfall that occurs during the growing season of a crop, or is otherwise stored in the soil for later use,

Figure 4
Kern River Flows at First Point of Measurement

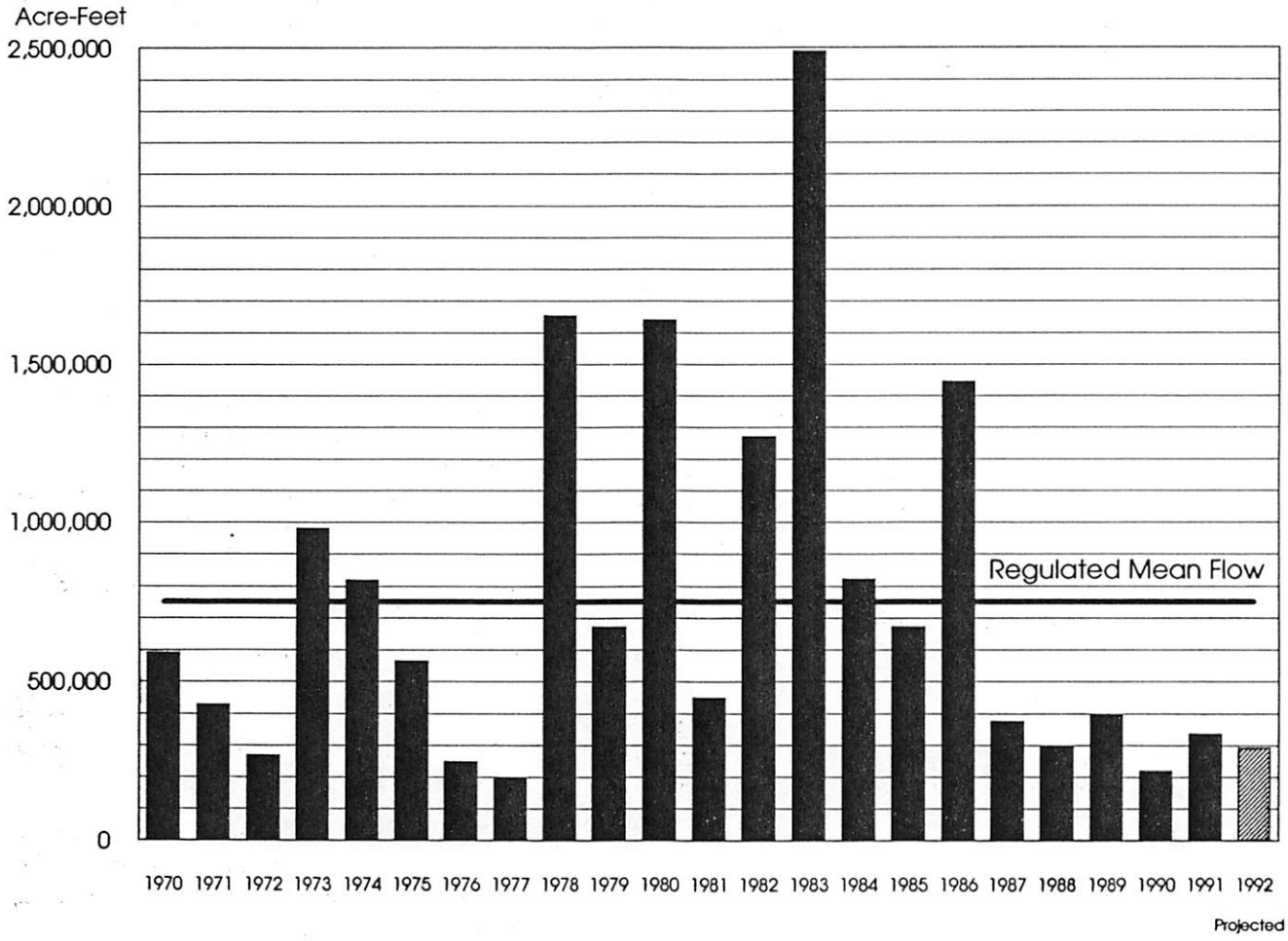


Table 6
1991 Summary of Kern River Water
Diversions by Entity
(in acre-feet)

Area of Use	Deliveries
Above First Point	
Olcese WD	1,465
Other Diversions	954
Sub-total	**2,419**
Below First Point	
Buena Vista WSD	54,616
Cawelo WD	40,104
City of Bakersfield, Irrigation and Spreading (1)	23,499
Improvement District No. 4	25,728
Kern Delta WD	152,267
Kern-Tulare WD	192
North Kern WSD	27,984
Rag Gulch WD	28
Rosedale-Rio Bravo WSD	9,076
Sub-total	**333,494**
Grand Total	**335,913**

(1) Includes Carrier Canal loss and percolation, Kern River channel and percolation.

Table 7
1991 Central Valley Project
Deliveries by Entity
(in acre-feet)

	Class 1	Non-Project Water	Cross Valley Canal (4) Pumped into F.K. Canal	Total
Arvin-Edison WSD (1)	32,815		200	33,015
Delano-Earlimart ID	14,993			14,993
Kern National Wildlife Refuge (2)	6,200			6,200
Kern-Tulare WD (3)	5,458	7,000	4,513	16,971
Rag Gulch WD (3)	5,081		0	5,081
Shafter-Wasco ID	44,116		500	44,616
So. San Joaquin MUD	83,333		187	83,520
Total	**191,996**	**7,000**	**5,400**	**204,396**

(1) Includes 15,020 AF delivered via the Cross Valley Canal.
(2) Delivered via the San Luis Canal.
(3) Per exchange of Cross Valley Canal water with Arvin-Edison WSD.
(4) Pump-in pursuant to USBR authorized Exchange/Transfer Agreements.

Note: No Class 2 allotments for 1991.

Table 8
Annual and Cumulative
Central Valley Project Deliveries
to Kern County
(in acre-feet)

Year	Annual Delivery	Cumulative Delivery	Year	Annual Delivery	Cumulative Delivery
1950	762	762			
1951	27,005	27,767	1981	469,966	7,899,255
1952	49,500	77,267	1982	656,608	8,555,863
1953	83,558	160,825	1983	550,874	9,106,737
1954	112,093	272,918	1984	425,371	9,532,108
1955	126,238	399,156	1985	337,514	9,869,622
1956	279,134	678,290	1986	589,262	10,458,884
1957	141,684	819,974	1987	291,981	10,750,865
1958	223,830	1,043,804	1988	292,828	11,043,693
1959	166,099	1,209,903	1989	293,865	11,337,558
1960	156,978	1,366,881	1990	200,141	11,537,699
1961	126,412	1,493,293	1991	204,396	11,742,095
1962	231,045	1,724,338			
1963	234,283	1,958,621			
1964	189,330	2,147,951			
1965	245,482	2,393,433			
1966	232,084	2,625,517			
1967	319,706	2,945,223			
1968	206,499	3,151,722			
1969	372,826	3,524,548			
1970	351,392	3,875,940			
1971	348,865	4,224,805			
1972	238,475	4,463,280			
1973	412,178	4,875,458			
1974	480,575	5,356,033			
1975	442,130	5,798,163			
1976	226,512	6,024,675			
1977	121,469	6,146,144			
1978	357,847	6,503,991			
1979	462,526	6,966,517			
1980	462,772	7,429,289			

Mean Delivery	279,574 AF
Median Delivery	245,482 AF
Mean Delivery 1975-91	375,651 AF
Median Delivery 1975-91	357,847 AF

Figure 5
Central Valley Project Deliveries to Kern County

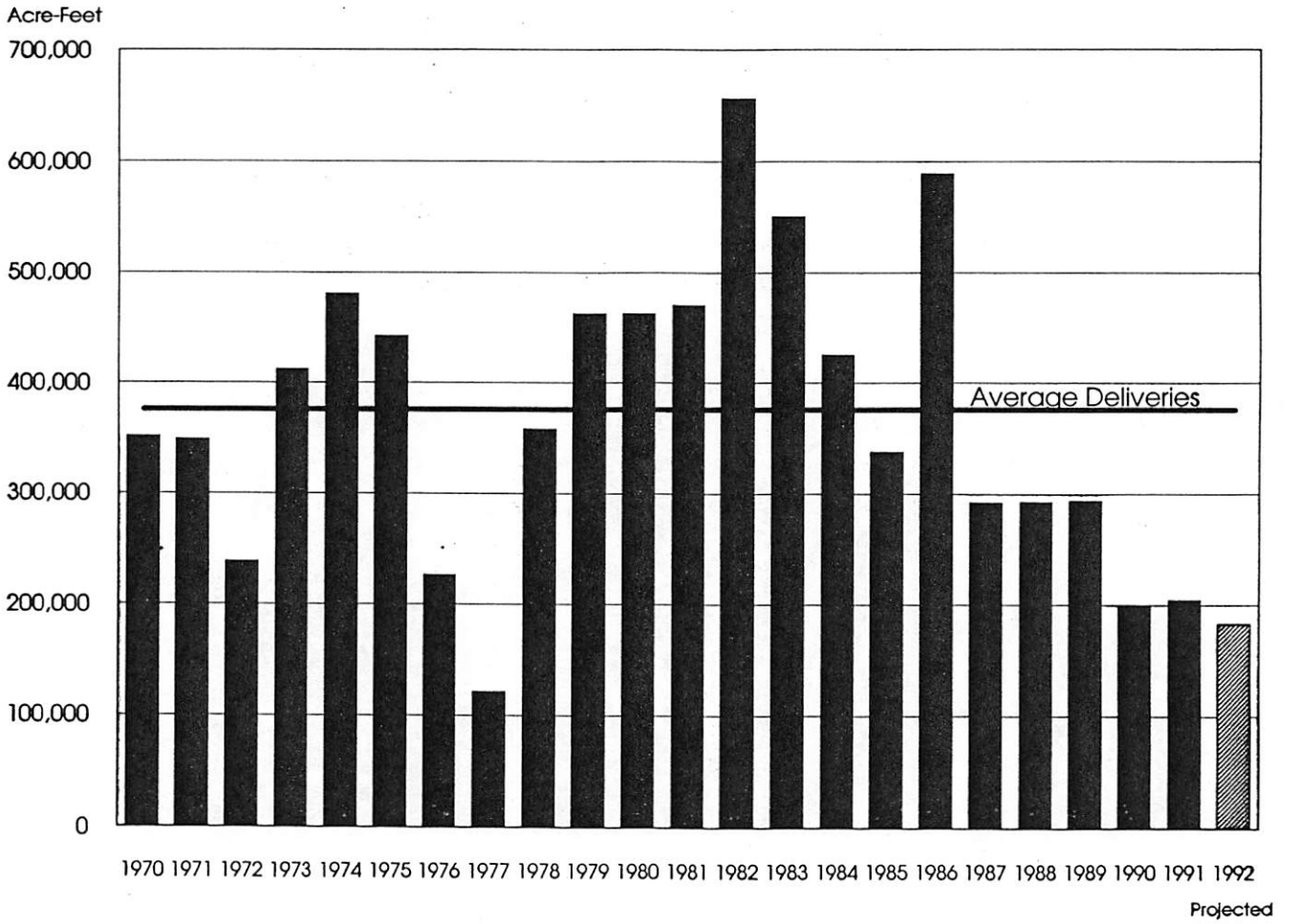


Table 9
Annual and Cumulative
Minor Stream Flows in the
San Joaquin Valley Portion of Kern County
(in acre-feet)

Year	Annual Stream Flows	Cumulative Stream Flows
1970	132,400	132,400
1971	63,200	195,600
1972	21,600	217,200
1973	22,900	240,100
1974	104,900	345,000
1975	39,400	384,400
1976	42,700	427,100
1977	32,900	460,000
1978	429,200	889,200
1979	96,700	985,900
1980	65,200	1,051,100
1981	63,600	1,114,700
1982	159,900	1,274,600
1983	327,700	1,602,300
1984	14,300	1,616,600
1985	20,200	1,636,800
1986	32,600	1,669,400
1987	28,600	1,698,000
1988	22,900	1,720,900
1989	26,300 *	1,747,200
1990	17,000 *	1,764,200
1991	34,600	1,798,800

Mean Flow	84,000 AF
Median Flow	37,000 AF

* Modified from previous Water Supply Reports

Figure 6
Minor Stream Flows in Kern County

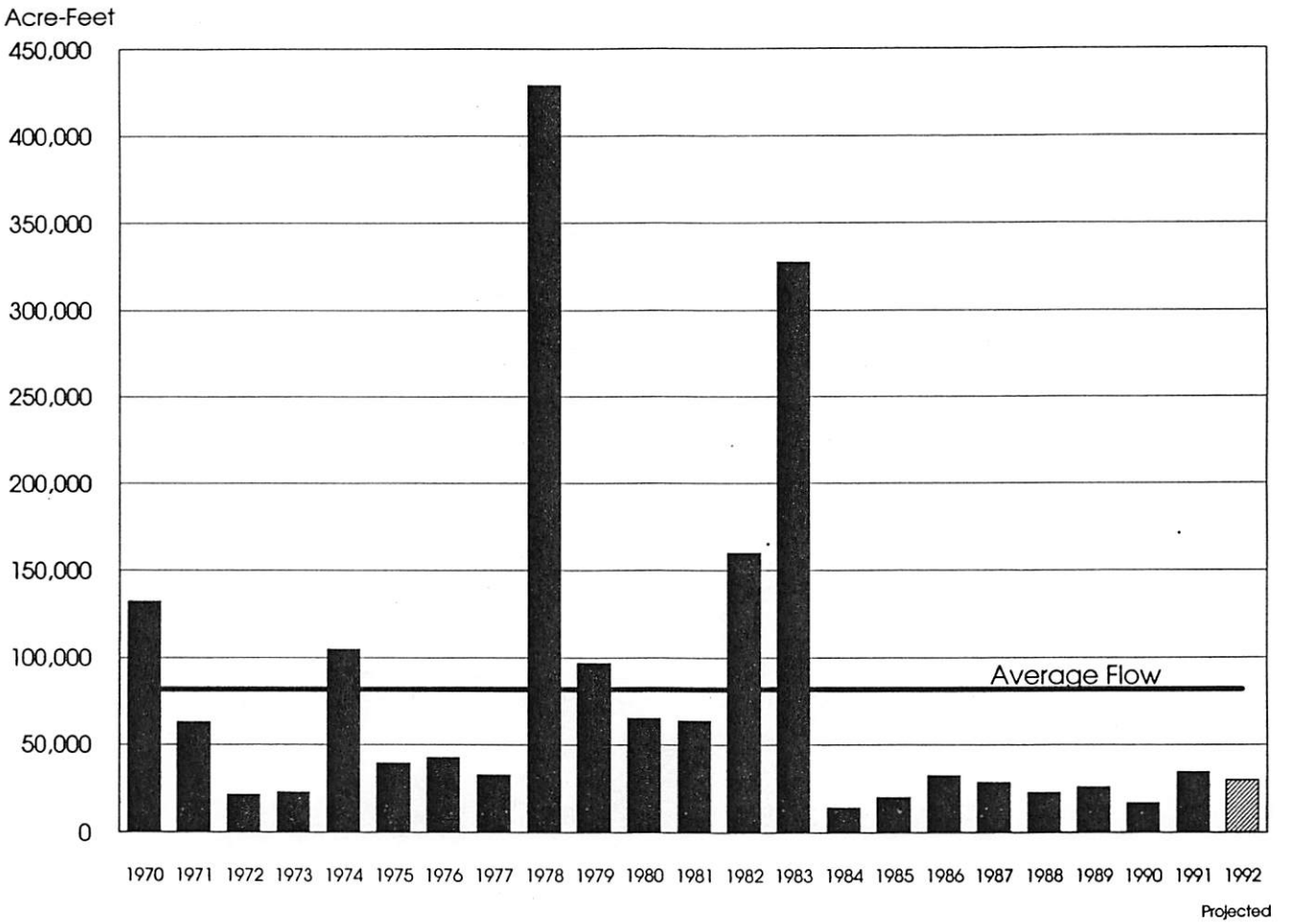
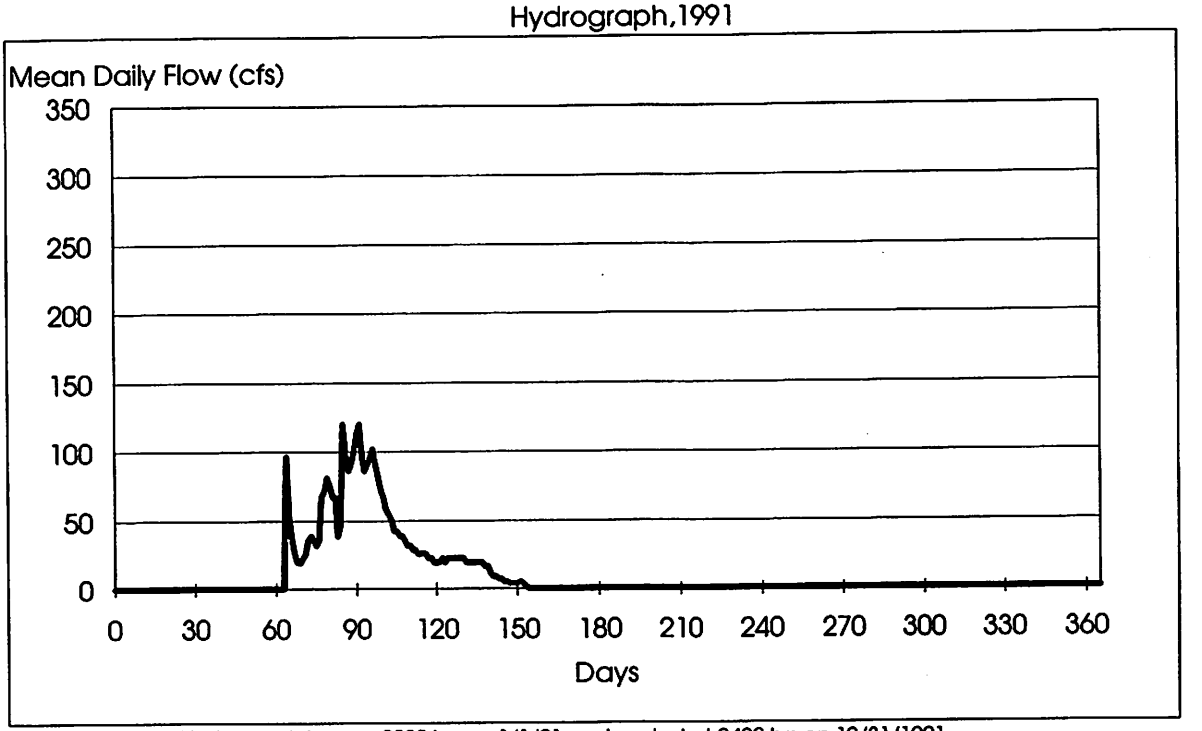
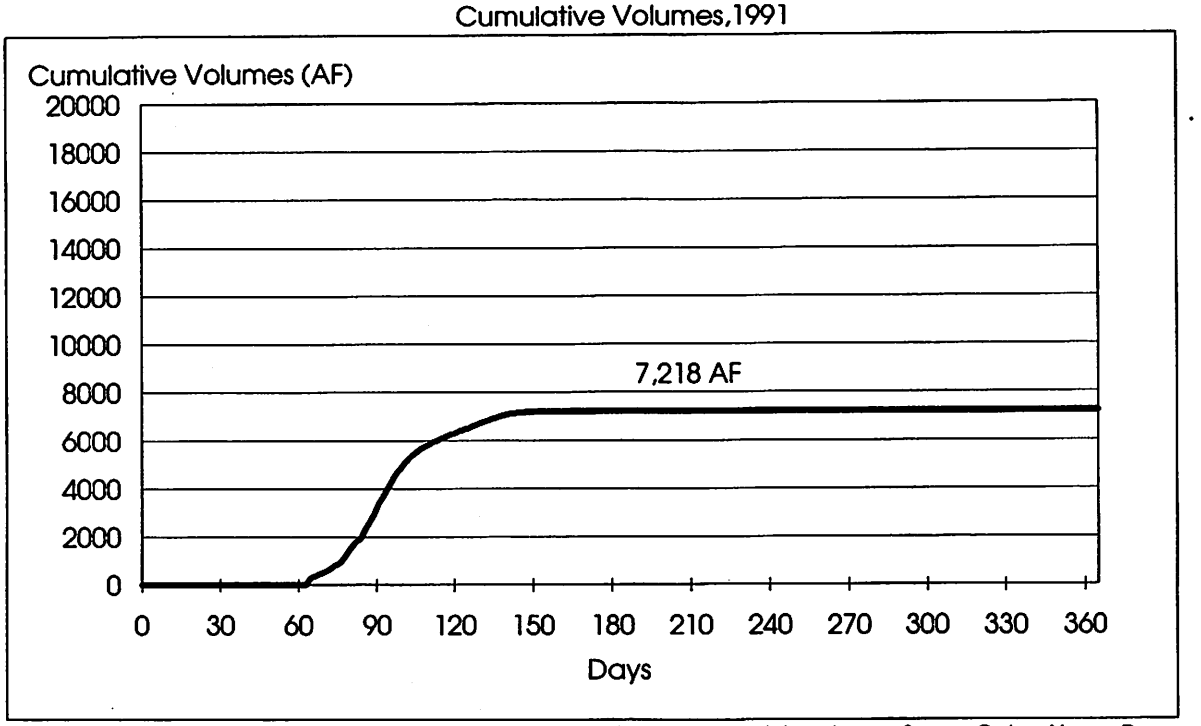


Figure 7a
Poso Creek
Hydrograph,1991



Note:
1. Hydrograph began 0000 hrs on 1/1/91 and ended at 2400 hrs on 12/31/1991.
2. Located at Lat.35 30' 49", Long. 118 54' 17", SW 1/4, SW 1/4, Sec. 6, T.28S., R.29E. Kern County.
3. Peak Discharge, 120 cfs, 3/26/91.

Figure 7b
Poso Creek
Cumulative Volumes,1991



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Volume (AF)	0	0	3415	2918	873	12	0	0	0	0	0	0
Cumulative Volume (AF)	0	0	3415	6333	7206	7218	7218	7218	7218	7218	7218	7218

provides water that would otherwise be applied by the farmer. By reducing the total crop water needs that the farmer must fulfill, rainfall can reduce the total volume of water that needs to be imported or withdrawn from groundwater supplies. So, rainfall provides an alternative water supply, referred to as effective precipitation.

Not all rainfall contributes to crop water needs, however. Only that portion that satisfies crop water requirements can properly be called effective precipitation. A large portion of rainfall evaporates from the soil surface and the profile before it can be used by the crop. The timing of the rainfall is also an important factor determining its effectiveness. During years of extremely heavy rainfall, a small amount may percolate past the crop root zone and recharge the underlying groundwater, particularly during early stages of growth. In addition, a heavy rain immediately after an irrigation cycle may not be useable by the crop.

Most urban storm runoff is captured in unlined sumps and allowed to percolate. It is not usually measured. A small amount of storm runoff is diverted into the Kern River, where it becomes available for delivery or recharge. About 50 acre-feet of rainfall was diverted into the Kern River system in 1991.

The Agency gathers monthly rainfall data for most of the measuring stations in the San Joaquin Valley portion of Kern County. Data for some mountain stations are also gathered. This rainfall data is subsequently used to compute effective precipitation, or in the case of mountain stations, minor stream runoff. Table 10 gives monthly rainfall for every measuring station gathered by KCWA. New to Table 10 is the addition of several mountain stations used to compute minor stream runoff. Except for March, very low rainfall in 1991 contributed 171,700 acre-feet of effective precipitation, with 157,700 acre-feet occurring over the useable groundwater basin. This includes the urban storm water diverted into the Kern River. Rainfall at Meadows Field, Bakersfield in 1991 was about 113 percent of normal, compared to 61 percent of normal during 1990. Following is a tabulation of 1990 and 1991 versus average monthly rainfall for Meadows Field near Bakersfield. The Agency estimates that rainfall provided about 2.45 inches of useable water for crops grown during 1991. Usually, rainfall provides about 2.5 inches of useable water for crops.

Rainfall at Meadows Field, Bakersfield

	1990	1991	Average	1991 Percent of Average
Jan	0.85	0.62	1.02	61
Feb	0.93	0.13	1.00	13
Mar	0.45	4.33	0.94	461
Apr	0.18	0.66	0.65	9
May	0.29	—	0.30	—
Jun	—	—	0.07	—
Jul	—	—	0.01	—
Aug	—	—	0.02	—
Sep	0.05	0.01	0.10	10
Oct	0.03	0.30	0.31	97
Nov	0.47	0.01	0.52	2
Dec	0.26	1.04	0.80	130
Total	**3.51**	**6.50**	**5.74**	**113**

A glaring anomaly in 1991 was March, with 461 percent of normal rainfall, followed by five straight months of practically no rain. This demonstrates the erratic nature of precipitation in the arid climate of the southern San Joaquin Valley. Most of the effective precipitation during 1991 occurred in March. The heavy March rains were roughly equivalent to an irrigation event for most crops. Thus, total yearly pre-irrigation and irrigation needs were reduced. (Pre-irrigation fills the soil profile with water prior to planting, so that the growing seedlings will have sufficient moisture. Many field crops and vegetables are planted in April-May after the spring rains). Likely, the March rains decreased the amount of water purchased from the State Bank. Figure 8 shows annual rainfall recorded at four selected climatic stations in Kern County. Rainfall in the Wheeler Ridge area is normally higher than on the valley floor. This is due to the effects of orographic uplift associated with the mountains at the southern end of the valley. Table 11 lists the annual amounts of effective precipitation, expressed as total acre-feet and inches per acre, along with cumulative amounts and descriptive statistics. Figure 9 is a graphic depiction of the same information.

Waste Water Reuse

The reuse of municipal and industrial waste water provides a minor source of water for Kern County agriculture. There are 13 active waste water sewage

Figure 8
Annual Precipitation at Three Stations
in the San Joaquin Valley of Kern County, California

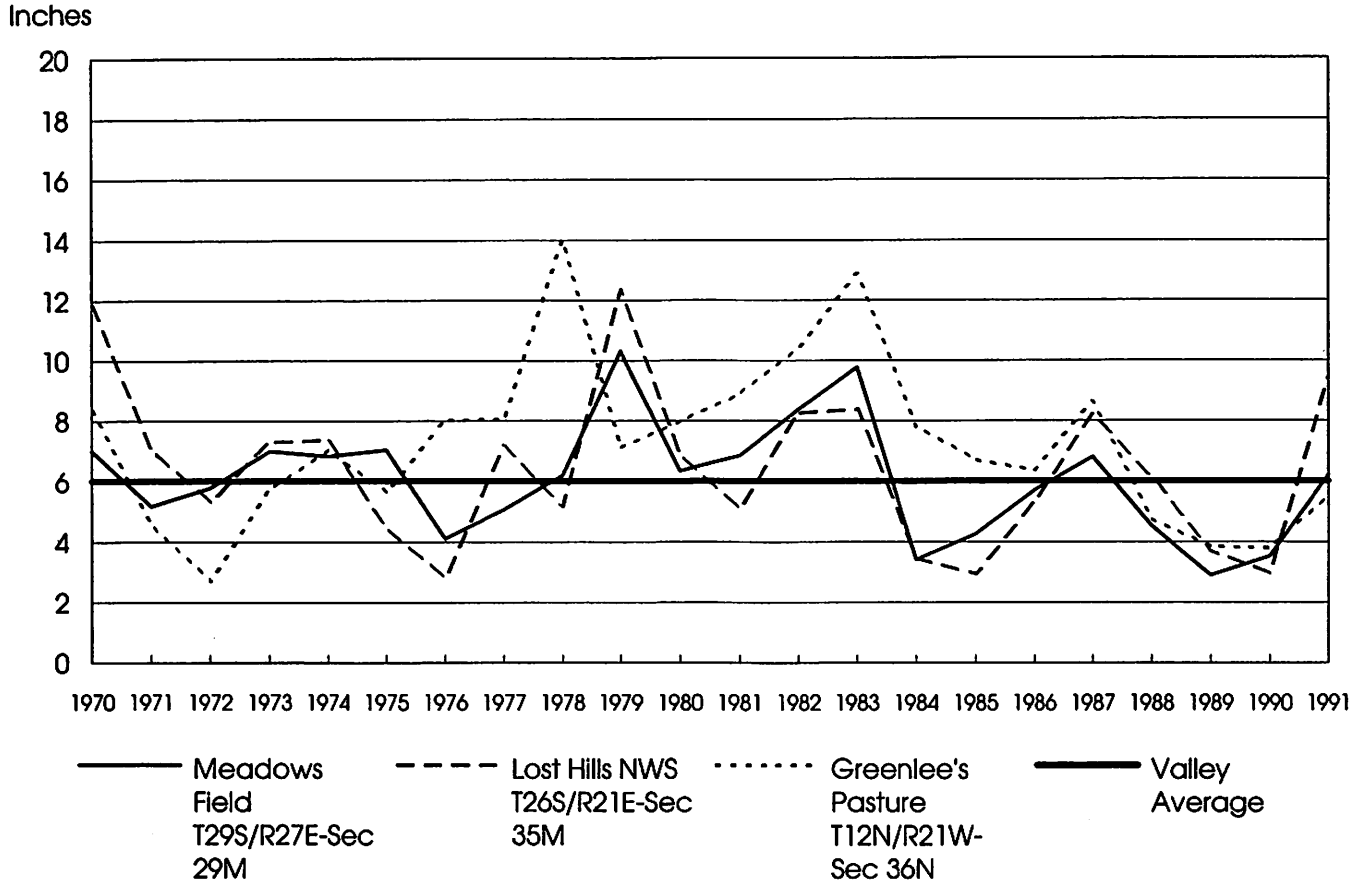


Table 10

1991 Monthly Rainfall at Selected Stations (in inches)

OPERATOR/Station	Elevation (ft)	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ARVIN-EDISON WATER STORAGE DISTRICT															
District Headquarters	500	31S/30E-00	1.00	0.06	5.16	0.02	0.01	0.02	--	--	--	1.16	0.04	1.15	8.62
Sycamore	420	31S/30E-20	0.82	0.05	5.14	0.02	--	0.02	--	--	--	1.16	0.04	1.10	8.35
Tejon	480	32S/29E-15	1.00	0.08	3.75	0.06	--	0.02	--	--	--	0.92	--	1.10	6.93
CALIFORNIA DEPARTMENT OF WATER RESOURCES															
Lamont 2NW		30S/28E-25M	0.82	0.14	3.90	0.04	0.01	--	--	--	--	0.41	0.01	0.94	6.27
Lost Hills O&M Center		27S/21E-03	0.46	0.93	4.93	0.05	--	0.02	--	--	--	0.31	--	1.23	7.93
Wind Gap O&M Center		11N/20W-26	0.92	0.12	5.01	0.19	0.12	--	--	--	--	0.93	--	1.76	9.05
Buena Vista Ranch		30S/25E-03	0.70	0.23	3.71	0.07	--	--	--	--	--	0.32	--	1.01	6.04
Bakersfield 12S	300	31S/27E-36D	0.99	0.24	3.47	0.01	0.01	--	--	--	--	0.47	--	1.00	6.19
J.G. BOSWELL COMPANY															
Buena Vista "T"		32S/25E-27	0.71	0.08	1.75	--	--	--	--	--	--	0.43	--	NM	2.97
Kern Lake Shop		32S/28E-18	0.79	0.10	3.10	0.05	0.01	--	--	--	--	0.58	0.02	0.98	5.63
Paloma		32S/24E-02	0.92	0.17	3.36	0.02	0.01	--	--	--	--	0.56	--	1.01	6.05
Kern Lake Timeroom		32S/27E-16	0.95	0.03	3.39	0.03	--	--	--	--	--	0.54	--	1.00	5.94
Buena Vista Gin		32S/25E-12	1.30	1.75	--	--	--	--	--	--	--	0.07	--	0.93	4.05
Guena Vista #4		32S/25E-06	0.79	0.10	3.10	0.05	--	--	--	--	--	0.56	--	1.12	5.72
Buena Vista Office		31S/25E-25	0.71	0.18	3.36	0.07	--	--	--	--	--	0.43	--	0.96	5.71
KERN COUNTY PLANNING DEPARTMENT															
Edmonston Pump Station	1,300	10N/18W-17M	0.56	1.18	8.20	0.48	0.06	--	--	--	--	1.22	0.03	3.69	15.42
Arvin Fire Station		31S/29E-28	0.89	0.06	3.75	0.02	--	--	--	--	0.02	0.56	--	0.09	5.39
Buttonwillow Fire Station		29S/23E-14	0.51	0.52	2.77	0.07	0.05	--	--	--	--	0.22	--	0.07	4.21
Buena Vista Aquatic Rec Area		31S/25E-15	0.56	0.49	3.08	--	0.02	--	--	--	--	0.32	--	1.15	5.62
Communications Center		29S/28E-16	0.55	0.02	3.79	0.03	--	--	--	--	--	0.30	--	0.92	5.61
McFarland Fire Station		26S/25E-10	0.23	0.19	3.36	0.08	0.01	--	--	--	--	0.72	0.05	1.24	5.88
Rio Bravo Fire Station		29S/29E-04	0.06	0.55	3.96	0.02	--	--	--	--	--	0.39	0.05	0.85	5.88
NATIONAL WEATHER SERVICE															
Pine Mountain	5,400		2.17	2.34	10.92	0.05	0.13	--	--	0.59	0.28	0.55	0.37	3.65	21.05
Piute	4,290		1.55	0.25	6.33	0.03	0.05	--	--	0.01	--	0.94	0.70	1.14	11.00
Maricopa	700		0.40	0.06	4.23	--	0.03	--	--	--	--	0.16	--	0.90	5.78
Bakersfield NWS			0.62	0.13	4.33	0.06	--	--	--	--	0.01	0.03	0.01	1.04	6.23

Table 10 (continued)
1991 Monthly Rainfall at Selected Stations (in inches)

OPERATOR/Station	Elevation (ft)	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
NATIONAL WEATHER SERVICE continued															
Wasco			0.39	0.36	5.31	0.07	0.01	--	--	--	--	--	0.03	0.95	7.12
Woody	1,600	25S/29E-34	0.49	0.16	5.82	0.18	0.29	--	--	--	--	1.19	0.35	1.27	9.75
Keene	2,900		0.90	--	6.89	--	0.08	--	--	--	--	1.73	--	0.44	10.04
Tehachapi	3,980		0.64	1.88	6.30	--	0.18	--	--	--	--	0.62	0.57	1.56	11.75
Lost Hills			0.13	0.66	6.86	--	0.03	0.06	--	0.02	--	0.45	--	1.20	9.41
Glennville	3,100		0.71	0.26	9.15	0.26	0.28	--	--	0.02	--	0.10	1.25	1.47	13.50
Bear Valley	4,100		1.51	0.26	9.43	0.12	0.06	--	--	0.05	--	1.97	0.58	1.65	15.63
Lebec	3,600		0.56	--	9.57	0.18	0.31	--	--	--	--	0.55	0.20	3.42	14.79
TEHACHAPI-CUMMINGS COUNTY WATER DISTRICT															
Station 6	4,890		1.55	2.53	6.25	0.03	0.20	--	0.75	--	--	0.65	0.65	2.15	14.76
Station 20	5,730		1.74	2.75	7.45	--	0.27	--	0.70	--	--	0.75	0.80	2.30	16.76
WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT															
District Headquarters	480	11N/12W-11	0.92	0.59	3.62	--	--	--	--	--	--	0.94	--	1.12	6.07
PA-2	960	11N/19W-30	0.90	0.64	4.69	--	--	--	--	--	--	0.67	--	1.61	6.90
2PP	510	32S-24E-35	0.88	0.45	3.04	--	--	--	--	--	--	0.17	--	0.9	4.54
5PP2	590	11N/22W-09	0.85	0.68	3.45	--	--	--	--	--	--	0.68	--	0.81	5.66
Spill Basin	850	11N/18W-31	0.87	0.36	5.82	--	--	--	--	--	--	0.97	--	2.08	8.02
Greenlee's Pasture	380	12N/21W-36	0.87	0.61	3.28	--	--	--	--	--	--	0.76	--	1.08	5.52
OTHER OPERATORS															
City of Bakersfield Corp. Yd.		30S/27E-06	0.66	0.46	3.82	0.04	0.03	--	--	--	--	0.28	0.04	1.13	6.46
Del Kern Station (KDWD)		31S/27E-06C	0.79	0.07	3.51	0.04	--	--	--	--	--	0.45	--	1.10	5.96
Delano Fire Station		25S/25E-11A	0.19	0.32	5.71	--	--	--	--	--	--	0.56	0.02	1.61	8.41
Belridge WSD Office		28S/21E-34	0.55	0.35	5.60	--	--	--	--	--	--	0.15	--	0.70	7.35
Blackwell's Corner (BMWD)		25S/19E-00	0.56	1.18	3.99	0.13	0.11	--	--	--	--	0.13	--	0.87	6.97
Shafter Cotton Research Sta.	370	27S/25E-33J	0.59	0.39	4.95	0.09	--	--	--	--	0.03	0.45	0.02	1.35	7.87
So. Belridge (Shell Calif.)		28S/21E-33	0.30	0.78	4.45	0.11	0.03	--	--	--	--	0.02	--	0.56	6.25
Average Valley Floor Stations*			**0.79**	**0.51**	**4.74**	**0.07**	**0.08**	**0.03**	**0.73**	**0.14**	**0.09**	**0.53**	**0.27**	**1.21**	**9.18**

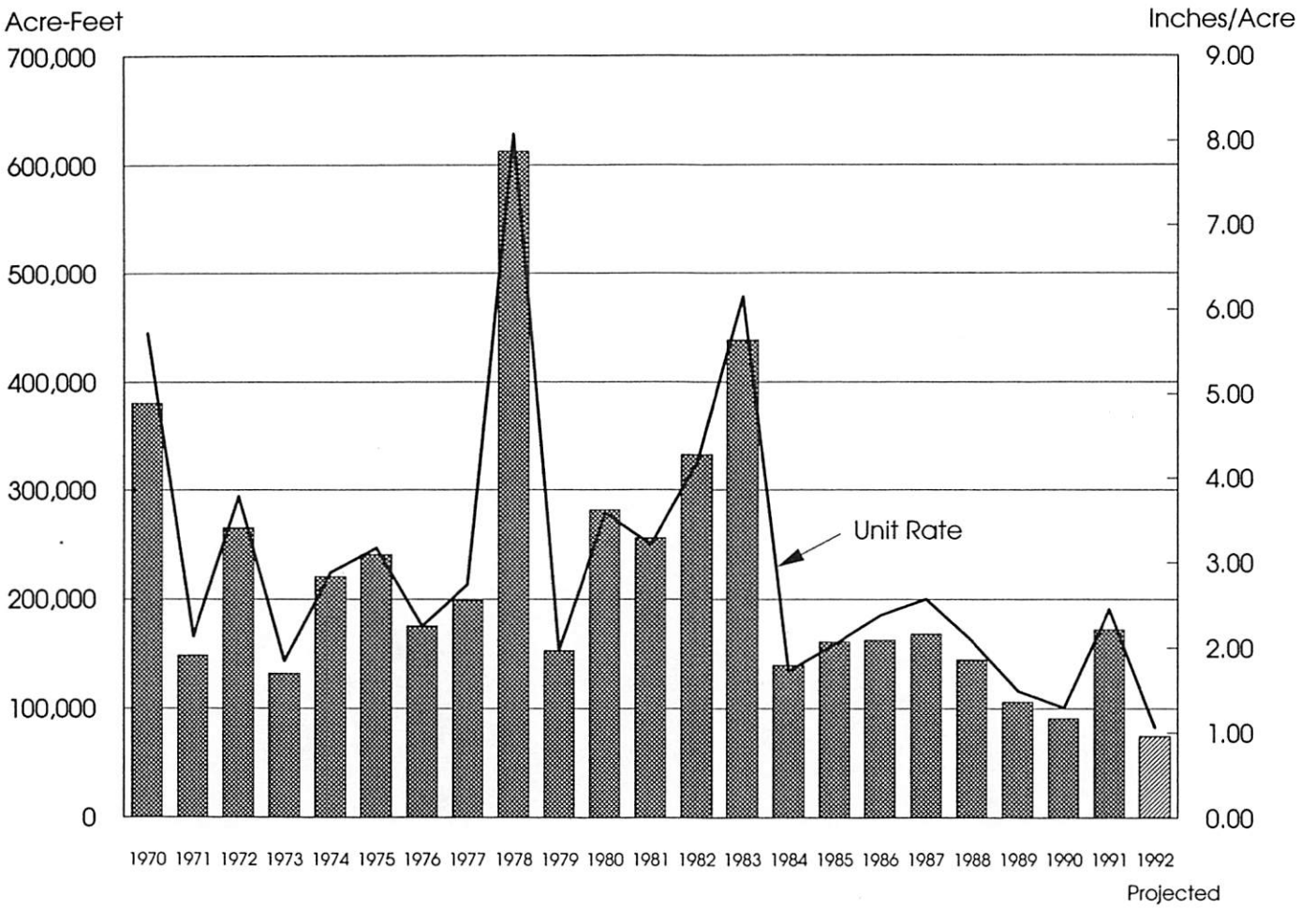
* All stations with elevation of 700 feet above sea level or less.

Table 11
Annual and Cumulative Effective Precipation
in the San Joaquin Valley Portion of Kern County
(in acre-feet)

	Annual Effective Precipitation	Unit Rate (inches per acre)	Cumulative Effective Precipitation
1970	380,200	5.72	380,200
1971	148,300	2.13	528,500
1972	264,900	3.78	793,400
1973	131,900	1.84	925,300
1974	220,200	2.88	1,145,500
1975	240,500	3.17	1,386,000
1976	175,300	2.25	1,561,300
1977	198,400	2.74	1,759,700
1978	612,500	8.08	2,372,200
1979	152,600	1.97	2,524,800
1980	281,200	3.58	2,806,000
1981	255,400	3.21	3,061,400
1982	332,300	4.18	3,393,700
1983	438,100	6.15	3,831,800
1984	139,300	1.72	3,971,100
1985	160,700	2.04	4,131,800
1986	162,600	2.38	4,294,400
1987	168,200	2.57	4,462,600
1988	144,200	2.08	4,606,800
1989	106,100	1.49	4,712,900
1990	90,500	1.29	4,803,400
1991	171,700	2.45	4,975,100

Mean EP (total)	219,600	AF
Median EP (total)	171,700	AF
Mean EP (per acre)	2.99	Inches/Acre
Median EP (per acre)	2.45	Inches/Acre

Figure 9
Effective Precipitation in the San Joaquin Valley Portion of Kern County



treatment plants in the valley portion of Kern County. Waste water treatment processes are classified as primary, secondary or tertiary. Primary treatment removes most of the suspended matter from the sewage (usually via settling ponds), but little or no colloidal or dissolved matter. Secondary treatment provides some biological action or filtration to remove any remaining organic matter from the sewage. Tertiary treatment removes harmful chemicals (such as heavy metals) and nutrients. Nearly all of the waste water treatment facilities in Kern County provide secondary treatment of sewage. About half of the effluent from these treatment plants is used to irrigate several salt-tolerant crops on bordering lands, such as cotton, pasture and some grains. A small amount is directly recharged to the groundwater basin. The remainder is evaporated. In 1991, about 45,200 acre-feet of waste water was treated (see Table 12).

Another source of waste water reuse results from agricultural tail water return systems. Many farming operations have installed these systems to intercept water that would normally run off the field during irrigation. This recovered water is either transported back to the main irrigation system or it is applied on an adjacent field (from the foot of one field to the head of another). Tail water return systems are widely used on fields which are furrow or border irrigated. Their efficiency lies in the saving of energy required to recover the water from wells, or by reducing the need to import additional surface supplies. From a basin-balance standpoint, these two water reuse activities are internal and do not add to the hydrologic system.

Oilfield Waste Water

Another source of waste water is a by-product of oilfield production. Unlike treated municipal effluent or tail water, oilfield waste water is a true addition to the hydrologic system, being drawn from deep, connate waters which are intermixed with oil deposits. In the Kern Front oilfield, which lies astride the Kern River east of Bakersfield, substantial quantities of water are removed with each barrel of oil. The chemical quality of this water is generally within acceptable limits for agriculture. Thus, much of this water is discharged into irrigation canals. A total of 2,100 acre-feet of production water from the Kern Front oilfield was reused in 1991. This was about 3,200 acre-feet less than was produced during 1990. Likely, this is an indicator of the severity of the continued oilfield slowdown which has accompanied lower prices for crude oil.

In other areas, some oil companies discharge their waste waters into lined and unlined sumps, some of which recharges the underlying aquifer, probably degrading it in the process. These amounts cannot be quantified, however, since accurate records of such discharges are seldom kept.

Total waste water reuse was estimated to be about 47,300 acre-feet in 1991, excluding any tailwater reuse, which were not estimated. Table 13 gives a historical summary of waste water reuse in the San Joaquin Valley portion of Kern County since 1970. Figure 10 charts the same information as a hydrograph. Note that waste water production stays fairly constant.

Groundwater Extractions

Most of the groundwater extractions in Kern County are not recorded. In the past, agricultural power records from the utility companies were matched with calculated numbers for groundwater production. However, the accuracy of such power record calculations were unsatisfactory. Thus, in this report groundwater extractions are estimated by backing in, or solving for the missing number in the groundwater change-in-storage equation (see Figure 14).

Total groundwater extractions in 1991 were calculated to be about 2,002,400 acre-feet. This is about 203,500 acre-feet more than was extracted in 1990. The obvious reason for this increase was the reduction in surface water supplies due to the lingering drought. Groundwater is pumped for a variety of uses in the valley. Agriculture, the largest user of groundwater, used about 1,889,400 acre-feet in 1991. Municipal and industrial uses of groundwater were about 113,000 acre-feet. Since the present drought began in 1987, about 8,134,400 acre-feet of groundwater have been pumped, with resultant water level declines of 40-80 feet.

Since 1977 it has become apparent that groundwater pumping is very sensitive to available surface water supplies. During years when abundant surface water is available at a price commensurate with the price of pumping, farmers use the surface water in-lieu of

Table 12
1991 Wastewater Treatment Plant
Volumes

Facility	Volume (MG)*	Volume (AF)	Influent Source	Treatment System	Effluent Use
City of Arvin	302	927	Dom	Secondary	Agriculture
City of Bakersfield					
#2	6,163	18,912	Dom/Ind	Secondary	Restricted Agriculture
#3	2,962	9,089	Dom/Ind	Secondary	Restricted Agriculture
Kern County Public Works					
Mt. Vernon	1,399	4,293	Dom	1/2 Primary, 1/2 Secondary	Agriculture,
BVARA	10	31	Agr	Secondary	Evaporation,
Sheriff's Lerdo Facility	76	233	Dom	Secondary	Percolation
NOR Sanitary District #1	1,166	3,578	Dom/Ind	Secondary	Restricted Agriculture, Percolation
City of Delano	1,009	3,096	Dom	Secondary	Restricted Agriculture
Lamont Public Utilities District	500	1,534	Dom	Primary	Agriculture
City of McFarland	230	706	Dom	Secondary	Agriculture
City of Shafter	333	1,022	Dom/Ind	Secondary	Agriculture
Shafter Airport	50	153	Ind	Secondary	Percolation
City of Wasco	520	1,596	Dom/Ind	Secondary	Agriculture
Total	**14,720**	**45,170**			

For influent source:
- Dom - domestic
- Ind - industrial
- Agr - agricultural

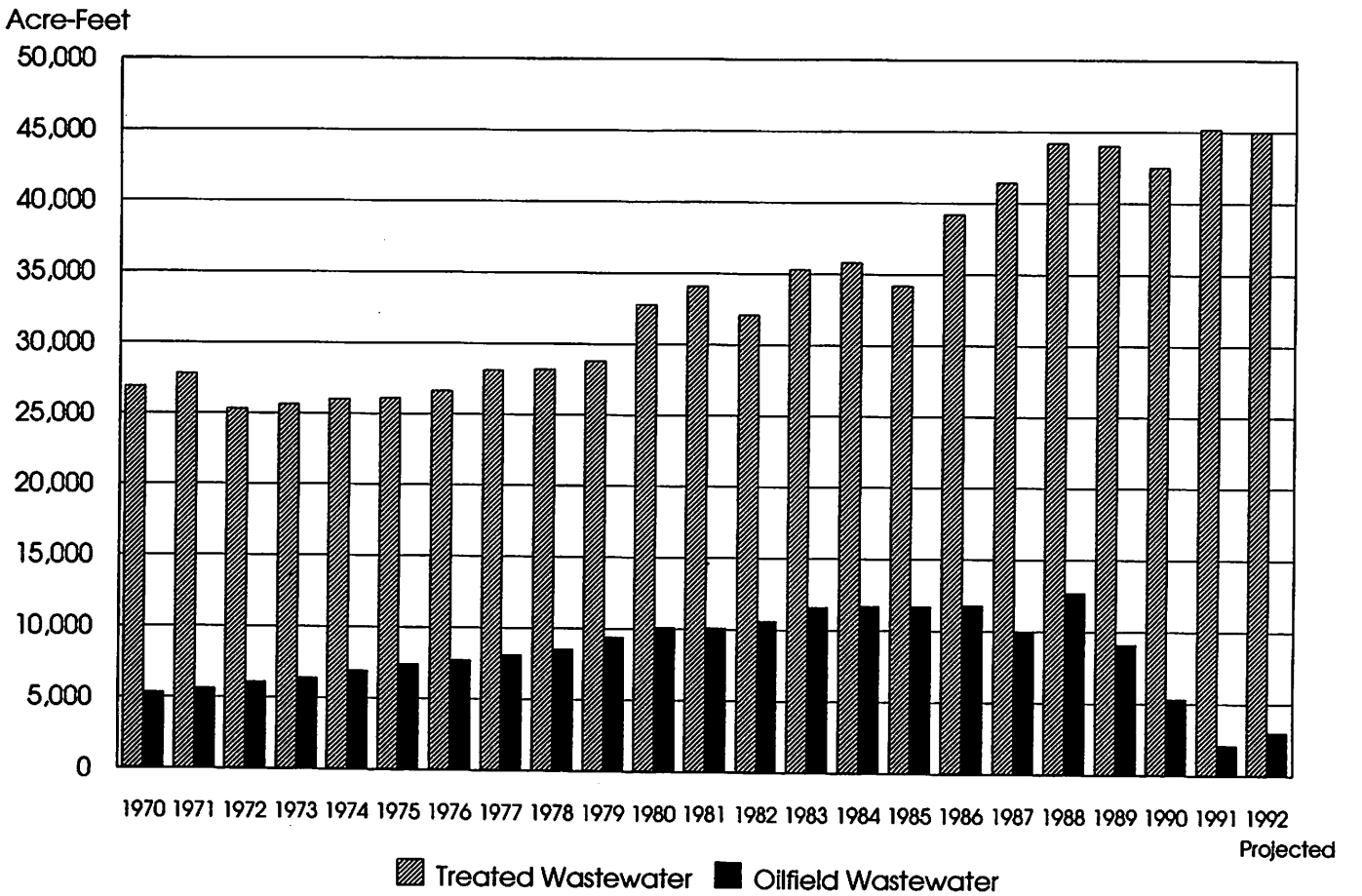
* Million gallons, based on daily average flow.

Table 13
Historic Waste Water Reuse
(in acre-feet)

	Treated Wastewater		Oilfield Wastewater	
Year	Annual Flows	Cumulative Flows	Annual Flows	Cumulative Flows
1970	26,900	26,900	5,300	5,300
1971	27,800	54,700	5,600	10,900
1972	25,300	80,000	6,100	17,000
1973	25,600	105,600	6,400	23,400
1974	26,000	131,600	6,900	30,300
1975	26,100	157,700	7,400	37,700
1976	26,600	184,300	7,700	45,400
1977	28,100	212,400	8,100	53,500
1978	28,200	240,600	8,500	62,000
1979	28,800	269,400	9,400	71,400
1980	32,800	302,200	10,100	81,500
1981	34,100	336,300	10,100	91,600
1982	32,100	368,400	10,600	102,200
1983	35,300	403,700	11,600	113,800
1984	35,800	439,500	11,700	125,500
1985	34,200	473,700	11,700	137,200
1986	39,200	512,900	11,800	149,000
1987	41,400	554,300	10,000	159,000
1988	44,200	598,500	12,700	171,700
1989	44,000	642,500	9,100	180,800
1990	42,500	685,000	5,300	186,100
1991	45,200	730,200	2,100	188,200

Mean Waste Water Flows	33,700	AF
Median Waste Water Flows	32,800	AF
Mean Oilfield Flows	8,300	AF
Median Oilfield Flows	8,500	AF

Figure 10
Wastewater Reuse in Kern County



pumping groundwater. However, when surface water supplies are low, the opposite is true and farmers are forced to rely more heavily on their groundwater pumps in order to grow their crops. Hence, the development of additional water storage facilities capable of supplying a firm yield at a reasonable cost would greatly benefit Kern County's groundwater basin.

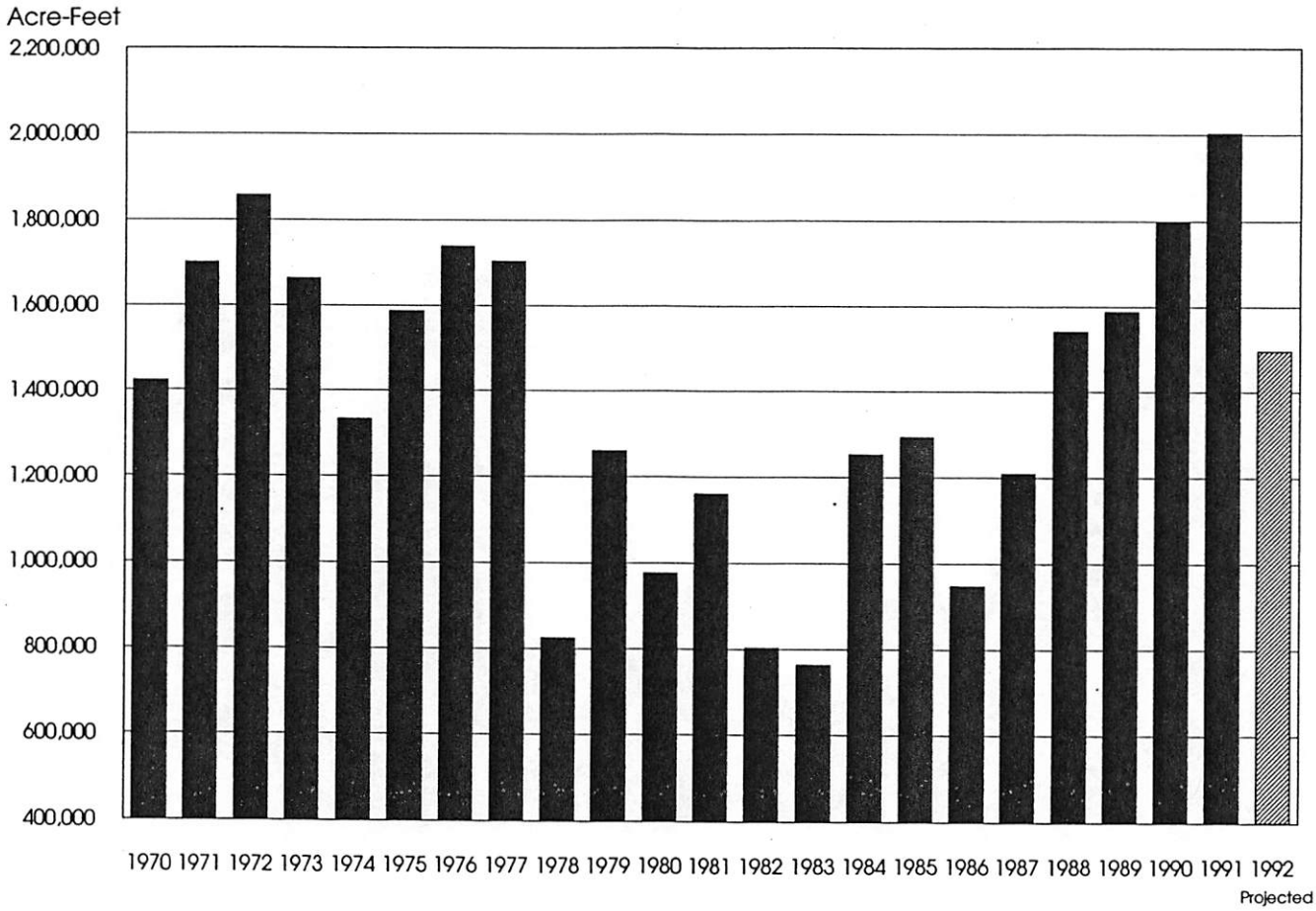
Timing is another factor affecting groundwater pumping. Although surface water may be available during the early spring months, it may not be available during the peak irrigation season (typically during the hot summer months). Hence, absent a storage facility (like Lake Isabella) or a conjunctive use program to normalize the availability of surface water, farmers would have no choice but to pump the additional water to meet peak demands. Table 14 gives historic groundwater pumping in the San Joaquin Valley portion of Kern County since 1970. Both annual and cumulative amounts are tabulated, along with descriptive statistics. Figure 11 provides a histograph of groundwater pumping, graphically displaying the relative variations.

Table 14
Historic Ground Water Pumping
(in acre-feet)

Year	Annual Ground Water Pumped	Cumulative Ground Water Pumped
1970	1,422,000	1,422,000
1971	1,700,000	3,122,000
1972	1,857,000	4,979,000
1973	1,662,000	6,641,000
1974	1,333,000	7,974,000
1975	1,587,000	9,561,000
1976	1,738,000	11,299,000
1977	1,703,000	13,002,000
1978	825,000	13,827,000
1979	1,260,000	15,087,000
1980	977,000	16,064,000
1981	1,161,000	17,225,000
1982	802,200	18,027,200
1983	762,700	18,789,900
1984	1,252,200	20,042,100
1985	1,293,800	21,335,900
1986	947,600	22,283,500
1987	1,208,700	23,492,200
1988	1,540,200	25,032,400
1989	1,588,500	26,620,900
1990	1,796,500	28,417,400
1991	2,002,400	30,419,800

Mean Ground Water Pumping	1,387,600 AF
Median Ground Water Pumping	1,422,000 AF
Minimum Pumping in 1983	762,700 AF
Maximum Pumping in 1991	2,002,400 AF

Figure 11
Groundwater Pumping
in the San Joaquin Valley Portion of Kern County



Water Requirements

Agricultural

Gross irrigated acreage in the San Joaquin Valley portion of Kern County was about 767,600 acres in 1991. Since about 27,700 acres were double-cropped, total gross cropped acreage in 1991 was about 739,900 acres. About 701,400 acres (including double-cropping) were irrigated over the useable groundwater basin, and about 66,300 acres were irrigated on lands outside the useable groundwater basin. Some of the acreage outside the useable groundwater basin received only partial irrigation during the early part of the year, then was abandoned when the water supply situation became clear. Cotton acreage decreased about 50,000 acres from 1990, likely reflecting the continuing drought conditions. Vegetables showed a 15,000 acre increase over 1990, perhaps due to the favorable prices received for fresh-market produce. Particularly, carrots increased by about 18,000 over 1990. Potatoes decreased about 9,000 acres from 1990. Potatoes are a fairly cyclical crop, with acreage changes following product prices. Small grains showed a decrease of about 16,000 acres from 1990. Grains are typically a rotation crop with cotton. Thus, the decrease is likely due to the large drop in cotton acreage. A total of about 101,700 acres were idled during 1991, an obvious victim of the lingering drought. Much of this reduction came from the west side areas, which are entirely dependent upon surface water for irrigation. A historical summary of irrigated acreage is provided on Table 15, along with descriptive statistics. Figure 12 shows historic irrigated acreage plotted as a bar graph.

Per unit crop water demands in 1991 were quite normal. Evaporation, which corresponds to crop water use, was only slightly higher than normal. Table 16 is a summary of monthly evaporation as measured at three climatic stations in the County. The Bakersfield 12S and Lamont 2NW stations (operated by the State Department of Water Resources) are representative of evaporation on the valley floor. Figure 13 displays monthly evaporation for these stations as a percent of normal. Overall, 1991 was a good growing season, marked by a long, warm summer and dry harvest season. The moderate growing season benefitted the cotton crop, which yielded an average 1,256 pounds of lint per acre (2.5 bales per acre), about the same as in 1990. The moderate growing season benefitted some vegetable crops, which showed increased yields over 1990. In particular, potatoes enjoyed a 20 percent yield increase, fresh garlic enjoyed a 30 percent increase in yields over 1990. While production levels for these crops were bright spots, overall field and vegetable crop yields in 1991 were slightly lower than in 1990. Permanent crops also saw a general decline in yields from 1990, part of which may be related to water stress as a result of the reduction in water availability and subsequent higher water costs. Hardest hit were oranges (which yielded only about 50 percent of 1990 per unit production), and olives (which went from a banner year in 1990 to a dismal year in 1991). Olive yields were reduced by 97 percent from 1990 production.

The Kern County Agricultural Commissioners annual crop report shows that, in 1991, the agricultural products of Kern County had a market value of $1,512,542,000, down 17 percent from 1990's value of $1,837,516,000. The reduction can be attributed to the impacts of the December, 1990 freeze which decimated local citrus groves, and the sixth consecutive year of drought when over 101,000 acres of agricultural land were idled. Citrus in particular was hard hit, showing a loss in value of 56 percent due to the December, 1990 freeze. Only 28 percent of the citrus crop for 1991 was harvested, clearly demonstrating the devastation reaped upon local citrus groves. Overall, the trend during 1991 was for unit values and gross crop values to be reduced from 1990 levels. Comparisons of 1991 to 1990 gross crop values shows:

	1991	1990	Change
Field crops	$348,446,000	$515,764,000	-$167,318,000
Fruits and nuts	614,306,000	736,408,000	-122,102,000
Vegetables	385,278,000	390,576,000	-5,298,000
Nursery	62,128,000	57,197,000	4,931,000
Other	111,384,000	137,471,000	-26,087,000
Total	**$1,521,542,000**	**$1,837,516,000**	**-$315,874,000**

Note that fruits and nuts account for about 40 percent of Kern County's gross agricultural value, reflecting the importance these crops hold in the local economy. While cotton is usually the number one crop in Kern County in terms of production value, the reduced acreage resulting from the drought was enough to

Table 15
Historic Irrigated Acreage *
in the San Joaquin Valley Portion
of Kern County
(in Acres)

Year	Total Irrigated Acreage
1970	797,300
1971	834,800
1972	841,000
1973	858,700
1974	919,000
1975	909,600
1976	934,800
1977	868,100
1978	909,400
1979	928,700
1980	943,500
1981	955,400
1982	954,100
1983	854,200
1984	972,800
1985	945,100
1986	819,500
1987	786,800
1988	831,100
1989	856,100
1990	842,400
1991	729,400

Mean Irrigated Acreage	876,900
Maximum Irrigated Acreage in 1984	972,800
Minimum Irrigated Acreage in 1991	729,400

* Double-cropped acreage is counted twice, since it is irrigated twice. Double-cropping is generally a small percentage of total irrigated acreage, in the order of 5,000 to 8,000 acres annually.

Figure 12
Irrigated Acreage in the
San Joaquin Valley Portion of Kern County

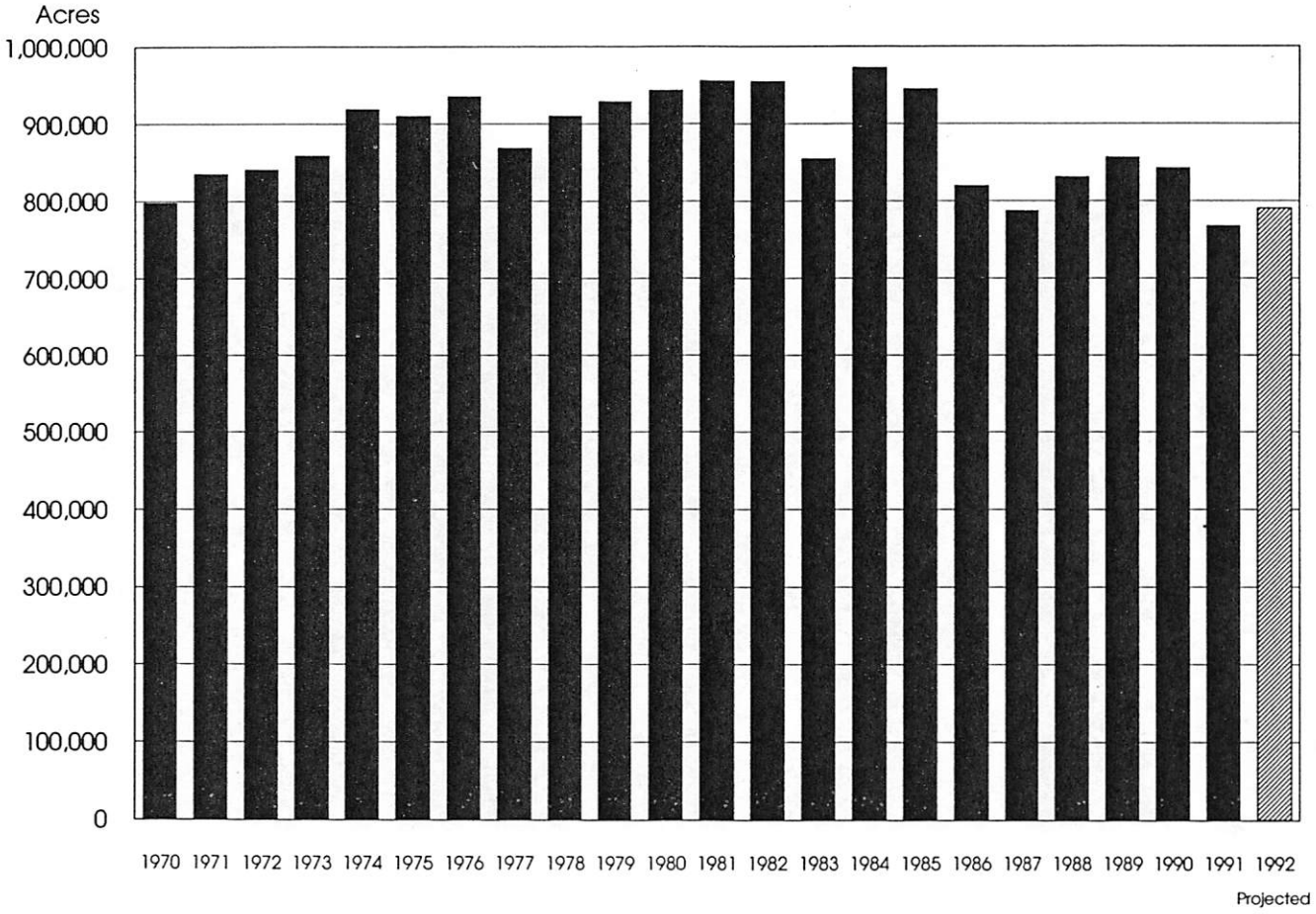


Table 16
1991 Monthly Evaporation for
Four San Joaquin Valley Climatic Stations
(in inches)

	Bakersfield 12S	Lamont 2NW	USDA Cotton Station	Greenlee's Pasture	All Stations
January	1.45	1.4	1.67	1.81	1.58
February	2.44	2.49	2.95	2.91	2.70
March	4.01	3.64	4.05	3.06	3.69
April	6.06	5.75	7.30	6.59	6.43
May	8.16	8.21	9.96	8.56	8.72
June	8.73	9.69	11.13	9.99	9.89
July	9.65	10.44	10.87	10.15	10.28
August	7.96	8.75	9.12	7.41	8.31
September	6.64	7.9	8.88	7.61	7.76
October	4.39	5.82	6.09	4.63	5.23
November	2.17	2.55	2.82	1.85	2.35
December	1.66	1.39	1.98	1.81	1.71
Total	**63.32**	**68.03**	**76.82**	**66.38**	**68.64**
Percent of Normal	**100**	**108**	**102**	**106**	**104**

Station Locations

Bakersfield 12S — NW1/4,NW1/4, Section 36, T31S, R27E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.

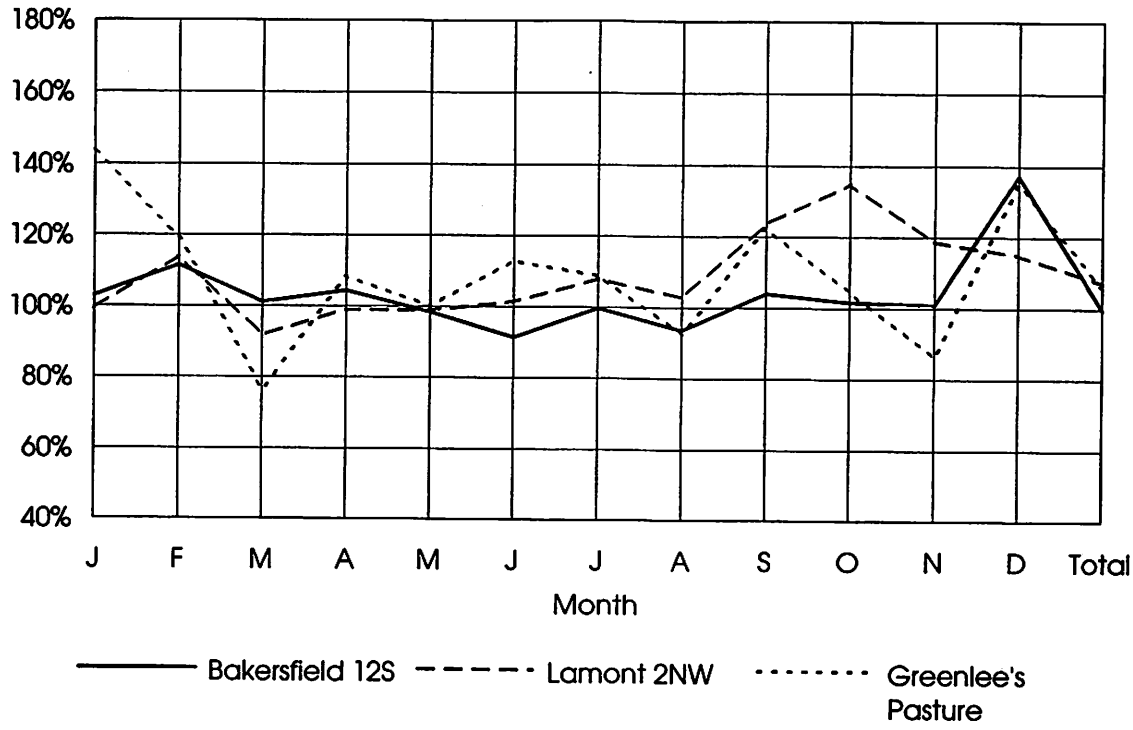
Lamont 2NW — NW1/4, SW1/4, Section 25, T30S, R28E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.

Greenlee's Pasture — SW1/4, SW1/4, Section 36, T12N, R21W, SBB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.

USDA Cotton Station — NW1/4, SE1/4, Section 33, T27S, R25E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated grass turf environment.

Figure 13

1991
Percent of Normal Evaporation



Percent of Normal, Total:	
Bakersfield 12S	**99.7**
Lamont 2NW	**107.1**
Greenlee's Pasture	**105.9**

Bakersfield 12S

1991 observed monthly EP, Bakersfield 12S (irrigated pasture) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP on the valley floor.

Lamont 2NW

1991 observed monthly EP, Lamont 2NW (irrigated pasture) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP on the valley floor.

Greenlee's Pasture

1991 observed monthly EP, Greenlee's Pasture (irrigated pasture - Wheeler Ridge area) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP in the foothill regions of the valley.

move it into the second position, allowing grapes to capture the number one position.

The Agency uses data from the California Irrigation Management and Information Service (CIMIS) to compute crop consumptive use on a district-by-district and crop-by-crop basis. CIMIS is a statewide computerized irrigation scheduling system that can help farmers to schedule their irrigations based upon soil moisture budgets, and hence, possibly reduce their total applied water requirements. There are four CIMIS weather stations in Kern County. CIMIS is funded and operated by the State Office of Water Conservation. Approximate crop water use, as computed using the CIMIS data for 1991, is summarized on Table 17, along with total irrigated acreage.

It is difficult to quantify applied water requirements over the valley. Areal differences, soil differences, cultural practices, leaching requirements (typically 5-10 percent) and irrigation technologies employed across the valley result in very different applied water rates on specific crops. For instance, farmers in areas suffering from perched water will usually apply less water on their crops than they would if the soil were well-drained. The intent is to manage the perched water problem. In addition, the crop may consumptively use some of the perched water, reducing the amount the farmer needs to apply. Also, sprinkler or low-volume irrigation typically requires somewhat less water than furrow or flood irrigation. Many factors govern the type of irrigation system chosen by a farmer. Furrow or flood irrigation systems are not necessarily less efficient than other systems. Under some conditions (such as level slopes and heavy soils), furrow irrigation may be as efficient as sprinklers. Generally, how well-managed an irrigation system is determines how efficient it will be.

Gross agricultural applied water requirements in 1991 were estimated to be about 2,502,900 acre-feet with 2,341,100 acre-feet occurring over the useable groundwater basin. This was about 409,000 acre-feet less than was applied in 1990. Likely, this decrease reflects the reduction in irrigated acreage during 1991, combined with the water-consciousness of the continuing drought. Net agricultural requirements in 1991 were about 2,093,500 acre-feet with about 1,934,800 acre-feet occurring over the groundwater basin. This was about 130,700 acre-feet less than was consumptively used in 1990, reflecting the decrease in irrigated acreage, along with lower per-unit applied water rates. The difference between gross and net water requirements over the basin (adjusted for effective precipitation) is an estimate of agricultural return flows to groundwater. Not all return flows return to useable groundwater. Some is lost to aline sinks (such as perched water areas). Over moisture-deficient soils, return flows are absorbed by the soils and are irrecoverable. About 112,800 acre-feet of water was lost to saline sinks during 1991, and about 7,100 acre-feet was lost to moisture-deficient soils. About 368,100 acre-feet of agricultural applied water in 1991 returned to useable groundwater storage.

Quite a large amount of applied water data has been collected over the years by many entities. The Agency and the State Department of Water Resources both have programs of applied water data collection. The amount of water applied on a crop is affected by several factors: the slope and texture of the soil, the type of irrigation system being used and the age of the crop (for trees and vines). Table 18 provides a basin-wide average applied water requirement for some major crops grown in Kern County.

Municipal and Industrial (M&I)

Gross M&I requirements in 1991 were estimated to be about 134,800 acre-feet, with about 120,000 acre-feet required over the useable groundwater basin. Of the total amount used over the useable basin, 19,800 acre-feet was supplied by the Agency's water treatment plant. The Olcese Water District, which serves the Rio Bravo area, used about 600 acre-feet of Kern River water. The East Niles Community Services District received an additional 1,400 acre-feet of surface water from Arvin-Edison Water Storage District. The remainder, about 98,200 acre-feet, was likely drawn from groundwater. Table 19 gives a breakdown of urban water deliveries by water purveyor service area. The total production of these purveyors, as listed on Table 19, is somewhat less than the gross M&I requirements. The reason for this is that many rural families and businesses maintain their own water systems, and as such, their volumes of production are not recorded. In addition, some small water companies do not keep accurate records of their water production. The gross M&I requirements reflect this fact and include an estimate of what these rural areas and small water companies used.

Table 17
1991 Irrigated Acreage
in the San Joaquin Valley Portion of Kern County, California

Crop	Acres	Percent of Total	Consumptive Water Use (AF/Acre)	Crop	Acres	Percent of Total	Consumptive Water Use (AF/Acre)
Alfalfa (including seed)	90,823	11.8	3.72	Misc. Truck Crop	4,182	0.5	0.38
Almonds	71,601	9.3	3.54	Nursery	3,052	0.4	2.42
Apples	4,955	0.6	3.36	Oats	1,493	0.2	1.62
Apricots	907	0.1	3.36	Olives	8,044	1.0	3.47
Asparagus	704	--	3.01	Onions, Garlic	11,709	1.5	3.32
Avocado	6	--	3.74	Pasture, Turf	4,677	0.6	4.79
Barley	9,235	1.2	1.68	Peaches, Nectarines	4,198	0.5	3.33
Beans	8,010	1.0	1.90	Pears	75	--	3.54
Broccoli	10	--	0.00	Peas	2	--	1.56
Carrots	36,847	4.8	0.56	Peppers	1,589	0.2	2.05
Citrus	40,033	5.2	3.30	Pistachios	24,189	3.2	3.36
Corn, Field	5,647	0.7	2.76	Plums, Prunes	3,202	0.4	3.39
Cotton	240,480	31.3	2.88	Potatoes	18,159	2.4	1.98
Figs	12,379	1.6	2.81	Rice	710	--	0.00
Grapes	75,257	9.8	2.54	Safflower	4,570	0.6	2.56
Guayale and Jojoaba	502	--	1.00	Sorghum/Milo	9,759	1.3	2.24
Kiwi	507	--	2.57	Sudan Grass	2,011	0.3	2.37
Lettuce	6,173	0.8	0.24	Sugar Beets	7,907	1.0	3.44
Melons, Squash, Cucumbers	8,272	1.1	1.79	Tomatoes	4,441	0.6	2.48
Misc. Deciduous Trees	6,440	0.8	2.96	Turnips	436	--	0.70
Misc. Field Crop	2,680	0.3	1.82	Walnuts	1,730	0.2	2.84
Misc. Hay/Grain	1,924	0.3	2.00	Wheat	15,446	2.0	2.29
Misc. Subtropical Trees	12,659	1.6	3.24				
				Total	**767,632**	**100.0**	**2.77***

Note: Double-cropped acreage is counted twice, since it is irrigated twice.

* Weighted average consumptive use of all crops.

Table 18
Average Applied Water Requirements for Various Crops
in Kern County
(in acre-feet per acre)

Crop	Drip (1)	Sprinkler (2)	Row/Border (3)
Alfalfa		3.45-4.35	3.5-5.15
Almonds	2.85-4.10	2.85-4.50	2.85-4.50
Apples	1.95-3.80	3.40-4.75	
Beans (dry)			2.00-2.75
Carrots		1.75-2.45	
Citrus	2.05-3.75	2.75-4.40	3.50-4.50
Corn (field)			3.00-5.00
Cotton		2.25-3.75	2.45-3.75
Grapes	2.00-4.00	2.15-4.50	2.35-4.85
Lettuce			1.50-2.50
Onions, Garlic		1.00-2.65	1.25-4.25
Melons, Squash, Cucumbers			2.00-3.40
Misc. Deciduous Trees	2.75-3.35	3.00-4.00	3.00-4.50
Nursery			2.25-3.50
Pasture, Irrigated		3.50-4.50	3.50-6.00
Pistachios	2.65-4.40	2.35-3.35	3.00-3.50
Potatoes		1.10-2.30	
Small Grains		1.00-2.50	1.00-2.50
Tomatoes			2.50-3.50
Walnuts			3.50-5.00

(1) Includes emitters, misters, mini-sprinklers and fan jets.

(2) Includes portables, solid-sets, linear moves, sprinkler guns.

(3) Border includes border strip, level basin, contour strip.

Note: A blank entry indicates that an irrigation system is generally not utilized on a crop.

Table 19

1991 Urban Water Use, San Joaquin Valley Portion of Kern County

Water Purveyor Service area	Metered Connections	Non-metered Connections	Annual Water Use: Million Gals.	Annual Water Use: Acre Feet	Permanent Population	GPCD (1)
Arvin						
Arvin CSD	1,780	--	584	1,792	10,000	160
Bakersfield Metro Area						
Airport Mutual WC	--	--	10	32	--	--
California Water Service	13,415	39,426	19,250	59,071	210,600	250
Casa Loma WC	--	212	122	375	3,000	112
City of Bakersfield						
Ashe Water Division	15,913		5,710	17,522	62,060	252
East Niles CSD	6,035	--	2,085	6,398	21,122	270
Fairfax WC	--	--	2	5	--	--
Greenfield CWD	617	358	309	948	5,384	157
North of the River MWD	326	1,469	677	2,077	7,000	265
Oildale MWC	379	6,011	1,839	5,643	24,000	210
Rancho Verdugo WC	--	289	132	404	1,002	360
Stockdale MWC	--	--	47	143	--	--
Stockdale Annex MWC	--	--	38	116	--	--
Vaughn WC	1,796	1,028	1,557	4,778	12,665	337
Victory MWC	--	--	44	136	--	--
Metro Area Subtotal	**38,481**	**48,793**	**31,821**	**97,649**	**356,833**	**248**
Buttonwillow						
Buttonwillow CWD	--	406	47	146	1,250	104
Delano						
City of Delano	1,468	4,074	1,916	5,880	23,334	225
Lamont						
Lamont PUD and ID#1	250	2,952	not avail.	not avail.	12,600	--
Lost Hills						
Lost Hills Utility District	173	--	106	324	700	413 (2)
McFarland						
McFarland MWC	1,587	6	396	1,215	7,000	155
Rio Bravo						
Olcese WD	271	--	188	577	640	804 (3)
Shafter						
City of Shafter	19	3,032	821	2,519	10,133	222
Taft-Maricopa-McKittrick						
West Kern WD	6,887	--	4,695	14,407	25,000	515 (2)
Wasco						
City of Wasco	87	2,901	987	3,029	12,897	210
Wasco State Prison	--	--	57	175	2,450	64
					96,004	
Total	**89,484**	**110,957**	**73,439**	**225,361**	**452,837**	**240 (4)**

* 1991 data unavailable, data shown is for 1990.

(1) Gallons per capita per day. Note that the computed GPCD on this table includes residential, commercial, industrial and public authority water use. Residential use is about 200 GPCD.

(2) Includes significant quantities of water used by oil companies.

(3) Includes significant quantities of water used to irrigate a golf course.

(4) Weighted average gpcd, excluding Rio Bravo, Lost Hills and Taft-Maricopa-McKittrick.

The average municipal and industrial water use over the groundwater basin in 1991 was estimated to be about 250 gallons per capita per day (gpcd), about the same as 1990. Long-term, average M&I water use is about 250 gpcd. Residential water use is about 200 gpcd. Industrial, commercial and public authority water use accounts for the difference. It should be noted that domestic water use by the west side towns (Taft, Maricopa, Lost Hills) is quite low when compared to the average domestic water use over the groundwater basin. The average domestic water use during 1991 was about 136 gallons per capita per day for the west side towns.

Net M&I consumptive use in 1991 was about 45,400 acre-feet over the groundwater basin. Gross return flows from M&I uses over the groundwater basin were about 74,600 acre-feet. About 45,200 acre-feet of M&I return flows were treated in sewage treatment facilities and evaporated, percolated or reused for agriculture. The remaining 29,400 acre-feet returned to groundwater supplies. Since virtually all of the M&I water used outside the groundwater basin is for oilfield operations (only about 16 percent was used domestically), it is all consumptively used. Any water not consumptively used is lost to moisture deficient soils.

Exports

During periods of high runoff, some water may be introduced into the California Aqueduct via the Kern River-California Aqueduct Intertie and exported over the Tehachapi Mountains, or spilled into the Kern River Flood Channel, where it may flow north into Tulare Lake in Kings County. Essentially, this is not a useable surface supply. The dry-year conditions precluded any water being exported in this manner during 1991.

Water Surface Evaporation

Water surface evaporation normally accounts for a small amount of water lost from the valley portion of Kern County. In 1991, about 38,800 acre-feet of evaporation losses occurred, with about 38,300 acre-feet occurring over the groundwater basin. This was slightly less than was lost in 1990, due to a smaller water surface area. Any water lost in this manner is lost from this regional hydrologic system.

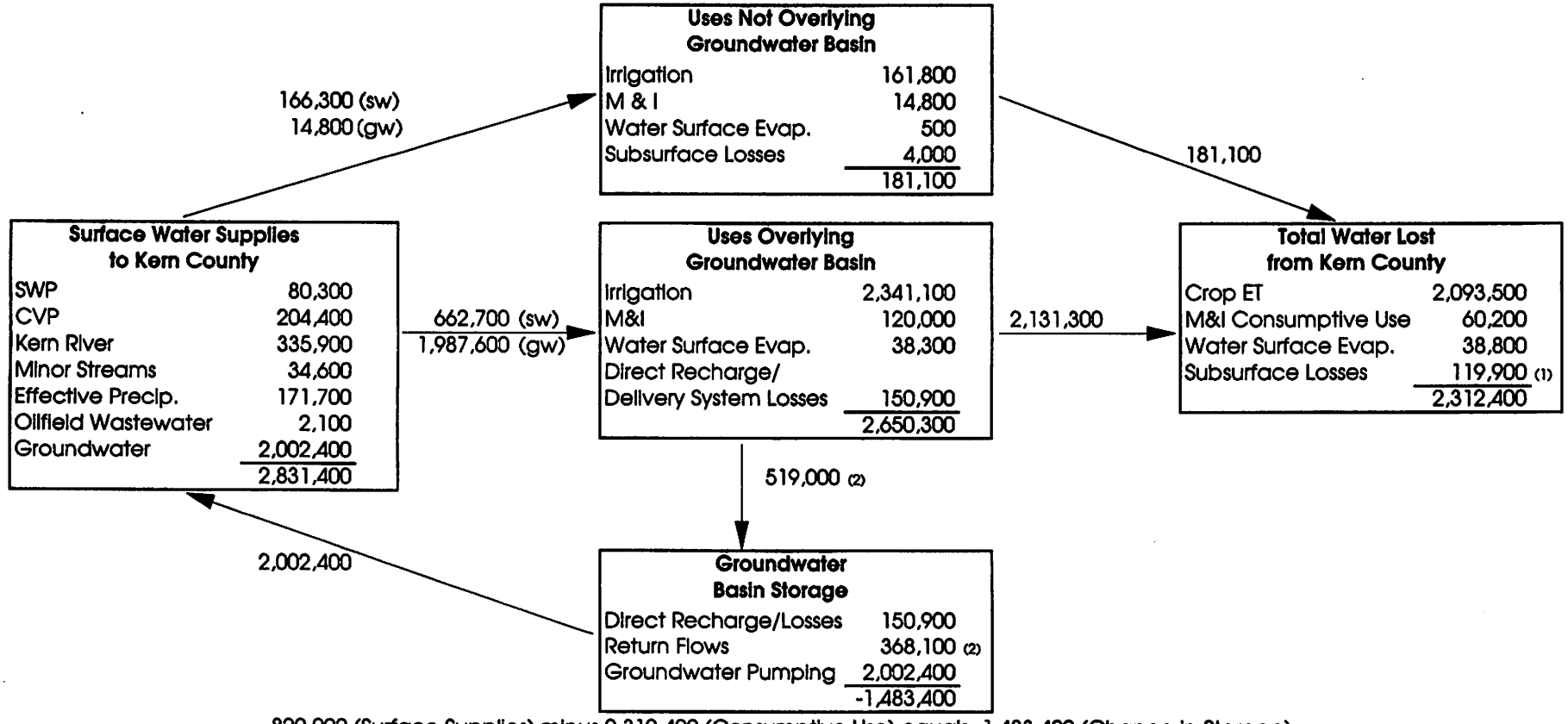
Change in Groundwater Storage

Water supplies and demands for the San Joaquin Valley portion of Kern County, as shown by Figure 14, show a total gross water demand of about 2,817,000 acre-feet in 1991. About 2,636,800 acre-feet occurred over the groundwater basin, including 150,900 acre-feet of water used for direct recharge or delivery system losses. Total net water losses were about 2,311,500 acre-feet, with about 2,131,300 acre-feet over the groundwater basin. Gross available surface water supplies were about 829,000 acre-feet. Hence, there was a net withdrawal from groundwater storage of about 1,482,500 acre-feet. This was consistent with the fact that 1991 was the fifth dry year in a row. The 1987-91 drought period has proven to be more severe than the 1976-77 drought, in terms of water lost from groundwater storage. During the 1976-77 period, 1,858,000 acre-feet of water was lost from underground storage. The 1987-91 period has seen 4,227,000 acre-feet of water lost from storage.

Figure 15 graphically displays the water supplies and demands of the San Joaquin Valley portion of Kern County since 1970 (when SWP water was first introduced over the groundwater basin). During 1970 to 1975, delivery systems were being developed, and the Cross Valley Canal had not been completed, therefore State Project deliveries were relatively low. During 1976 and 1977, not much surface water was available because of the drought. During 1970 to 1991, when about 10,870,000 acre-feet of water was withdrawn from groundwater storage, the balance of additions over extractions has replenished about 4,614,000 acre-feet. Figure 16 shows the cumulative groundwater balance since 1970 when SWP water was first introduced over the Kern County groundwater basin. In volume of groundwater storage, the basin now stands well below 1977 levels, erasing the improvements achieved during the 1978-86 wet period.

It has become apparent that Kern County's groundwater management plans depend upon the sustained delivery o surface water from all three major sources: Kern River, State Water Project and Central Valley Project. A reduction in one supply, unless accompanied by an increase in another, can have a serious impact upon the groundwater basin. Table 20, which provides a summary of supplies from these sources, shows this relative dependence. The dependence is especially illustrated by comparing supplies for the year 1986 with 1987. During 1986, surface water supplies were ample. Hence, groundwater comprised only 25 percent of the total water supply. But in 1987 the reverse was true, and groundwater pumping increased to make up for the dry-year conditions. Conditions during the ongoing drought have certainly demonstrated this dependence; as surface water sources were reduced, groundwater pumping increased to make up the shortfall.

Figure 14
1991 Hydrologic Balance
San Joaquin Valley Portion of Kern County
(in acre-feet)



829,000 (Surface Supplies) minus 2,312,400 (Consumptive Use) equals -1,483,400 (Change in Storage)

Notes:
(1) Includes 3,100 AF return flows, 4,000 AF delivery losses lost to moisture deficient soils.
(2) Of this, 45,200 AF was treated in wastewater facilities and reused.
(gw) Groundwater
(sw) Surface Water

Figure 15
Gross Water Supplies and Net Water Requirements
San Joaquin Valley, Kern County, California

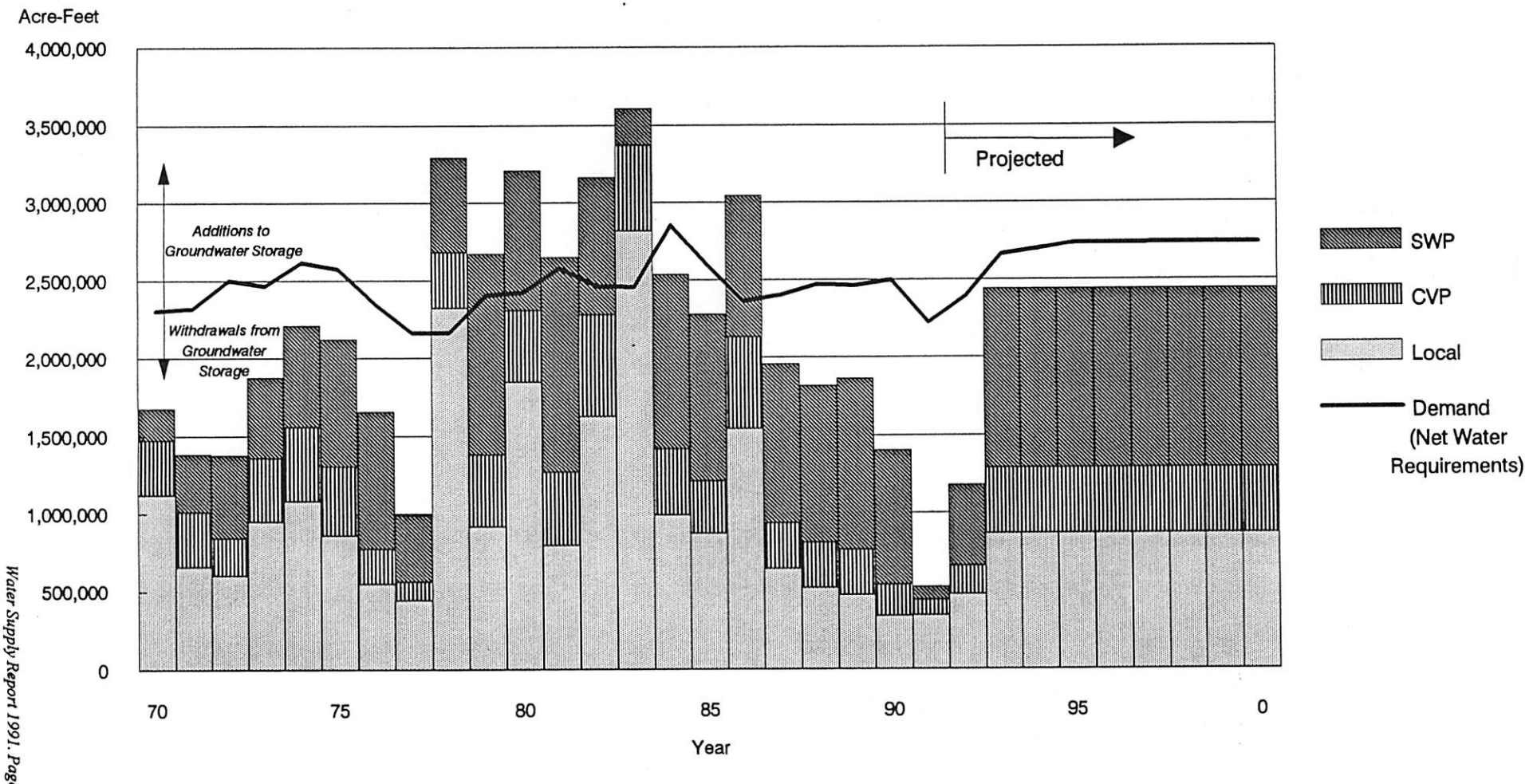


Table 20
Historic Surface* and Groundwater Usage or Availablity in the San Joaquin Valley Portion of Kern County (in acre-feet)

	Kern River		Other Local Water		Central Valley Project		State Water Project		Groundwater		
	Available	% of Total	Available	% of Total	Usage	% of Total	Usage	% of Total	Usage	% of Total	Total Supplies
1970	589,500	19.1	517,900	16.8	351,400	11.4	204,600	6.6	1,422,000	46.1	3,085,400
1971	427,500	13.9	217,100	7.1	348,900	11.4	375,500	12.2	1,700,000	55.4	3,069,000
1972	268,400	8.4	292,600	9.2	238,500	7.5	535,600	16.8	1,857,000	58.2	3,192,100
1973	979,700	26.3	161,200	4.3	412,200	11.0	515,500	13.8	1,662,000	44.6	3,730,600
1974	818,600	22.6	332,000	9.2	480,600	13.3	651,800	18.0	1,333,000	36.9	3,616,000
1975	564,600	15.2	287,300	7.8	442,100	11.9	821,700	22.2	1,587,000	42.9	3,702,700
1976	249,500	7.5	225,700	6.8	226,500	6.8	883,400	26.6	1,738,000	52.3	3,323,100
1977	197,000	7.3	239,400	8.9	121,500	4.5	429,400	16.0	1,703,000	63.3	2,690,300
1978	1,653,500	36.8	1,050,200	23.3	357,800	8.0	611,500	13.6	825,000	18.3	4,498,000
1979	672,700	17.0	258,700	6.6	462,500	11.7	1,291,800	32.7	1,260,000	31.9	3,945,700
1980	1,640,000	37.8	356,500	8.2	462,800	10.7	900,300	20.8	977,000	22.5	4,336,600
1981	449,300	11.8	329,100	8.7	470,000	12.4	1,384,700	36.5	1,161,000	30.6	3,794,100
1982	1,271,100	30.9	502,800	12.2	656,600	15.9	884,500	21.5	802,200	19.5	4,117,200
1983	2,489,100	51.7	777,400	16.1	550,900	11.4	238,200	4.9	762,700	15.8	4,818,300
1984	821,800	21.7	165,300	4.4	425,400	11.2	1,123,000	29.6	1,252,200	33.1	3,787,700
1985	672,400	18.8	192,600	5.4	337,500	9.5	1,074,100	30.1	1,293,800	36.2	3,570,400
1986	1,444,900	35.2	207,000	5.0	589,300	14.4	913,600	22.3	947,600	23.1	4,102,400
1987	375,900	12.1	206,800	6.7	292,000	9.4	1,025,900	33.0	1,208,700	38.9	3,109,300
1988	294,700	8.9	179,800	5.4	292,800	8.8	1,006,200	30.4	1,540,200	46.5	3,313,700
1989	397,000	11.3	141,500	4.0	293,900	8.3	1,100,000	31.2	1,588,500	45.1	3,520,900
1990	219,500	6.9	112,800	3.5	200,100	6.3	857,300	26.9	1,796,500	56.4	3,186,200
1991	335,900	11.9	208,400	7.4	204,400	7.2	80,300	2.8	2,002,400	70.7	2,831,400
Avg.	**765,100**	**23.3**	**230,000**	**7.0**	**373,500**	**11.4**	**768,600**	**23.4**	**1,382,700**	**42.0**	**3,289,900**

* Adjusted for deliveries within Kern County. SWP includes Intertie deliveries.

Basin-Wide Water Use Efficiency

Water applied to a crop that is in excess of its ET requirements percolates past the root zone and usually returns to groundwater supplies, where it is available for reuse. Most of this deep percolation returns to groundwater within two years. Sometimes the deep percolation is intercepted by shallow clay lenses in the soil. (This condition is referred to as perched water or shallow groundwater). In some areas the deep percolation may return to unusable saline groundwater. In the western portion of Kern County, most of the soils are moisture-deficient. That is, the water held in the soil is less than the amount of water the soil would normally retain after gravity drainage. Any deep percolation occurring over these moisture-deficient soils will be absorbed until the water holding capacity of the soils is satisfied. Geohydrologists estimate it would take over 3 million acre-feet of water to satisfy the holding capacity of these moisture-deficient soils.

Over the entire San Joaquin Valley portion of Kern County, gross water demands were about 2,831,400 acre-feet during 1991 (2,502,900 for agriculture, 134,800 for M&I, 38,800 of evaporation losses, 150,900 acre-feet for groundwater recharge, and 7,100 of unrecoverable delivery system losses). The total consumption of water was about 2,192,500 acre-feet (2,093,500 by agriculture, 60,200 by M&I, 38,800 of evaporation losses). Effective precipitation was about 171,700 acre-feet. The agricultural irrigation efficiency, therefore, was about 77 percent. A total of 45,200 acre-feet of M&I water was treated and reused, mostly by agriculture. The difference between gross and net requirements (adjusted for waste water reuse) is an estimate of groundwater returns, which amounted to 638,900 acre-feet. However, about 112,800 acre-feet of deep percolation was intercepted by perched water and about 7,100 acre-feet was absorbed by moisture-deficient soils. Therefore, net groundwater returns were 368,100 acre-feet in 1991. Expressed another way, of the 2,831,400 acre-feet of gross water demand during 1991, 2,711,500 acre-feet was beneficially used or available for reuse (via net deep percolation). As a percent, 96 percent of the total applied water during 1991 was beneficially used or available for reuse. This percentage is termed basin-wide water use efficiency. Kern County is one of the most efficient areas of the state in terms of basin-wide water use efficiency.

Intertie Activity

The Kern River-California Aqueduct Intertie is a structure connecting the Kern River to the California Aqueduct near Tupman. Built by the Army Corps of Engineers in 1977, its basic purpose is to dispose of floodwater, thereby preventing damages on the Kern River floodplain downstream. Flows into the California Aqueduct through the Intertie may contain water from the Kern, Kaweah, San Joaquin or Tule Rivers, or a combination of these. Generally, Kern River flows must exceed about 200 percent of normal before the Intertie gates need to be opened. Water from the Kern River channel first passes through a sedimentation basin to remove sand and silt. Water then passes through trash racks to remove floating debris before it enters the aqueduct. The structure has a capacity of 3,500 cfs. However, downstream aqueduct demands can become the limiting factor in wet years when demands are low.

When it enters the California Aqueduct, Intertie water becomes the property of the state Department of Water Resources, and is used to meet SWP system needs. Occasionally, during periods of extremely heavy runoff, temporary pumps may be installed to pump the water to aqueduct reaches north (upstream) of the Intertie as well. Such water displaces an equal amount of SWP water that would have been pumped from the Sacramento-San Joaquin River Delta, thereby producing a power saving for the SWP users.

The Intertie has not operated since 1986. Through the end of 1986, a total cumulative flow of 1,143,081 acre-feet of water has passed through its gates into the California Aqueduct. About 47 percent of this was used in Kern County, the remainder went to southern California. Table 21 is a historical summary of Intertie activity to date, showing the inflow by source, as well as amounts exported and retained in the County.

Table 21
Summary of Kern River-California Aqueduct Intertie Activity
(in acre-feet)

	Intertie Inflow			Amount Exported			Retained in County		
	Kern River	Friant-Kern	Total	Kern River	Friant-Kern	Total	Kern River	Friant-Kern	Total
1978	168,818	9,113	177,931	n/a*	n/a*	113,831	n/a*	n/a*	64,100
1980	138,816	0	138,816	74,024	0	74,024	64,792	0	64,792
1982	10,339	11,968	22,307	5,928	2,700	8,628	4,411	9,268	13,679
1983	662,856	96,200	759,056	n/a*	n/a*	393,551	n/a*	n/a*	365,505
1984	27,524	0	27,524	13,885	0	13,885	13,639	0	13,639
1986	1,867	15,580	17,447	0	4,746	4,746	1,867	10,834	12,701
Total	**1,010,220**	**132,861**	**1,143,081**			**608,665**			**534,416**

* A breakdown between sources was not available.

Source: Department of Water Resources and City of Bakersfield Kern River Annual Reports.

Groundwater Conditions

Groundwater Recharge

Several entities in Kern County are actively engaged in groundwater replenishment operations. Kern River water is recharged to groundwater by a combination of deliberate spreading in recharge areas, by losses in unlined canals, or by percolation in the Kern River channel. Central Valley Project water is recharged in spreading works operated by the Arvin-Edison Water Storage District or in the Kern River and Poso Creek channels. State Water Project water is recharged by the Agency and several water districts in the Kern River channel via the Cross Valley Canal, in unlined irrigation canals, or in district operated recharge sites. During wet periods, every effort is made to deliver water through unlined canals, in order to maximize seepage, and the recharge that occurs during such wet times.

Many of the water districts in Kern County use conjunctive use and banking programs to help balance their supplies. A correctly managed conjunctive use or banking program is an effective groundwater management tool that allows a district to smooth over periods when surface water is unavailable. The intent is to store water during times when the available supply exceeds demand, and recover the water when the opposite is true. Also, a correctly managed program puts limits to the amount of water that can be withdrawn in any year, so adverse regional effects are minimized. A tremendous amount of groundwater recharge in Kern County is accomplished as part of these programs. Table 22 outlines major conjunctive use and banking programs since 1971, listing the amounts of water by source. About 150,900 acre-feet of water was spread in 1991, both deliberately and incidentally. The approximate breakdown between sources was:

Kern River	106,000
SWP	8,500
CVP	200
Waste water	3,300
Minor Streams	32,900
	150,900

These numbers should only be considered as best estimates since many times the supplies are intermixed in the same canal systems. Hence, any differentiation becomes impossible. The amount of recharge shown on Table 22 is more than the amount of recharge listed here. This is because Table 22 includes in-lieu recharge, but excludes incidental recharge and minor stream flows that have naturally recharged the groundwater basin.

Such recharge efforts, from whatever source, show the importance attached to reducing groundwater overdraft in Kern County, as well as saving water by conservation. Since the 1976-77 drought, a total of about 7,773,100 acre-feet of water has been recharged (both deliberately and incidentally) to replenish groundwater supplies. The effectiveness of such recharge activities are apparent in Figure 16. The Agency estimates that the 7,773,100 acre-feet of recharged water results in a gross basin-wide groundwater pumping lift difference of about 77 feet, or about one foot for every 100,000 acre-feet.

Groundwater Banking

Groundwater banking is a concept that has picked up momentum in recent years. The state DWR's ability to provide a dependable water supply is less than its contractual obligations. Since groundwater storage is now more environmentally acceptable and financially feasible, DWR is expanding its below-ground storage planning and operations. The intent of banking programs is to store surface water in the underground when it is available and extract it during times of need. Hence, available surface water supplies are used conjunctively with groundwater. This mode of operation is known as conjunctive use. While conjunctive use has been practiced since the turn of the century by local water managers, it is a new approach for the SWP.

The Kern Water Bank is a planned banking/extraction program which will ultimately provide as much as 100,000 acre-feet of annual dry-year yield for the State Water Project. On the local level, the City of Bakersfield has maintained its 2,800 acre recharge area as a banking site for many years, where KCWA and others have deposited water. Tables 23a, 23b, 23c,

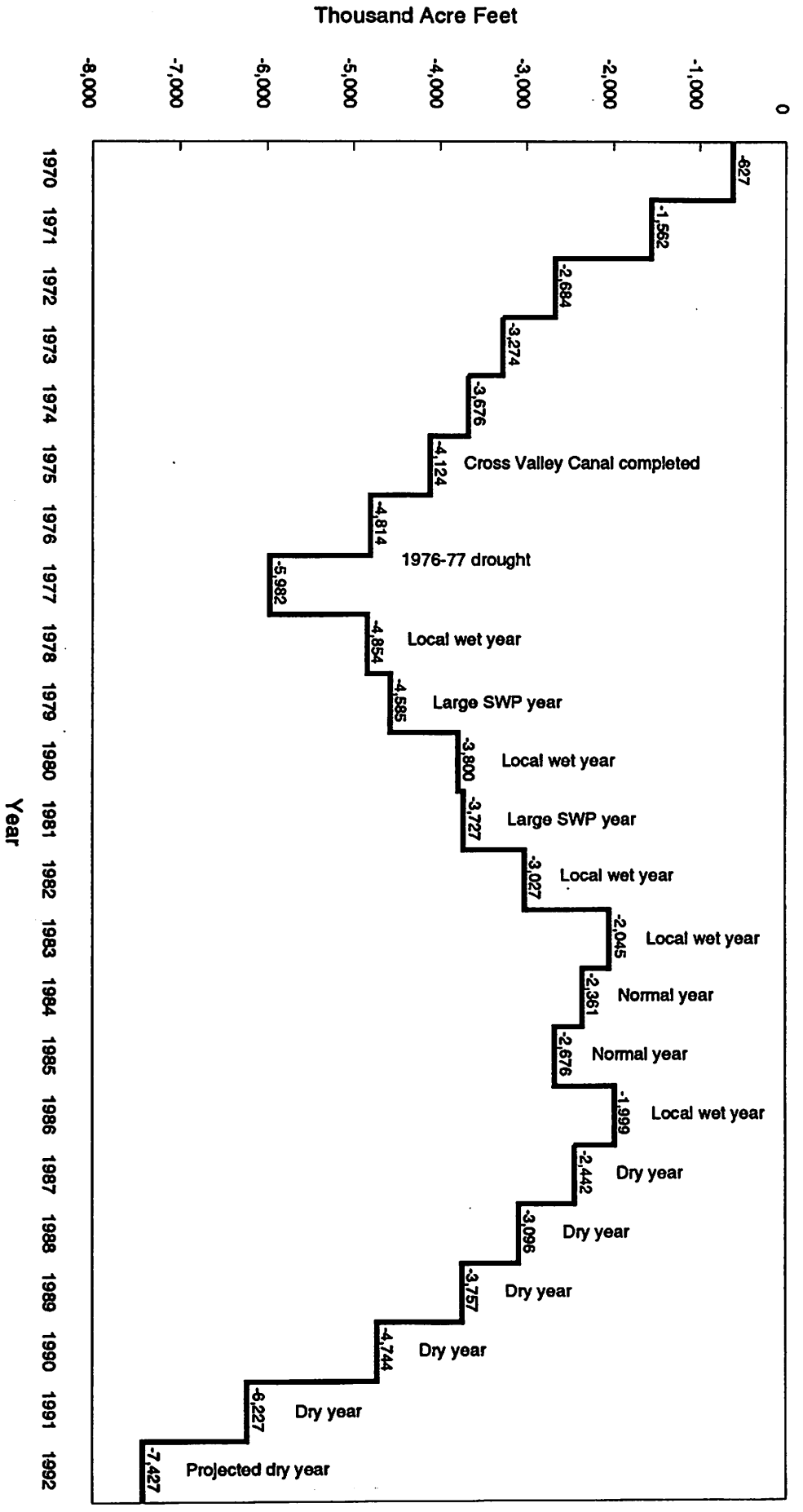


Figure 16
Accumulative Change in Groundwater Storage
in the San Joaquin Valley Portion of Kern County

Table 22
Summary of Groundwater Recharge Activities *
(in acre-feet)

Entity/Location	Source	1971-86	1987	1988	1989	1990	1991	Total
BANKING								
City of Bakersfield **								
2,800 Acre Spreading Area	Kern	539,803	0	0	0	0	0	539,803
	SWP	21,010	0	0	0	0	0	21,010
	F-K	70,361	0	0	0	0	0	70,361
Subtotal COB		631,174	0	0	0	0	0	631,174
Kern County Water Agency								
Berrenda Mesa Spreading Area	Combined	33,960 1)	0	0	0	0	0	33,960 (1)
Kern River Channel (in ID4)	SWP	33,552	0	0	0	0	0	33,552
2,800 Acre Spreading Area	SWP	82,733	0	0	0	0	0	82,733
Subtotal KCWA		150,245	0	0	0	0	0	150,245
DWR-Kern Water Bank								
2800 Acre Spreading Area	SWP	0	7,379	0	0	0	0	7,379
Local Elements*** In-lieu Rechg.	SWP	0	0	0	0	136,300	0	136,300
Local Elements*** Direct Rechg.	SWP	0	0	0	0	4,200	0	4,200
Subtotal DWR		0	7,379	0	0	140,500	0	147,879
Total Banking		781,419	7,379	0	0	140,500	0	929,298
CONJUNCTIVE USE								
Arvin-Edison WSD	F-K	742,603	6,386	3,334	0	0	170	752,493
Buena Vista WSD	Kern	239,360	3,086	0	2,723	0	0	245,169
	SWP	8,400	0	20,500	809	0	0	29,709
Semitropic WSD Direct Rechg.	SWP	0	0	17618	18,654	16,400	6,800	59,472
In-Lieu Rechg.	SWP	473,701	51,624	15,328	60,751	34,870	697	636,971
	Combined	6,303 1)	986 1)	–	–	–	–	7,289 (1)
I.D. No. 4 Direct Rechg.	Kern	349,490	18,200	29,850	14,040	3,116	6,279	420,975
	SWP	220,694	14,000	5,210	6,990	10,713	1,651	259,258
	F-K	18,300	535	0	0	0	0	18,835
Kern Delta WD Direct Rechg.	Kern	103,035	47,747	38,341	49,966	0	0	239,089
	SWP	1,351	0	0	0	0	0	1,351
North Kern WSD Direct Rechg.	Kern	1,320,360	23,000	22,109	15,707	0	4,038	1,385,214
In-Lieu Rechg.	Kern	421,700	15,908	15,135	6,762	0	1,326	460,831
Rosedale-Rio Bravo WSD	Kern	489,404	6,000	6,000	7,500	0	9,076	517,980
	SWP	436,455	21,888	23,600	32,700	0	0	514,643
	F-K	161,807	0	0	0	0	62	161,869
	Combined	279,800 1)	–	–	–	–	–	279,800 (1)
Wheeler Ridge-Maricopa WSD								
In-Lieu Recharge	SWP	86,186	377	0	0	9,000	0	95,563
Total Conjunctive Use		5,358,949	209,737	197,025	216,602	74,099	30,099	6,086,511
OVERDRAFT CORRECTION								
Groundwater Replenishment								
Program (GRP) In-Lieu Rechg.	SWP	96,871	0	0	0	0	0	96,871
Direct Rechg.	SWP	257,920	0	0	0	0	0	257,920
	Kern	57,230	0	0	0	0	0	57,230
	F-K	7,723	0	0	0	0	0	7,723
Idle Lands Spreading	Kern	130,955	0	0	0	0	0	130,955
Total Overdraft Correciton		550,699	0	0	0	0	0	550,699
GRAND TOTALS	Kern	3,651,337	113,941	111,435	96,698	3,116	20,719	3,997,246
	SWP	1,718,873	95,268	82,256	119,904	211,483	9,148	2,236,932
	F-K	1,000,794	6,921	3,334	0	0	232	1,011,281
	Combine	320,063 1)	986 1)	0	0	0	0	321,049 (1)
	Total	6,691,067	217,116	197,025	216,602	214,599	30,099	7,566,508

* Includes direct and in-lieu recharge.

** Includes banking by Olcese WD, Hacienda WD, Buena Vista WSD, City of Bakersfield; for breakdown between districts see Table 23.

*** Includes 1990 Kern Water Bank Demonstration Program deliveries.

(1) Breakdown between sources not available.

Note: For a breakdown of 1971 to 1986, see prior Water Supply Reports.

Table 23a
Kern County Water Agency
Groundwater Banking Summaries
Recharge/*Purchase* or Recovery/*Sale* by Year and Contracting Entity
City of Bakersfield 2,800 Acre Recharge Facility
(in acre-feet)

Calendar Year	KCWA General Account			Wheeler Ridge-Maricopa WSD			Berrenda Mesa WD		
	Recharge/ *Purchase*	Recovery/ *Sale*	Recoverable Balance	Recharge/ *Purchase*	Recovery/ *Sale*	Recoverable Balance	Recharge/ *Purchase*	Recovery/ *Sale*	Recoverable Balance
1981	29,812	0	29,812	5,600	0	5,600	9,500	0	9,500
1982	0	0	29,812	0	0	5,600	0	0	9,500
1983	0	0	29,812	0	0	5,600	0	0	9,500
1984	0	0	29,812	0	0	5,600	0	0	9,500
1985	15,055	0	44,867	0	0	5,600	0	0	9,500
1986	10,000	0	54,867	0	0	5,600	0	0	9,500
1987	0	0	54,867	0	0	5,600	0	0	9,500
1988	0	0	54,867	0	0	5,600	0	0	9,500
1989	0	*16,105* (1)	38,762	*15,019*	0	20,619	0	0	9,500
1990	0	0	38,762	0	0	20,619	0	*9,500* (3)	0
1991	*44,131*	33,316	49,577	0	0	20,619	0	0	0
	98,998	**49,421**	**49,577**	**20,619**	**0**	**20,619**	**9,500**	**9,500**	**0**

Calendar Year	Improvement District No. 4			State of California			Total of All Accounts		
	Recharge/ *Purchase*	Recovery/ *Sale*	Recoverable Balance	Recharge/ *Purchase*	Recovery/ *Sale*	Recoverable Balance	Recharge/ *Purchase*	Recovery/ *Sale*	Recoverable Balance
1981	0	0	0	0	0	0	44,912	0	44,912
1982	0	0	0	0	0	0	0	0	44,912
1983	0	0	0	0	0	0	0	0	44,912
1984	0	0	0	0	0	0	0	0	44,912
1985	0	0	0	0	0	0	15,055	0	59,967
1986	12,766	0	12,766	0	0	0	22,766	0	82,733
1987	0	0	12,766	7,379	0	7,379	7,379	0	90,112
1988	0	0	12,766	0	0	7,379	0	0	90,112
1989	*3,500* (2)	0	16,266	0	0	7,379	18,519	16,105	92,526
1990	0	0	16,266	*107,505*	0	114,884	107,505	9,500	190,531
1991	0	0	16,266	0	0	114,884	44,131	33,316	201,346
	16,266	**0**	**16,266**	**114,884**	**0**	**114,884**	**260,267**	**58,921**	**201,346**

(1) Total of 1,086 AF owed by ID#4 to KCWA General and delivered in 1991; 15,019 AF transferred to Wheeler Ridge-Maricopa WSD's acc

(2) Assignment of 3,500 AF from City of Bakersfield groundwater storage to ID#4 on behalf of Kern-Tulare WD (2,800 AF) and Rag Gulch

(3) Transferred to DWR as part of 1990 Demonstration Program.

Note: Purchases and sales are shown as italicized and larger.

Table 23b
Kern County Water Agency
Groundwater Banking Summaries
Recharge and Recovery Accounting
Berrenda Mesa Spreading Grounds
(in acre-feet)

Calendar Year	RECHARGE			RECOVERY			RECOVERABLE BALANCE		
	SWP	Imported Floodwater	Total	SWP	Imported Floodwater	Total	SWP	Imported Floodwater	Total
1981	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0
1983	0	14,155	14,155	0	0	0	0	14,155	14,155
1984	0	416	416	0	0	0	0	14,571	14,571
1985	0	0	0	0	0	0	0	14,571	14,571
1986	3,093	16,296	19,389	0	0	0	3,093	30,867	33,960
1987	0	0	0	0	0	0	3,093	30,867	33,960
1988	0	0	0	0	0	0	3,093	30,867	33,960
1989	0	0	0	0	0	0	3,093	30,867	33,960
1990	0	0	0	0	0	0	3,093	30,867	33,960
1991	0	0	0	0	15,298	15,298	3,093	15,569	18,662
	3,093	30,867	33,960	0	15,298	15,298	3,093	15,569	18,662

Table 23c
Kern County Water Agency
Groundwater Banking Summaries
Recharge and Recovery Accounting
Kern River Channel Within Improvement District No. 4
(in acre-feet)

Calendar Year	RECHARGE			RECOVERY			RECOVERABLE BALANCE		
	SWP	Imported Floodwater	Total	SWP	Imported Floodwater	Total	SWP	Imported Floodwater	Total
1981	33,552	0	33,552	0	0	0	33,552	0	33,552
1982	0	0	0	0	0	0	33,552	0	33,552
1983	0	0	0	0	0	0	33,552	0	33,552
1984	0	0	0	0	0	0	33,552	0	33,552
1985	0	0	0	0	0	0	33,552	0	33,552
1986	0	0	0	0	0	0	33,552	0	33,552
1987	0	0	0	0	0	0	33,552	0	33,552
1988	0	0	0	0	0	0	33,552	0	33,552
1989	0	0	0	0	0	0	33,552	0	33,552
1990	0	0	0	0	0	0	33,552	0	33,552
1991	0	0	0	18,161	0	18,161	15,391	0	15,391
	33,552	**0**	**33,552**	**18,161**	**0**	**18,161**	**15,391**	**0**	**15,391**

Table 23d
Groundwater Banking Summaries
Recharge/Purchase and Recovery/Sale
Department of Water Resources, Kern Water Bank
(in acre-feet)

Calendar Year	Contracting Entity or Location: Buena Vista WSD	City of Bakersfield 2,800 Acres	KCWA ID#4	Kern Delta WD	Kern Fan Element	La Hacienda WD	North Kern WSD	Rosedale-Rio Bravo WSD	Semitropic WSD	West Kern WD	Total
1987	0	7,379	0	0	0	0	0	0	0	0	7,379
1988	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0
1990	20,000	9,500 (1)	0	7,500	0	98,005	0	7,500	105,500	0	248,006
1991	0	0	0	0	0	0	0	0	0	0	0
	20,000	16,879	0	7,500	0	98,005	0	7,500	105,500	0	255,385

(1) Transfer of storage account from Berrenda Mesa WD to DWR as a result of 1990 Demonstration Program.
Source: KCWA records.

Table 23e
Groundwater Banking Summaries
Recharge/Purchase and Extraction/Sale
Contracting Entities Other Than KCWA or DWR
City of Bakersfield 2,800 Acre Recharge Facility*
(in acre-feet)

Calendar Year	City of Bakersfield		Olcese/Hacienda WD		Buena Vista WSD		Total Banking		Storage Balance
	Recharge	Extraction	Recharge	Extraction	Recharge	Extraction	Recharge	Extraction	
1978	104,587		24,328		6,056		134,971	0	134,971
1979	4,505				9,913		14,418	0	149,389
1980	68,804	(13,772)	52,604				121,408	(13,772)	257,025
1981	2,603	(100,837)	4,465				7,068	(100,837)	163,256
1982	37,913		14,266		24,465		76,644	0	239,900
1983	113,380						113,380	0	353,280
1984	16,058	(472)					16,058	(472)	368,866
1985	402	(1,615)					402	(1,615)	367,653
1986	64,168		56,197		10,000		130,365	0	498,018
1987	109	(656)	5,344			(6,000)	5,453	(6,656)	496,815
1988		(5,432)	3,214			(5,000)	3,214	(10,432)	489,597
1989		(2,859)		(873)		(3,138)	0	(6,870)	482,727
1990		(23,318)		(99,405)		(2,242)	0	(124,965)	357,762
1991		(57,159)	22,096	(23,496)		(4,410)	22,096	(85,065)	294,793
	412,529	(206,120)	182,514	(123,774)	50,434	(20,790)	645,477	(350,684)	294,793

* A more detailed breakdown is provided in the City of Bakersfield 2,800 Acre Recharge Facility Report.
Source: City of Bakersfield 2,800 Acre Recharge Facility 1991 Report.

Table 23f
Private Land Owner Transfers of Groundwater in 1991

	CASTLE & COOK		STRAND RANCH	BARTEL			West Kern WD	ID#4	
	ID#4 to WRMWSD	ID#4 to ID#4	Non-district to WRMWSD	ID#4 to ID#4	ID#4 to Cawelo	ID#4 to Belridge	WKWD to Belridge	Well to Tr. Plant	Total
Amount Pumped (AF)	3,631	318	1,891	448	50	590	4,425	1,646	12,999
Acres Idled	1,007	N/A	600	176 *	*	*	N/A	N/A	1,783

* 176 acres is the total acres idled for the Bartel transfers.

23d, 23e and 23f outline the banking account balances for those entities who are involved in various banking programs. These tables are an in-depth breakdown of the banking portion of Table 22, and includes recharge, extractions and transfers-sales of bank accounts.

In January, 1991 the Agency began developing the 1991 Emergency Groundwater Recovery Program that would recover about 100,000 acre-feet of previously banked water and deliver it via local canals to the California Aqueduct. Agreements with DWR provided for re-regulation of the local groundwater by using SWP storage reservoirs. Essentially, DWR delivered about 100,000 acre-feet of water from reservoir storage on an agricultural demand schedule (with the bulk of the deliveries made during the summer months). In return, local groundwater was pumped into the California Aqueduct at a fairly constant rate until the entire amount was repaid. Groundwater production began in January, 1991 and continued until mid-1992. Through the end of December, 1991 approximately .63,000 acre-feet of groundwater had been pumped into the Aqueduct, as shown on Tables 23a, b, and c.

In addition to KCWA's banking program, Table 23f shows the result of local, water district-sponsored programs. A total of 13,000 acre-feet of groundwater was pumped and delivered to west side lands under these district programs. Generally, these programs involved farmers overlying the groundwater basin idling their lands and allowing their wells to be used to pump groundwater for the west side areas. The water was needed to keep perennial crops alive, since no alternative supplies are available on the west side. West Kern WD pumped 4,425 acre-feet from its bank account with Buena Vista WSD. Also, KCWA's Improvement District No. 4 drilled two new wells and pumped 1,646 acre-feet for use in their Henry C. Garnett Water Treatment Plant. This water was needed to make up a shortfall in surface water for the urban purveyors who normally receive water from the treatment plant.

Perched Groundwater

When the downward movement of water is intercepted by shallow clay beds, perched water accumulations result. These accumulations generally are undesirable in farming operations if the water accumulates enough to reach the crop root zone. Loss of crop yields, build-up of salts in the soils, and farm equipment bogging in poorly drained fields are symptoms associated with perched water problems.

Not enough is known about the perched water phenomenon to allow for definite conclusions as to its causes. In 1986, KCWA began a pilot program to systematically measure perched water levels on a monthly basis, along with associated information. The intent is to provide a long-term, consistent data set on which to base a reliable analysis. The program has been in effect for nearly six years. An analysis of the data thus far seems to suggest that perched water levels are not static, but can change considerably from month to month or year to year. In addition, in some areas the electrical conductivity (EC) of perched water seems to vary with depth. Recent studies by the United States Geological Survey (USGS) suggest that such EC layering may indicate the relative age of the water deposits. Much more study is needed before perched water relationships can be well understood.

Generally, the areas suffering from perched water in Kern County follow the historic lower-elevation trace of the Kern River channel, including the old Kern Lake and Buena Vista Lake beds (where Kern River flows ponded). Increases in perched water area appear after a year of high Kern River runoff. Likewise, contractions seem to occur during years when runoff is low. In this sense, perched water appears to be largely a natural phenomenon. Table 24 lists historic areas with perched water problems, categorized into five foot increments, along with the number of monitoring wells measured. At first glance, it would seem that an enormous increase in perched water area occurred between 1979 and 1980. Likely, this increase is perceived rather than real. KCWA and cooperating water districts have been expanding the monitoring grid, therefore this large increase was more likely the result of better monitoring as the grid was expanded. Table 24 clearly show the continuing expansion of the monitoring grid. Expanding the grid has now allowed the eastern and western boundaries of the perched water areas to be fairly well defined. Monitoring wells located in these areas are consistently reading dry.

Depth to perched water, as measured in shallow monitoring wells, is contoured on Plate 1. Water within five feet of the ground surface occurred under

Table 24
Areal Extent of Shallow Groundwater
(in acres)

	Summer Measurements						Winter Measurements					
Year	0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.	No. of Piezo's.	0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.	No. of Piezo's.
1976	27,940	64,700	--	79,680 (1)	172,320	--	--	--	--	--	--	--
1977	19,320	68,980	--	95,960 (1)	184,260	180	16,930	52,530	--	67,300 (3)	136,760	143
1978	27,680	65,760	--	87,920 (1)	181,360	174	9,600	59,520	--	86,400 (3)	155,520	--
1979	30,270	67,310	--	95,870 (1)	193,450	--	15,320	83,200	--	80,640 (3)	179,160	126
1980	74,357	82,787	--	125,883 (1)	283,027	--	45,882	92,998	126,665	62,578	328,123	154
1981	62,002	85,556	--	128,323 (1)	275,881	178	46,746	75,318	36,736	104,200	263,000	168
1982	78,725	95,615	76,271	30,226	280,837	259	90,658	85,541	55,392	43,181	274,772	199
1983	109,915	90,090	63,510	48,980	312,495	227	--	--	--	--	--	--
1984	110,500	57,650	45,400	47,649	261,199	246	--	--	--	--	--	--
1985	49,396	120,396	123,776	90,323	383,891	290	--	--	--	--	--	--
1986	84,160	79,774	73,698	83,264	320,896	330	--	--	--	--	--	--
1987	57,600	84,864	89,816	76,672	308,952	261	90,800	74,100	61,200	72,200	298,300	--
1988	82,700	86,500	83,900	93,400	346,500	288	--	--	--	--	--	--
1989	65,536	95,949	83,558	85,760	330,803	328	--	--	--	--	--	--
1990	67,561	91,257	82,823	-- (2)	241,641	350	--	--	--	--	--	--
1991	40,363	101,888	45,141	-- (2)	187,392	351	--	--	--	--	--	--

(1) 10-20 ft. measurement.

(2) Data insufficient to establish a 20 foot contour. Total is area within 15 feet.

(3) No 15 foot contour established. Total is within 20 feet.

-- Data not available.

Note: Annual changes in perched water area may be perceived rather than real, due to increases in the number of monitoring wells used to prepare the maps. More monitoring wells may have provided better coverage, allowing for a more accurate map to be produced.

an area of about 40,400 acres in the summer of 1991. This was a 40 percent decrease from the summer of 1990 area. The area of shallow groundwater between 5-10 feet of the ground surface increased from 91,300 acres to 101,900 acres in the same period. This 12 percent increase is due mainly to the migration of water that was formerly in the 0-5 foot area to a greater depth. Water in the 10-15 feet of the ground surface decreased from 82,800 acres in the summer of 1990 to 45,100 acres in the summer of 1991. This amounted to a 45 percent decrease. Total acreage between ground surface and a depth of 15 feet decreased from 241,600 acres to 187,400 acres, or a 22 percent decrease.

For the summer of 1990, the area with shallow groundwater from 15-20 feet was not computed, due to shallow groundwater levels dropping below the 20 foot deep monitoring wells situated along the boundaries of the affected area. This situation had continued into the summer of 1991, with many wells that had previously shown shallow groundwater at 15 feet or less being dry. Large portions of the 15 foot contour are now dashed to show its predicted location due to the lack of adequate data. It appears that the boundary areas and also the area outlined by the five foot contour are experiencing the greatest effect from the drought. The decrease in area affected by the shallow groundwater problem may be the result of a combination of factors. Imported surface water to this area has been severely restricted during the protracted drought conditions. As a result, groundwater use in the vicinity increased, with the possible effect of lowering perched groundwater levels. This would suggest that more of a hydraulic connection between perched groundwater and the unconfined aquifer may exist than previously interpreted. Additionally, large portions of farmland throughout this area have been taken out of production due to the cutbacks in surface water. Again, the resulting decrease in irrigation could result in a decrease in the conditions which lead to perched water accumulations.

Groundwater Quality

The groundwater basin in the Kern County portion of the San Joaquin Valley has no outflow, except in extremely wet years. Therefore, new salts introduced into the basin with imported water supplies are retained in the basin. The groundwater is the recipient of these salts in the form of recharge waters or return flows from irrigation, municipal and industrial users.

Surface water supplies over the useable groundwater basin in 1991 (some 855,700 acre-feet) carried about 198,800 tons of new salts into the groundwater basin. This volume of salt was about 140,700 tons less than was introduced in 1990, reflecting the reduced surface water availability from the worsening drought. It should be noted that SWP water carries about twice as much salt as local supplies. Following is a table of salt loads by surface water source for 1991:

Source	Volume (AF)	Avg. TDS (ppm)	Salt Load (Tons)
SWP Over G.W. Basin	80,300	350	38,100
Kern River	335,900	112	51,100
Minor Streams	34,600	575	27,000
Other Local Supplies	202,300	150	41,300
CVP	202,600	150	41,300
Total	**855,700**		**198,800**

Groundwater pumped and used for irrigation will become degraded as salts are leached from the crop root zones. A portion (averaging about 25 percent in this basin) of applied water percolates through the soil profile to the groundwater. This smaller volume of water carries most of the salts once held by the total volume applied, resulting in a concentration of the salts. The introduction of local drainage projects would help reduce this build-up of salts by removing some near-surface accumulations in the perched water areas. In areas dependent upon supplemental water supplies, sustained large-scale importation of water and large-scale agriculture will eventually result in the degradation of groundwater supplies, and ultimate loss of irrigable land. This phenomena is likely occurring in the unconfined groundwater aquifers of Kern County by the introduction of additional salts from applied waters and fertilizers. It should be noted that this is a normal by-product of water use, whether for agricultural, municipal or industrial purposes. One of the greatest challenges of water leaders is to relieve the destruction of our precious groundwater by improved water management, including salt management.

Chemical analyses of well water samples collected over the years have been used as a basis for drafting the well water quality maps in this report. Plate 2 illustrates the variations in groundwater quality samples taken from the unconfined water system, as revealed

by the total dissolved solids (TDS) obtained. TDS are shown in parts per million (PPM). These are generally more shallow wells, usually less than 400 feet. Higher salt contents are prevalent in the west side areas and in an area west of Delano.

Plate 3 is a compilation of data from groundwater wells producing from the confined or lower aquifer system. This lower system is partially protected from surface contaminants by the Corcoran Clay. Contours on this map show the overall quality of this supply to be superior to that of the unconfined zone.

In November, 1981 the Kern County Board of Supervisors adopted and agricultural water well ordinance to help deal with the problem of deteriorating groundwater quality conditions. The ordinance, originally administered by the Agency, is aimed at reducing further degradation of the groundwater by setting standards for construction and abandonment of wells to prevent poor quality groundwater from moving into fairly high quality groundwater. The ordinance requires close monitoring of new well construction and abandonment of old wells in order to ensure that degradation of groundwater quality is avoided.

Following adoption of the ordinance in 1981, problems surfaced regarding the implementation of the agricultural well ordinance. A separate municipal well ordinance was administered entirely by the County of Kern Department of Environmental Health. Inconsistencies between the municipal and agricultural well ordinances brought about a re-thinking of the ordinances. A committee was established to study the possibility of a combined municipal and agricultural well ordinance. After much discussion, a combined ordinance was adopted by the Board of Supervisors in April, 1989. The new ordinance spells out the respective duties of KCWA and County Department of Environmental Health, as well as appeal procedures, much more clearly than before. To better address the revised ordinance, KCWA funded a study that focused upon the regional geologic structure of the shallow sediments of the San Joaquin Valley portion of Kern County. This study mapped the structure and areal extent of the regional confining clay layer north of the Kern River. South of the river, the study focused upon the structure of the shallow sediments, but could not directly address the existence of a southern correlation to the regional confining clay. The inability to correlate this clay to the south is due to the broad northeast-to-southwest trending basement high known as the Bakersfield arch, which lies beneath the present Kern River channel. The confining clay to the north terminates on the northern flank of this broad structure. The results of this study have many immediate applications, which include correlation of strata(s) for implementation of the well ordinance, implementation of the wellhead protection program, design of industrial waste injection wells, groundwater modelling, and increased efficiency of conjunctive use programs. The study was subjected to a peer review by numerous groundwater geologists working in the public and private sectors. The direction of future hydrogeologic studies will remain unclear until a comprehensive groundwater management plan for the basin is defined. This plan is presently being formulated by the KCWA. A common technical data base as well as a common methodology for problem solving are requisite for a groundwater management plan to be effective. The development and implementation of this plan will require resolution of differences in institutional perspective of the various local and state governmental entities.

The persistent drought resulted in a continuation of increased water well activity during 1991. A total of 152 well permits were issued by the Kern County Environmental Health Services Department in 1991. Of these permits, 142 were for the construction of agricultural wells. Annular seals were required in 69 of the new wells to prevent degradation of lower groundwater zones. Annular seals are plugs of cement between the well casing and the drilled hole adjacent to a regional stratum of low permeability. Water quality is also a concern during the destruction of existing wells. The permitted destruction of 10 wells required the casing to be parted and a cement seal set at depth to prevent downward migration of groundwater from above. From the time of implementation of the Kern County Water Well Ordinance in 1981 to the end of 1991, a total of 530 agricultural wells have been constructed, 181 of which required annular seals.

Groundwater Levels

Plate 4, Depth to Groundwater, Winter 1992 was prepared by the Agency using hundreds of well measurements taken by the Agency and others on a semi-annual basis. The water depths and elevations are plotted and contoured to aid in the evaluation of groundwater trends. Control wells include unconfined

and a few composite aquifer wells from areas where the two levels are compatible. The Depth to Groundwater map shows the distances in feet from the ground surface to the water surface.

The highest pumping lifts occur on the extreme eastern edge of the valley, areas south and east of the community of Arvin and in the White Wolf basin area. These areas have deeper water levels which are associated with higher surface elevations, being on foothill regions of the valley.

Areas of lesser pumping lifts appear in the west centra valley area, Lost Hills area, west of Delano, Buena Vista Lake area and near the Kern River channel (especially near Bakersfield). Some of the very shallow lifts, less than 50 feet, are probably linked to the shallow perched water problem. However, the shallow area west of Delano is probably related to heavy dependence on surface water, while the Kern River channel shallow area is due to natural and managed recharge efforts in the Kern River channel.

A Groundwater Surface Elevation map (Plate 5) was prepared, based on the same measured wells as the Depth to Groundwater map. This map exhibits movement of groundwater from higher to lower elevations. For simplicity, the directions of flow are assumed to be perpendicular to the contour lines. The contours emphasize the relative highs and lows of groundwater elevation.

The major direction of groundwater movement is away from the sources of recharge. Historically, the Kern River has been the major groundwater recharge source. Mounding of water occurs longitudinally along the Kern River channel, and groundwater is shown as moving away from this area. Other high areas are along the northeastern edge of the valley, and some local mounding is attributed to recharge efforts of local districts.

Groundwater lows are often areas of higher groundwater pumping. The largest of these areas is in the central portion of the valley where the most intensive pumping occurs. Other low areas are in the extreme south end of the valley and in the Edison-Lamont area.

Plate 6 depicts groundwater level changes from the winter of 1991 to the winter of 1992. Computed differences were plotted and contoured to show areas of relative improvement or decline. Color has been added to this map to emphasize significant changes. In an unexpected departure from the previous groundwater level change map representing the drought years, this years map shows areas in which groundwater levels appear to have risen by as much as 20 feet. One explanation for this occurrence may be that in 1991 many agricultural wells were being used at the time of monitoring (January-February) for pre-irrigation, because of extremely low rainfall and anticipated cuts in surface water supplies. These events may have produced significant lowering of the water table much earlier than normal. However, significant rainfall occurred during the time of the winter monitoring in 1992, which may have indicated a greater supply of imported water. Thus, much less demand may have been placed on the unconfined aquifer at that time. As a result, some areas would have shown higher groundwater levels even with the continuing drought. It should be noted that, unless the annual change for a given unconfined well exceeds 10 feet, little impact (either losses or gains) to storage can be deduced. This is due to the degree of error associated with surface elevation and pumping influence.

Plate 7 depicts groundwater level changes from the winter of 1985 to the winter of 1992. This map shows the impact of six years of drought conditions on the groundwater basin. In some areas water levels have dropped 80 to 100 feet. Average water level drop for the basin is probably in the range of 40 to 60 feet. As in the one-year change map (Plate 6), there are some anomalous areas showing rises in groundwater levels. Possible explanations may include agricultural acreage being taken out of production, sampling error, and sporadic groundwater recharge.

Water level changes in six key water wells are displayed on hydrographs as Figures 17a, 17b and 17c. Two wells are located in the Kern National Wildlife Refuge area, two wells are west of Wasco and two are located southwest of Bakersfield. In each case, one well is representative of the unconfined aquifer water levels and one is an example of the confined or semi-confined aquifer water levels. Both hydrographs are plotted on the same graph to observe and compare water level changes in both aquifers. In the Kern National Wildlife area, the unconfined water levels are likely affected by recharge from perched water accumulations. The confined well was showing a continual decline until the sharp rise in 1978, resulting from surface water deliveries to the area. The continuing drought is taking its toll, however. Water

Figure 17a
Water Well Hydrograph
Wildlife Refuge Area

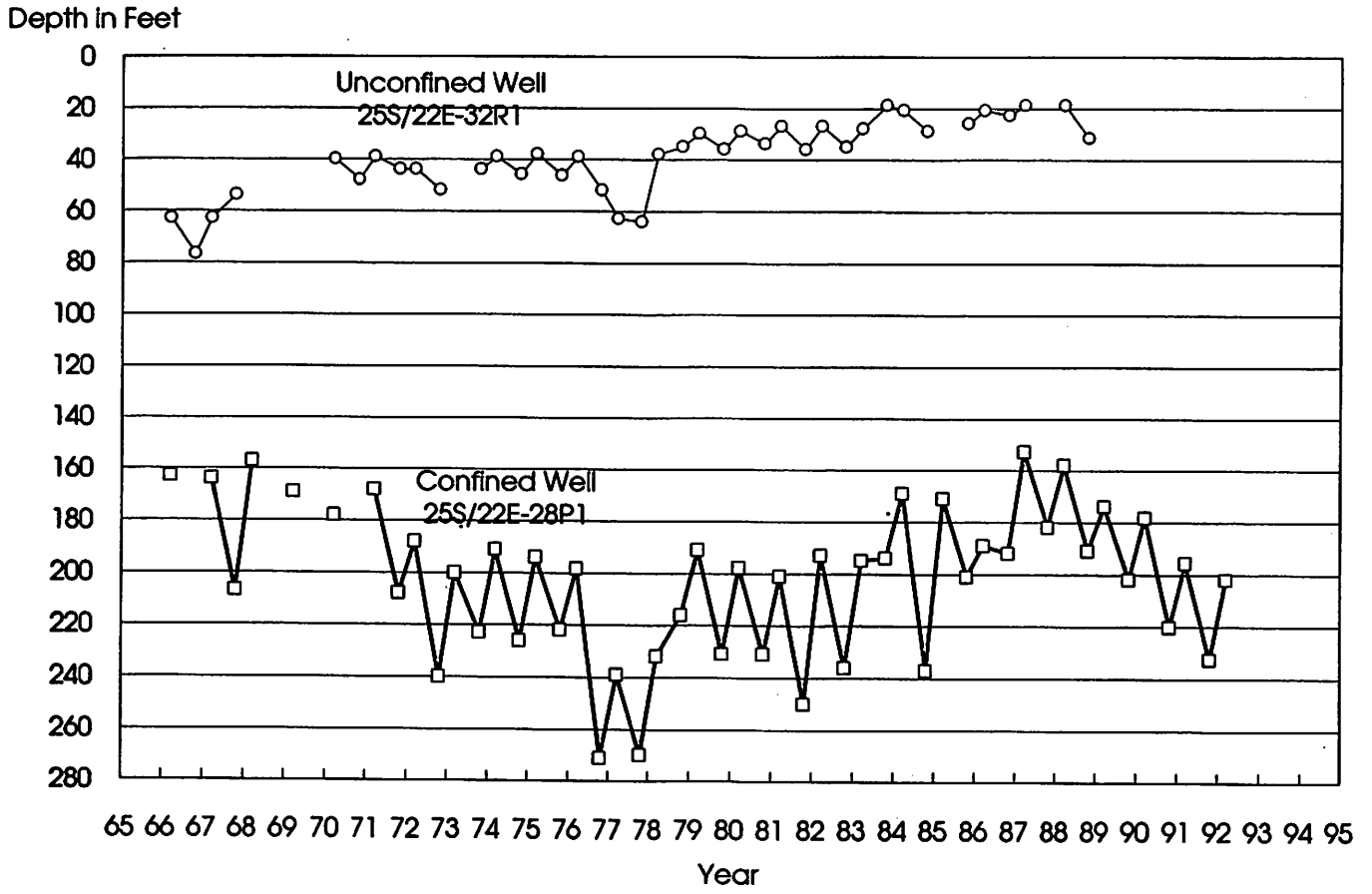


Figure 17b
Water Well Hydrograph
Wasco Area

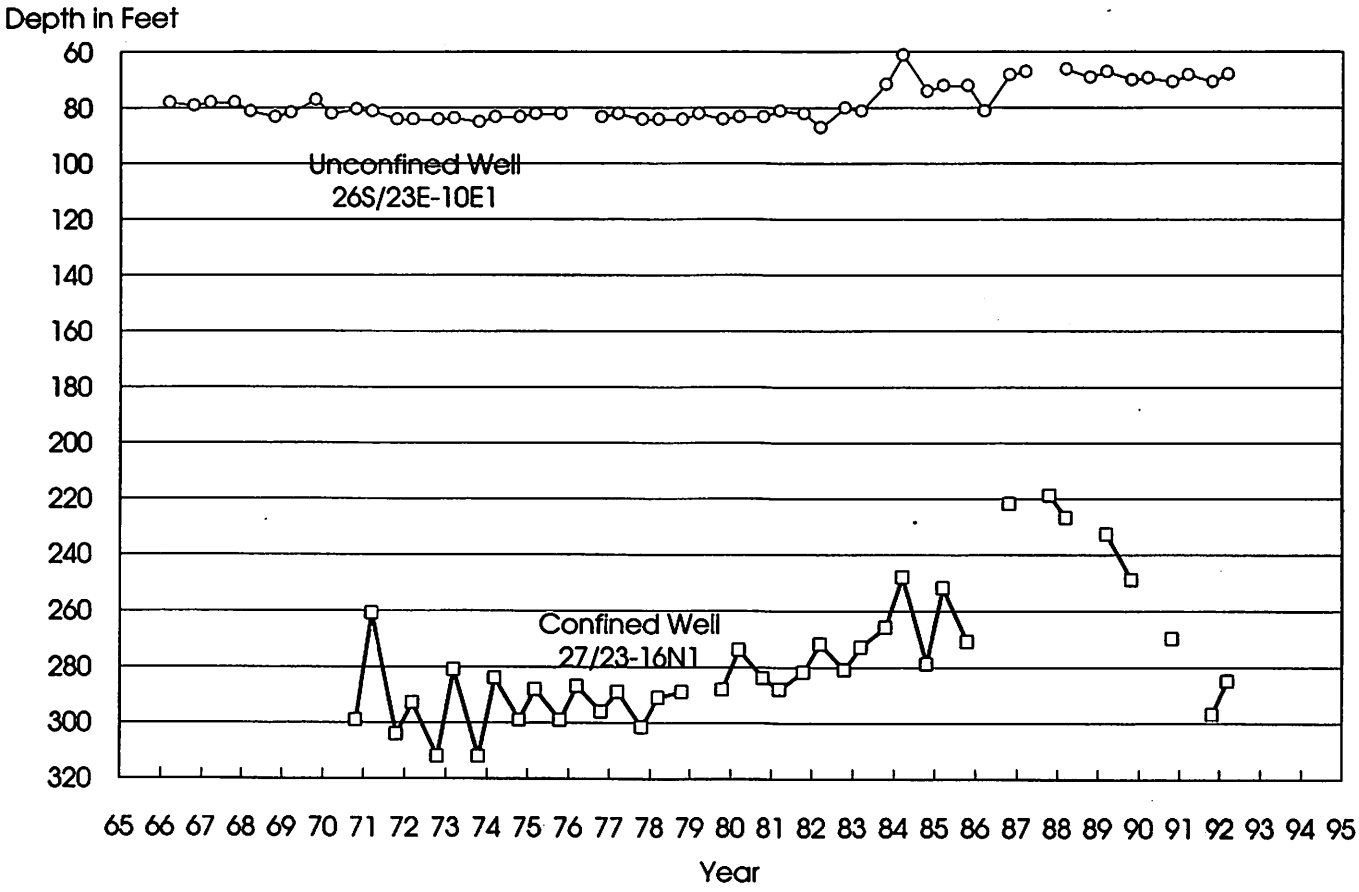
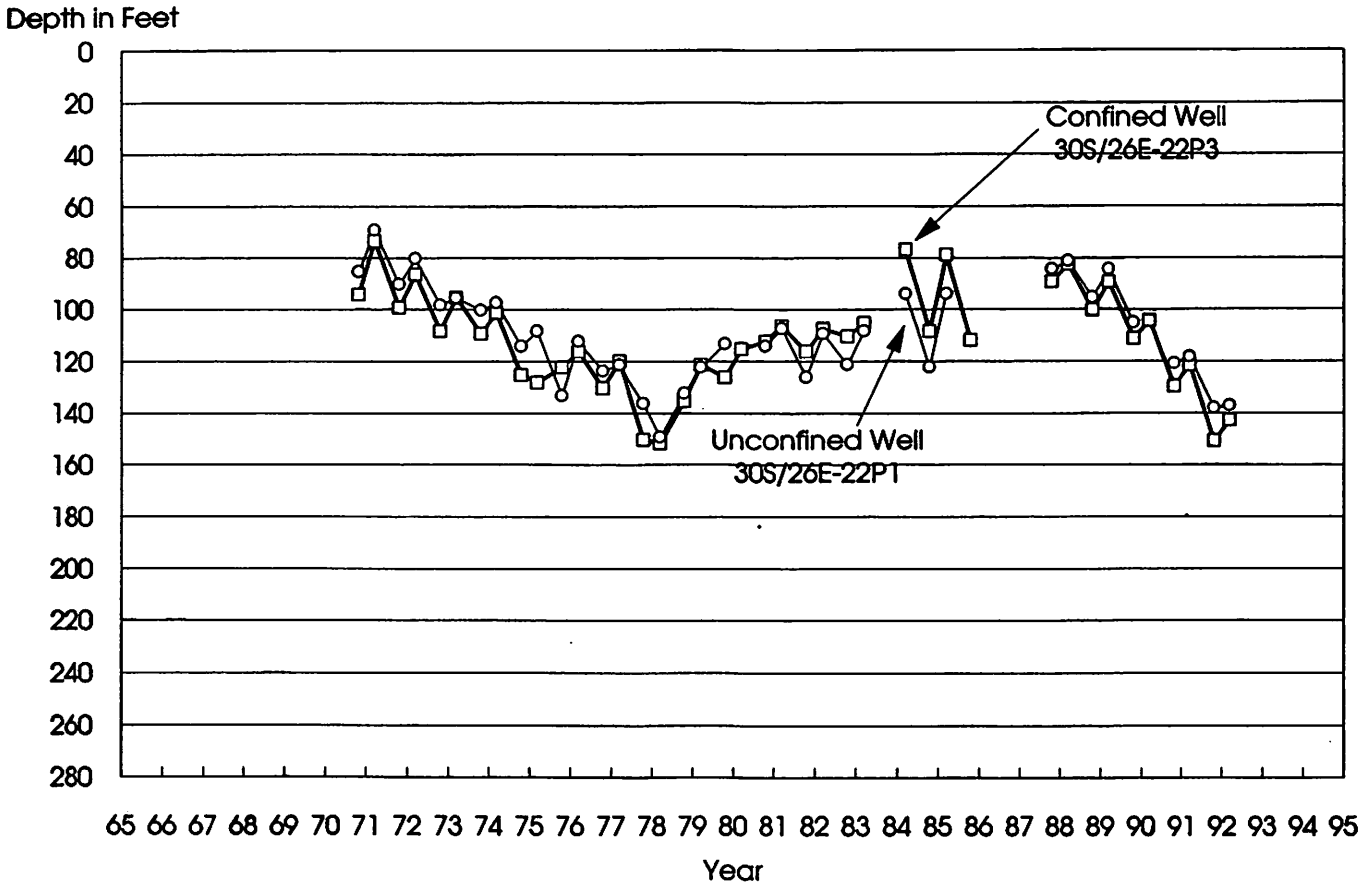


Figure 17c
Water Well Hydrograph
Southwest Bakersfield



levels are showing a downward trend in both the unconfined and confined wells in response to increased pumping since 1987. The Wasco area hydrographs show the unconfined well dropping in early years, but coming up in the early 1980s. Now it appears to be falling off somewhat. While the unconfined well seems to be fairly stable, the confined well is showing a pronounced downward trend. Most of the groundwater pumping in the Wasco area is from the confined aquifer, due to its better quality and transmissivity. The southwest Bakersfield graphs show the continual decline in water levels until 1978. From 1978 to 1986, the wet period is reflected by a rise, and now the persistent drought (and its associated increase in groundwater pumping) has caused a consistent decline in water levels in both the unconfined and semi-confined aquifers.

Economists studying the impacts of the current drought have estimated that the decline in groundwater levels (ranging from 40-60 feet throughout the valley portion of Kern County for 1987-1991) has resulted in increased energy costs of $9.30 per irrigated acre.

Partial records of well drilling activity show 266 new farm wells have been drilled due to the drought since 1990 (87 were permitted by the Kern County Health Department during 1990, 152 during 1991 and 27 were permitted by the end of June, 1992), at a cost of about $32 million. It is clear that the increased costs associated with the continuing drought are extremely large.

Indian Wells Valley

Indian Wells Valley is located in the northeast corner of Kern County. The valley encompasses about 480 square miles, extending about 35 miles in a north-south direction and 25 miles in an east-west direction. The valley is surrounded by the southern Sierra Nevada Mountains on the west, the Coso Range on the north, the Argus Mountains on the east, and the El Paso Mountains on the south. Elevations on the valley floor are around 2,300 feet above sea level, while surrounding mountains may reach 9,000 feet. The largest community in the valley is the city of Ridgecrest, with a population of about 25,400, making it the second largest city in Kern County. Total population in the valley is about 63,000, most of which is centered in the Ridgecrest/China Lake community. The valley is an arid desert, with rainfall of only 3-4 inches per year. Little rainfall reaches the groundwater table; it is rapidly evaporated by the high winds or transpired by desert plants. Presently, the only source of water is groundwater.

In October, 1987 a group of concerned citizens founded the Indian Wells Valley Water Coordinating Committee to address the groundwater management needs of the valley. The committees charge is to ensure that future water supplies are developed in a coordinated manner. The underground geology of the valley is quite complex. The U.S. Geological Survey and others have studied the area in recent years, but consensus has not been reached on the groundwater conditions of the valley. Recognizing this, the committee suggested that an independent review of available hydrologic data be done. A subsequent study funded by the California Department of Water Resources, Indian Wells Valley Water District, East Kern Resource Conservation District and KCWA resulted in a report entitled Hydrologic Conditions in Indian Wells Valley and Vicinity in February, 1989. The USGS has been studying the area for about 10 years, under a cost sharing arrangement with the US Navy, KCWA and local entities.

Recently, KCWA began a groundwater monitoring program in the valley. Measurements from 72 wells were the basis for Plate 8, Depth to Groundwater, Indian Wells Valley and Plate 9, Groundwater Surface Elevations, Indian Wells Valley . Plate 9 shows a large pumping depression extending from Ridgecrest to Inyokern, which is where most of the population is centered. The areal extent of the depression has expanded by about 21,000 acres since 1946. Comparatively, the population of the valley was about 15,000 in 1946, most of which was at China Lake Naval Weapons Center.

In 1990, the U.S. Bureau of Reclamation initiated the Indian Wells Valley Groundwater Project. This project is a cost-sharing program with local entities within Indian Wells Valley. The objective is to better define the groundwater resources in the area. Additionally, the goal is the development of a tool to predict aquifer response to various future pumping scenarios. The ultimate result will be a plan for the long-term optimal utilization of the areas groundwater resources. To date, eight multi-completion monitoring wells have been drilled under the project. The Indian Wells Valley Water District has concurrently drilled three

similar multi-completion monitoring wells that complement the Bureaus wells. The Geothermal Division of the US Naval Weapons Center has made available the 7,200 foot geothermal test well drilled in 1991. Portions of the upper 2,000 feet will be perforated, allowing a clustered piezometer at this site. This well will reasonably replace two Bureau wells previously scheduled to be drilled in this area. Completion of the entire Bureau project is scheduled for late 1992. The monitoring wells are expected to improve the base of information with respect to areal and vertical variations in groundwater chemistry, aquifer characteristics, long-term groundwater recharge and local/regional groundwater flows.

In 1991, KCWA began a weather monitoring program for the Indian Wells Valley. The primary purpose is to collect precipitation and temperature data in the Scodie Mountain watersheds tributary to the Indian Wells Valley to determine if climatic conditions would justify a precipitation enhancement program, similar to the program that the Department of Water Resources presently operates in the Feather River watershed in northern California. Even a modest increase in rainfall and runoff in this arid region could have a significant impact on the water supply for the population. In April, 1991 the Agency installed monitoring equipment at Horse Peak to determine icing conditions. A precipitation gage was installed in Indian Wells Canyon to collect rainfall data. This monitoring program is expected to continue through 1996.

Focus: Delano-Earlimart Irrigation District

The Delano-Earlimart Irrigation District (district) was formed in 1938, and signed its original water service contract with the U.S. Bureau of Reclamation (Bureau) in 1951. The contract calls for water service from the Friant Unit of the Central Valley Project. Mr. H. K. Nelson, who was instrumental in bringing the Friant Division of the CVP to fruition, and signed the districts contract with the Bureau, just retired from the Board of Directors in December, 1989 at the age of 92.

The district includes a total of 56,500 acres situated in southern Tulare County and northern Kern County, along the east side of the San Joaquin Valley. The district serves about 400 landowners with an average farm size of 147 acres. More than one-third of the landowners own less than 40 acres. Virtually all of the land in the district has been developed. About 75 percent is planted in permanent crops, grapes being the most prevalent. Other perennial crops include pistachios, almonds, and a variety of tree fruits. Over 30 different crops are grown in the district.

The irrigation water distribution system is completely piped, with all customer deliveries having water meters. This system allows the district to make water deliveries with virtually no system losses, thus creating an extremely efficient project that is the foundation for the districts overall water conservation and management program. The high operating efficiency has extended to the growers by the introduction of drip irrigation and mister technology. Today, much of the district's acreage utilizes these advanced water application techniques. Table 25 shows irrigated acreage in the Kern County portion of DEID during 1991.

The total gross value of crops grown in the district exceeds $159 million annually, which, by the most conservative estimates, translates into nearly one half billion dollars for the regional economy. The vast majority of this crop value, about $122 million, is produced by the permanent crops, most notably table and wine grapes. Less than five percent of the total crop value comes from crops that are part of any USDA subsidy program.

The district has limited groundwater available, thus growers do not have a reliable alternative water supply other than the districts water service contract. DEID holds the largest Class 1 contract in the Friant Division, totaling 108,800 acre-feet, nearly 14 percent of the total firm yield of the Friant Unit. The district also contracts for 74,500 acre-feet of Class 2 water. In an average water year, DEID would receive about 150,000 acre-feet, which allows an allocation of just under three acre-feet per acre to eligible lands.

In the late 1800s, development of the Delano-Earlimart area began with a water supply originating from numerous artesian wells. However, by the 1930s, groundwater supplies were rapidly diminishing to levels that threatened the area's continued economic viability. By 1947, the mean depth to groundwater was 209 feet. With the introduction of a surface water supply in 1951, groundwater conditions have improved dramatically. Considering that this area once had the largest groundwater overdraft in the San Joaquin Valley, it is quite an accomplishment that by the end of 1986 the average depth to groundwater had risen by 93 feet. However, the past six years of drought have taken their toll, forcing district growers to turn from surface supplies to groundwater. This has resulted in a drop of groundwater levels of 31 feet. Put another way, it took 35 years to raise the level by 93 feet, but only six years of drought to erase a third of the gain. Clearly, the groundwater is a fragile resource.

Table 25
1991 Irrigated Acreage in the Kern County Portion of Delano-Earlimart Irrigation District

Crop		Acres
Annual Crops		
	Alfalfa	626
	Cotton	25
	Dry Beans	15
	Milo	8
	Wheat	17
	Subtotal	691
Permanent Crops		
	Almonds	306
	Apples	110
	Citrus	745
	Grapes	4,94
	Olives	8
	Persimmons	12
	Plums	20
	Quince	6
	Subtotal	6,151
Total		**6,842**

Outlook: 1992

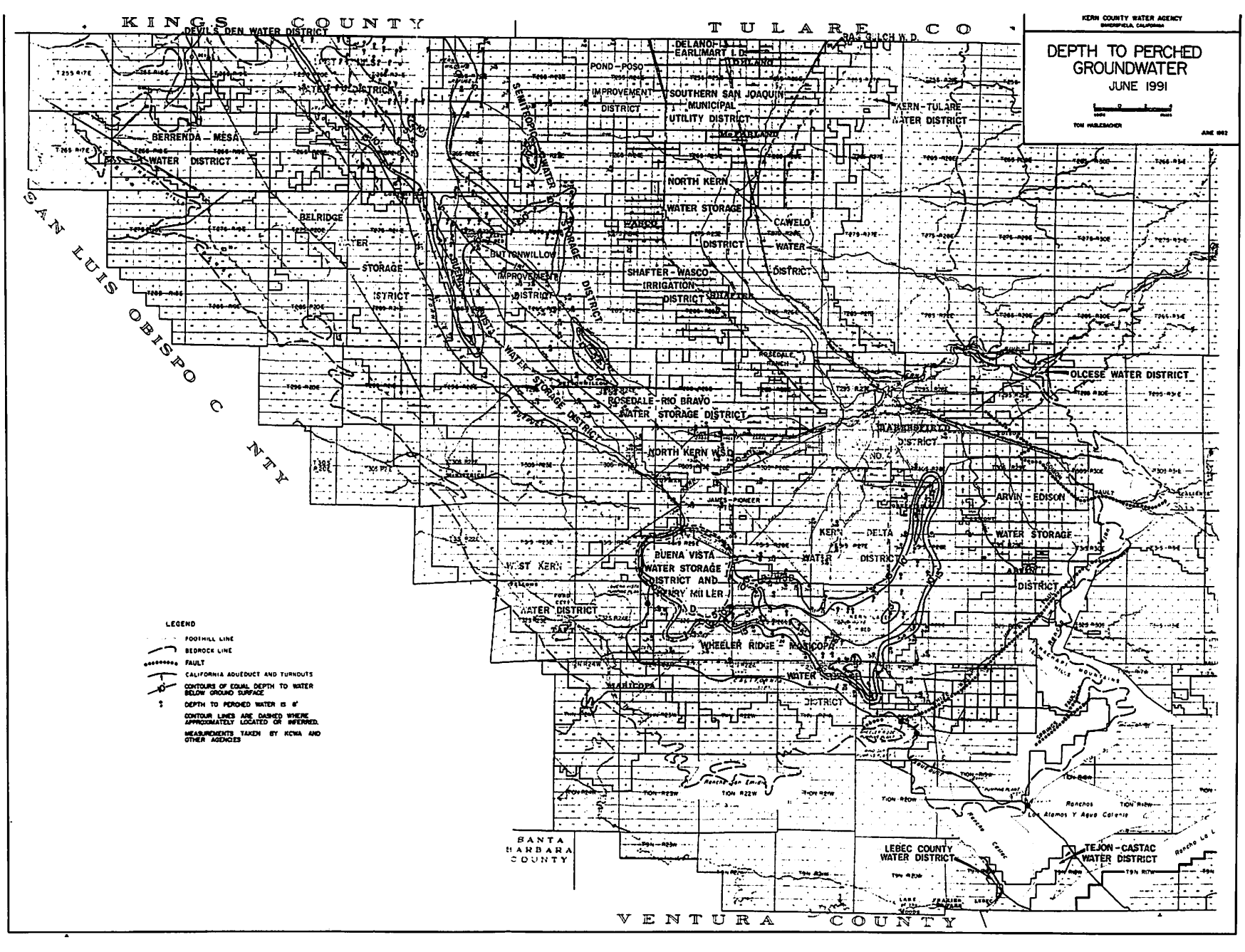
The good news is that the 1991-92 precipitation season was the best since 1986. El Nino, a condition of elevated sea surface temperatures, was in effect. This produced much higher than normal rainfall in the southern half of the state. Although the large storage reservoirs are in northern California, the higher rainfall in the south (primarily the Los Angeles basin) satisfied some of their demand for water. In fact, serious flooding occurred in February, 1992 with property damage and loss of life. Unfortunately, most of the floodwater (about 14,000 acre-feet) flowed out to sea instead of being stored for use. Another factor that is good news for Kern County agriculture is that it now shares allocated SWP water equally with other uses. According to the Agency's master contract with the state Department of Water Resources, if cuts in requested entitlement must be made, agriculture must first be cut up to 50 percent in any given year or 100 percent in any seven year period, before sharing available water equally with other uses. At the end of 1991, agriculture had already accumulated its 100 percent share during the past drought years.

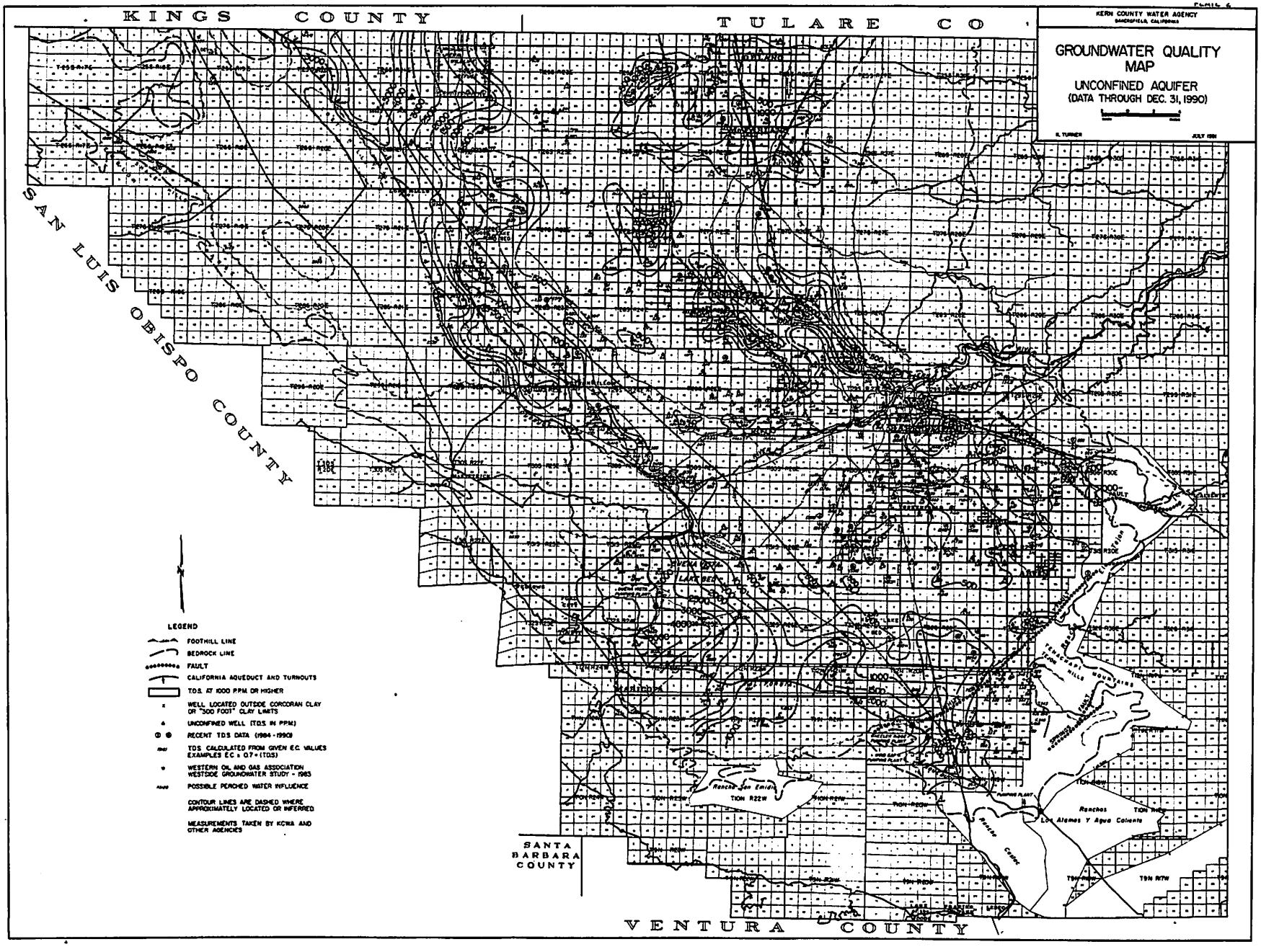
The bad news is that the northern half of the state did not fare so well with precipitation, including the Kern River watershed. Sacramento River tributaries were about 69 percent of normal, and Central Sierra watersheds were about 86 percent of normal. Statewide precipitation averaged 90 percent of normal. Other factors further reduced the effectiveness of the precipitation. In April, export pumping at the Sacramento Delta for storage in San Luis Reservoir was reduced for the protection of Winter-Run Salmon, which have been declared a threatened species. Unofficial estimates of the loss of storage to the water projects as a result of this declaration were about 250,000 acre-feet. Also, the cumulative effect of six years of drought has created a hydrologic deficit in the watersheds. The water which is held in the interstitial spaces in the rocks and alluvium has already drained into the streams over this time. These voids must first be refilled before normal runoff can resume. The result is that, even if precipitation were normal, runoff would be below normal. This is seen by a comparison of the 1992 Sacramento River watersheds rainfall of 69 percent of normal, with a projected runoff of only 49 percent of normal.

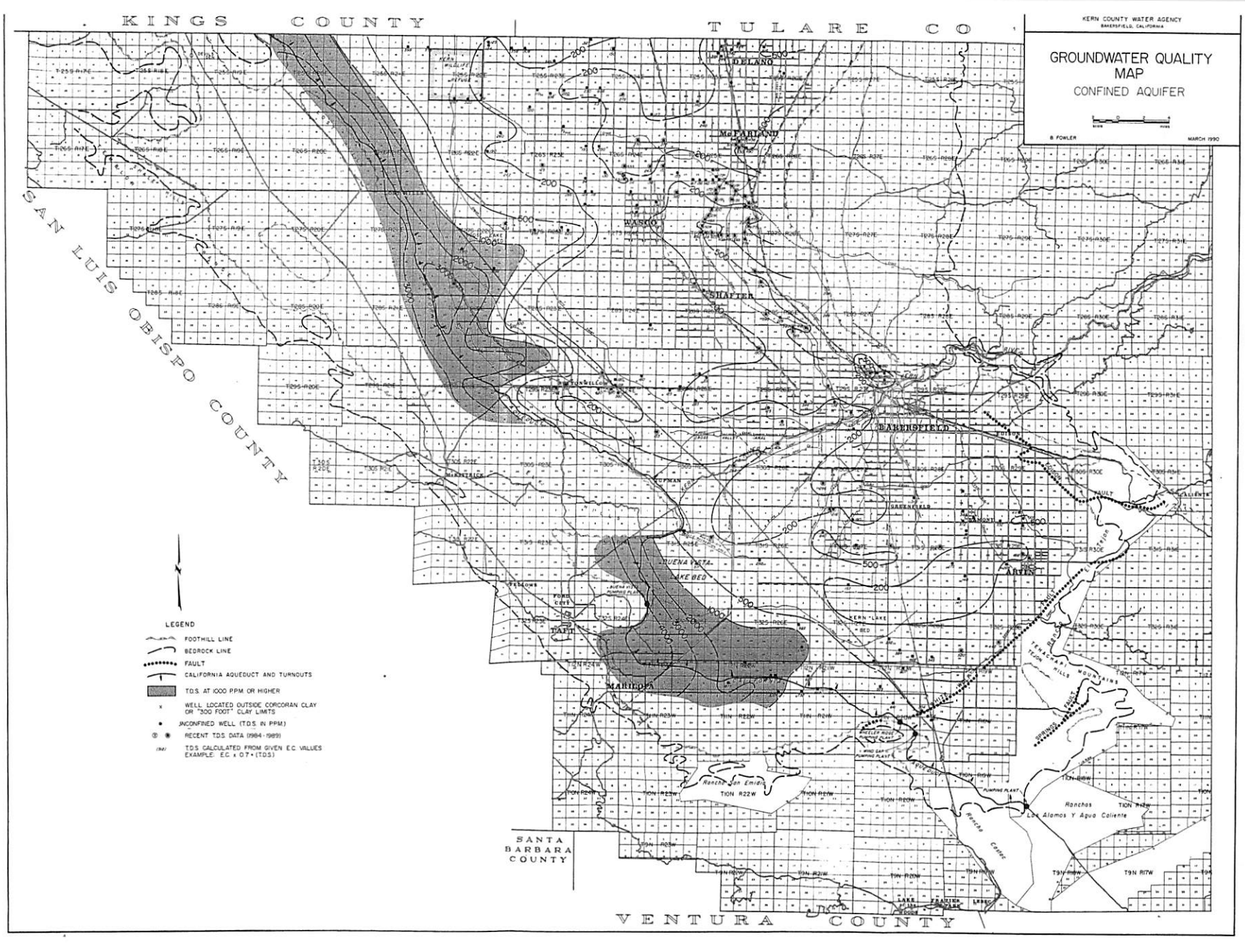
At this writing, the allocation to State Water Contractors is 45 percent of requested 1992 entitlement. The basic allocation to Kern County is 519,030 acre-feet. After allowing for carryover, payback of water to the State and other special programs, the SWP water available from the Delta for 1992 should be about 489,600 acre-feet. While very low, this is considerably better than the 82,600 acre-feet imported in 1991. About 484,000 acre-feet is scheduled for delivery over the San Joaquin Valley groundwater basin in Kern County.

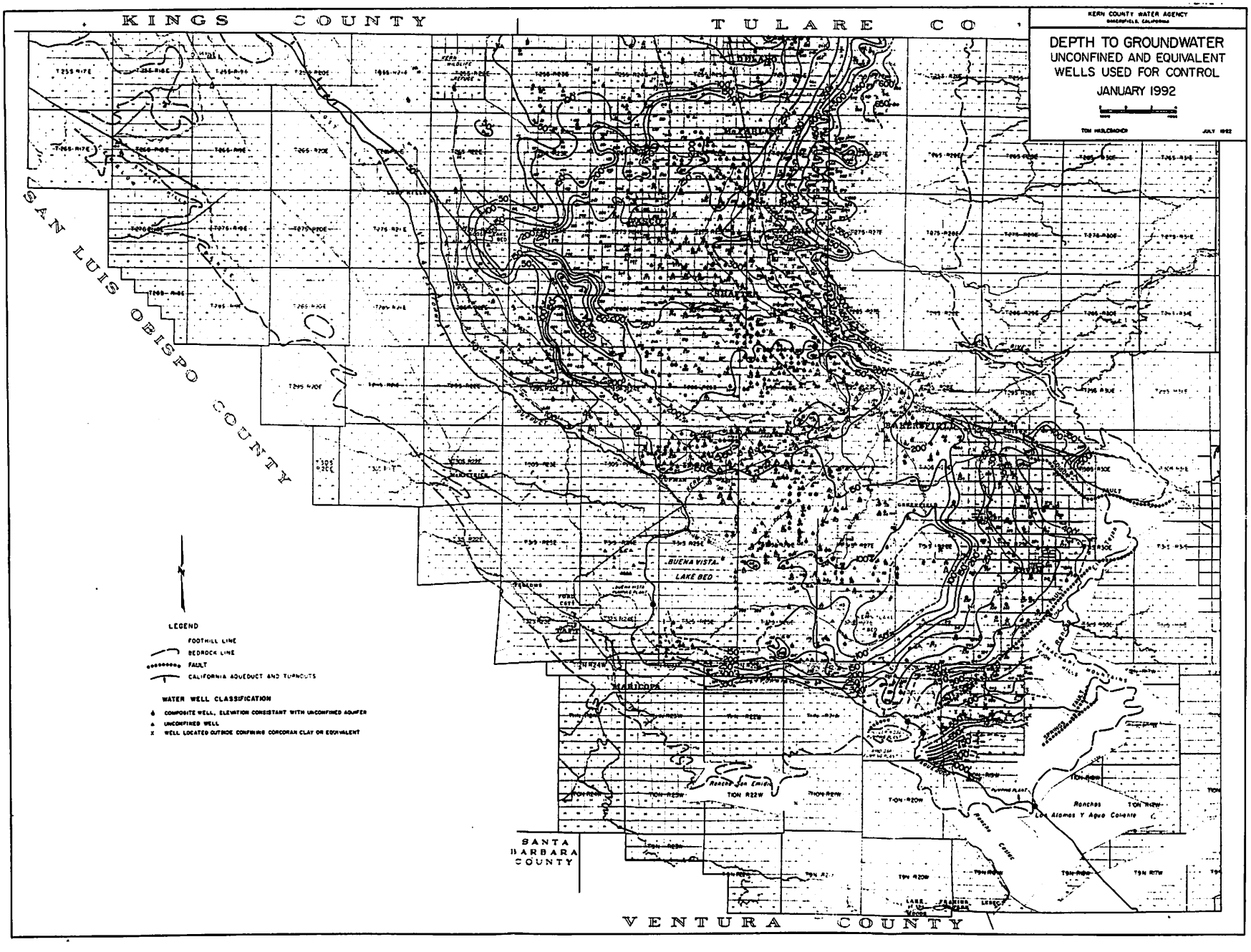
The Kern River was apparently a precipitation hole during the 1992 precipitation season. It is projected to yield only 38 percent of normal, or 270,000 acre-feet for 1992. Kern County CVP contractors allocations are projected to be 190,40 acre-feet, with 30,800 acre-feet from the Delta (25 percent of normal) and 152,700 acre-feet from the Friant Unit (82 percent of normal). Minor streams are expected to be somewhat more than in 1991, perhaps 36,000 acre-feet. Effective precipitation is expected to be slightly less than in 1991, due to lower spring rainfall, or about 160,000 acre-feet. Accordingly, total surface supplies in 1992 are expected to be about 1,772,000 acre-feet.

Total water demands during 1992 are projected to be about 2,940,000 acre-feet, slightly higher than in 1991. The availability of SWP water for west side agriculture should stimulate the planting of slightly more acreage than in 1991, thus irrigated acreage is projected to be about 790,000 acres. Consumption or losses for all types of uses are estimated to be about 2,392,000 acre-feet. Thus, KCWA projects that a net decrease in groundwater storage of about 1,200,000 acre-feet will occur in 1992. This would mark the sixth-straight year of groundwater storage decrease.


KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
DEPTH TO PERCHED GROUNDWATER
JUNE 1991
TOM HASLEBACHER
JUNE 1992
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO C NTY
SANTA BARBARA COUNTY
VENTURA COUNTY
DEVILS DEN WATER DISTRICT
BERRENDA MESA WATER DISTRICT
BELRIDGE WATER STORAGE DISTRICT
BUTTONWILLOW IMPROVEMENT DISTRICT
SEMITROPIC WATER STORAGE DISTRICT
POND-POSO IMPROVEMENT DISTRICT
DELANO-EARLIMART I.D.
SOUTHERN SAN JOAQUIN MUNICIPAL UTILITY DISTRICT
KERN-TULARE WATER DISTRICT
NORTH KERN WATER STORAGE DISTRICT
CAWELO WATER DISTRICT
SHAFTER-WASCO IRRIGATION DISTRICT
ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
OLCESE WATER DISTRICT
WASHINGTON DISTRICT
NORTH KERN W.S.D. NO. 2
ARVIN-EDISON WATER STORAGE DISTRICT
KERN DELTA WATER DISTRICT
BUENA VISTA WATER STORAGE DISTRICT AND HENRY MILLER W.D.
WEST KERN WATER DISTRICT
WHEELER RIDGE MARICOPA WATER STORAGE DISTRICT
LEBEC COUNTY WATER DISTRICT
TEJON-CASTAC WATER DISTRICT
LEGEND
FOOTHILL LINE
BEDROCK LINE
FAULT
CALIFORNIA AQUEDUCT AND TURNOUTS
CONTOURS OF EQUAL DEPTH TO WATER BELOW GROUND SURFACE
DEPTH TO PERCHED WATER IS 6'
CONTOUR LINES ARE DASHED WHERE APPROXIMATELY LOCATED OR INFERRED.
MEASUREMENTS TAKEN BY KCWA AND OTHER AGENCIES


KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
GROUNDWATER QUALITY MAP
UNCONFINED AQUIFER
(DATA THROUGH DEC. 31, 1990)
K. TURNER
JULY 1991
KINGS COUNTY
TULARE CO.
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
LEGEND
FOOTHILL LINE
BEDROCK LINE
FAULT
CALIFORNIA AQUEDUCT AND TURNOUTS
T.D.S. AT 1000 PPM OR HIGHER
WELL LOCATED OUTSIDE CORCORAN CLAY OR "500 FOOT" CLAY LIMITS
UNCONFINED WELL (T.D.S. IN PPM)
RECENT T.D.S. DATA (1984 - 1990)
T.D.S. CALCULATED FROM GIVEN E.C. VALUES EXAMPLES EC x 0.7 = (T.D.S.)
WESTERN OIL AND GAS ASSOCIATION WESTSIDE GROUNDWATER STUDY - 1985
POSSIBLE PERCHED WATER INFLUENCE
CONTOUR LINES ARE DASHED WHERE APPROXIMATELY LOCATED OR INFERRED
MEASUREMENTS TAKEN BY KCWA AND OTHER AGENCIES
Maricopa
Ranchos San Emidio
T10N R22W
Los Alamos Y Agua Colonia
T9N R17W


KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
GROUNDWATER QUALITY MAP
CONFINED AQUIFER
B. FOWLER
MARCH 1990
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
DELANO
MCFARLAND
WASCO
SHAFTER
BAKERSFIELD
TAFT
MARICOPA
ARVIN
LAMONT
BUENA VISTA LAKE BED
KERN LAKE BED
Ranchos Los Alamos Y Agua Caliente
LEGEND
FOOTHILL LINE
BEDROCK LINE
FAULT
CALIFORNIA AQUEDUCT AND TURNOUTS
T.D.S. AT 1000 P.P.M. OR HIGHER
WELL LOCATED OUTSIDE CORCORAN CLAY OR "300 FOOT" CLAY LIMITS
UNCONFINED WELL (T.D.S. IN P.P.M.)
RECENT T.D.S. DATA (1984-1989)
T.D.S. CALCULATED FROM GIVEN E.C. VALUES EXAMPLE: E.C. x 0.7 = (T.D.S.)


KERN COUNTY WATER AGENCY
DEPTH TO GROUNDWATER
UNCONFINED AND EQUIVALENT
WELLS USED FOR CONTROL
JANUARY 1992
TOM HAUSMANN
JULY 1992
KINGS COUNTY
TULARE CO.
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
MAXWELL
CHEVRON
BAKERSFIELD
BUENA VISTA
LAKE BED
MARICOPA
Rancho San Emigdio
Rancho Los Alamos Y Agua Caliente
LEGEND
FOOTHILL LINE
BEDROCK LINE
FAULT
CALIFORNIA AQUEDUCT AND TURNOUTS
WATER WELL CLASSIFICATION
COMPOSITE WELL, ELEVATION CONSISTANT WITH UNCONFINED AQUIFER
UNCONFINED WELL
WELL LOCATED OUTSIDE CONFINING CORCORAN CLAY OR EQUIVALENT

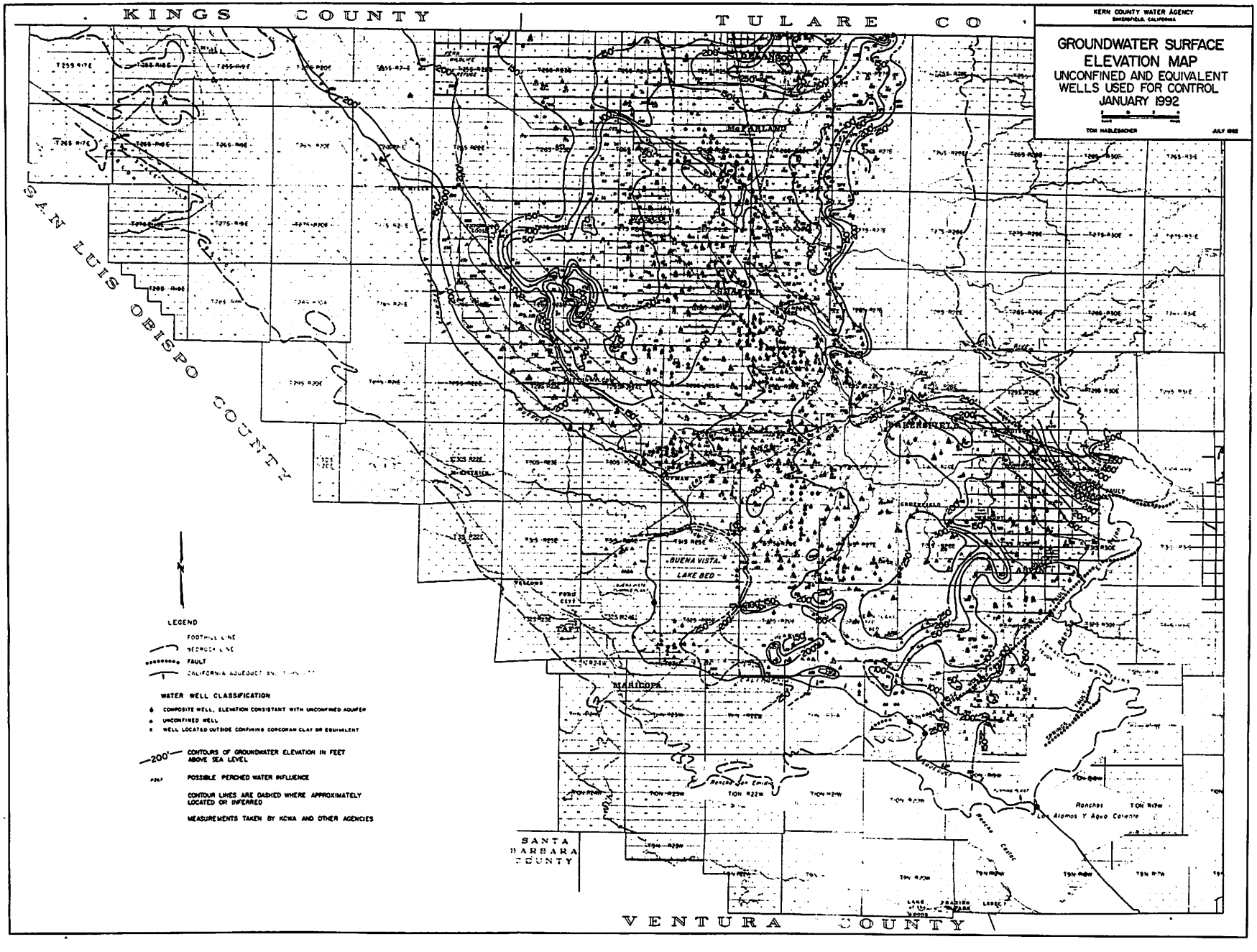

KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
GROUNDWATER SURFACE ELEVATION MAP
UNCONFINED AND EQUIVALENT WELLS USED FOR CONTROL
JANUARY 1992
TOM HABLEBACHER
JULY 1992
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
MAXWELL
BUENA VISTA LAKE BED
TAFT
MARICOPA
LEGEND
FOOTHILL LINE
BEDROCK LINE
FAULT
CALIFORNIA AQUEDUCT
WATER WELL CLASSIFICATION
COMPOSITE WELL, ELEVATION CONSISTANT WITH UNCONFINED AQUIFER
UNCONFINED WELL
WELL LOCATED OUTSIDE CONFINING CORCORAN CLAY OR EQUIVALENT
200' CONTOURS OF GROUNDWATER ELEVATION IN FEET ABOVE SEA LEVEL
PERCHED? POSSIBLE PERCHED WATER INFLUENCE
CONTOUR LINES ARE DASHED WHERE APPROXIMATELY LOCATED OR INFERRED
MEASUREMENTS TAKEN BY KCWA AND OTHER AGENCIES

PLATE 6

KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA

GROUNDWATER LEVEL CHANGES

JAN 1991 TO JAN 1992

UNCONFINED AND EQUIVALENT WELLS

T. HASLEBACHER — JUNE 1992

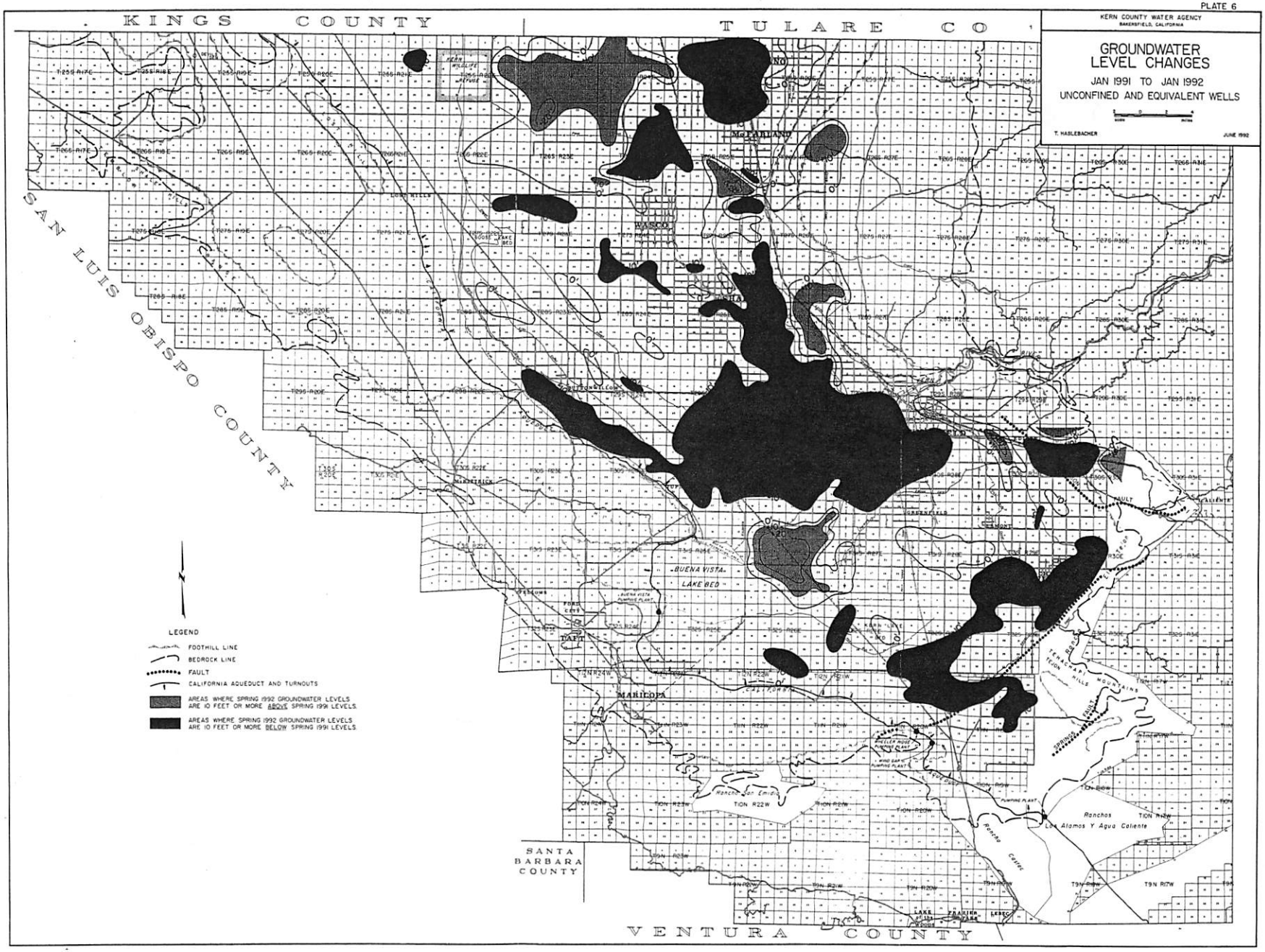


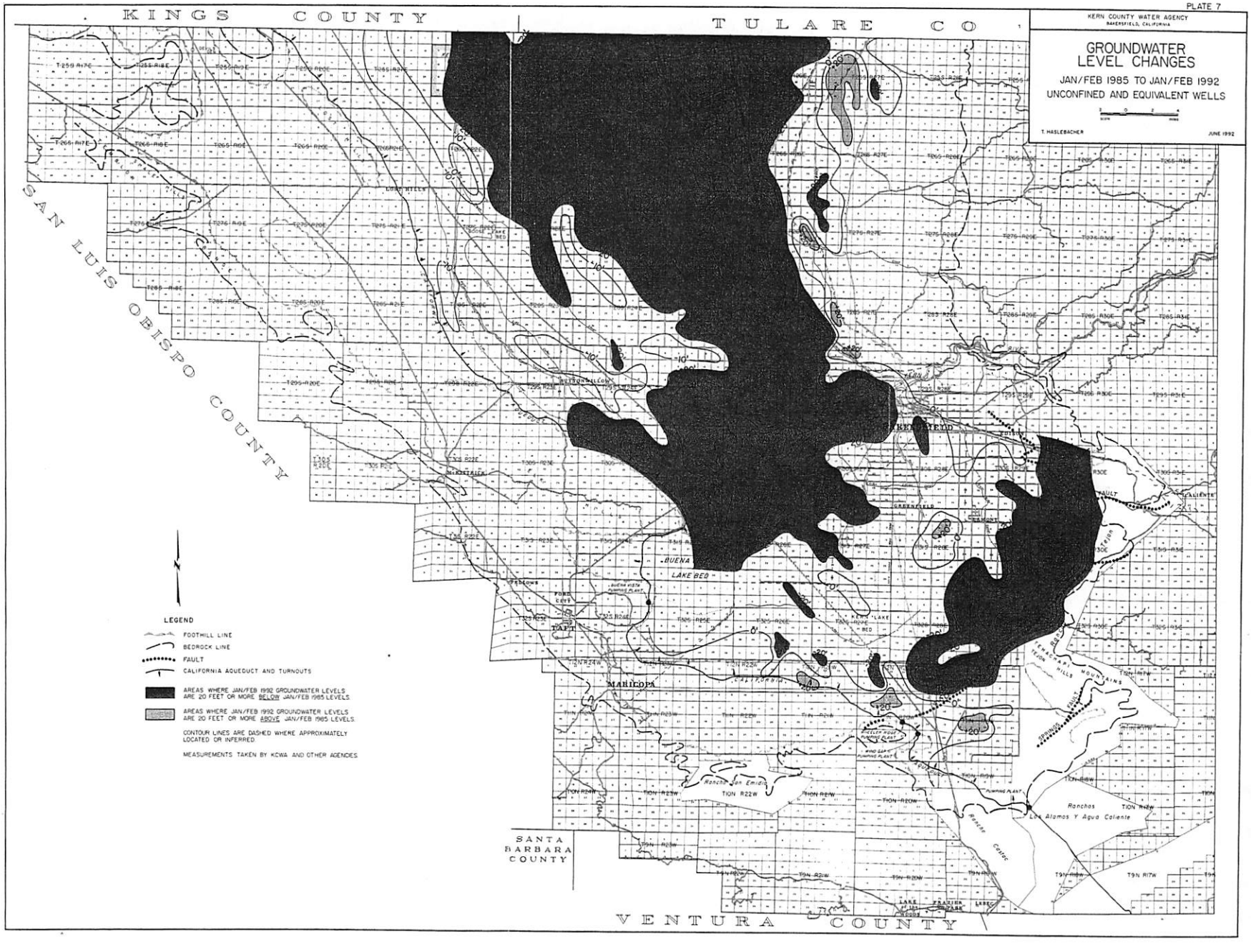
PLATE 7

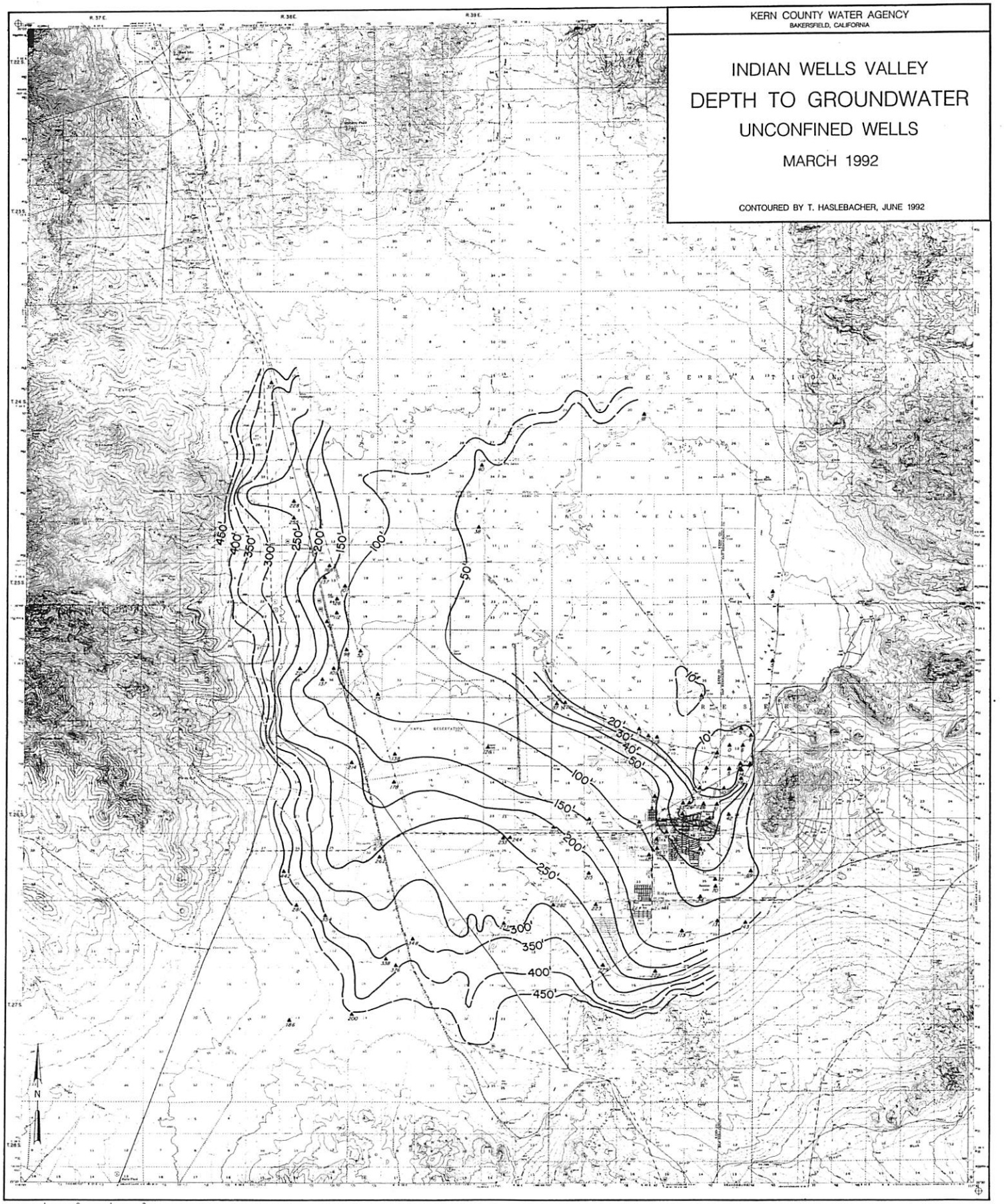
KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA

GROUNDWATER LEVEL CHANGES

JAN/FEB 1985 TO JAN/FEB 1992
UNCONFINED AND EQUIVALENT WELLS

T. HASLEBACHER — JUNE 1992

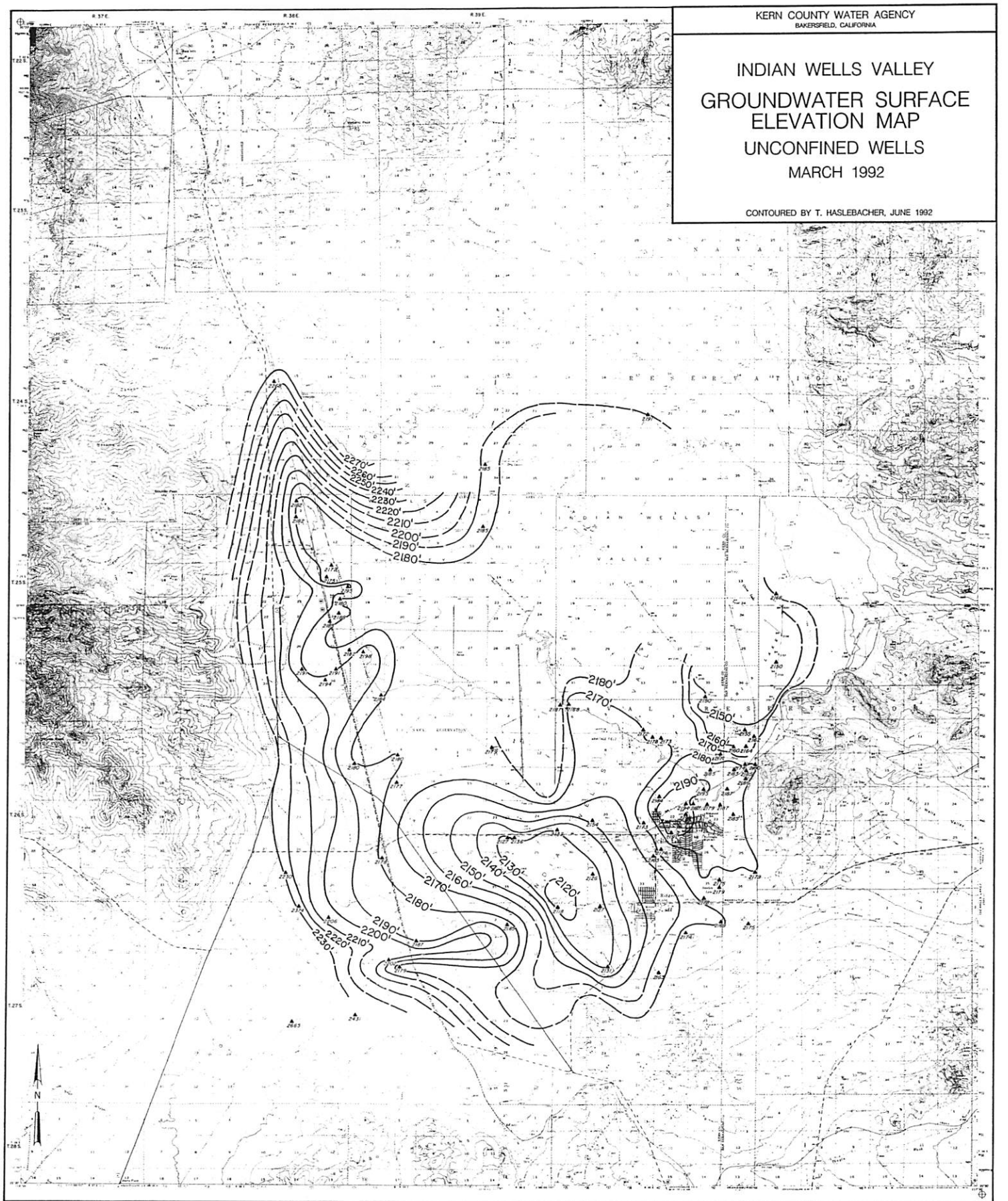



KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
INDIAN WELLS VALLEY
DEPTH TO GROUNDWATER
UNCONFINED WELLS
MARCH 1992
CONTOURED BY T. HASLEBACHER, JUNE 1992
R.37E.
R.38E.
R.39E.
T.25S.
T.26S.
T.27S.
NAVAL
RESERVATION
INDIAN WELLS
VALLEY
10'
20'
30'
40'
50'
100'
150'
200'
250'
300'
350'
400'
450'
N
CONTOURS OF DEPTH TO GROUNDWATER IN FEET BELOW GROUND SURFACE

KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA

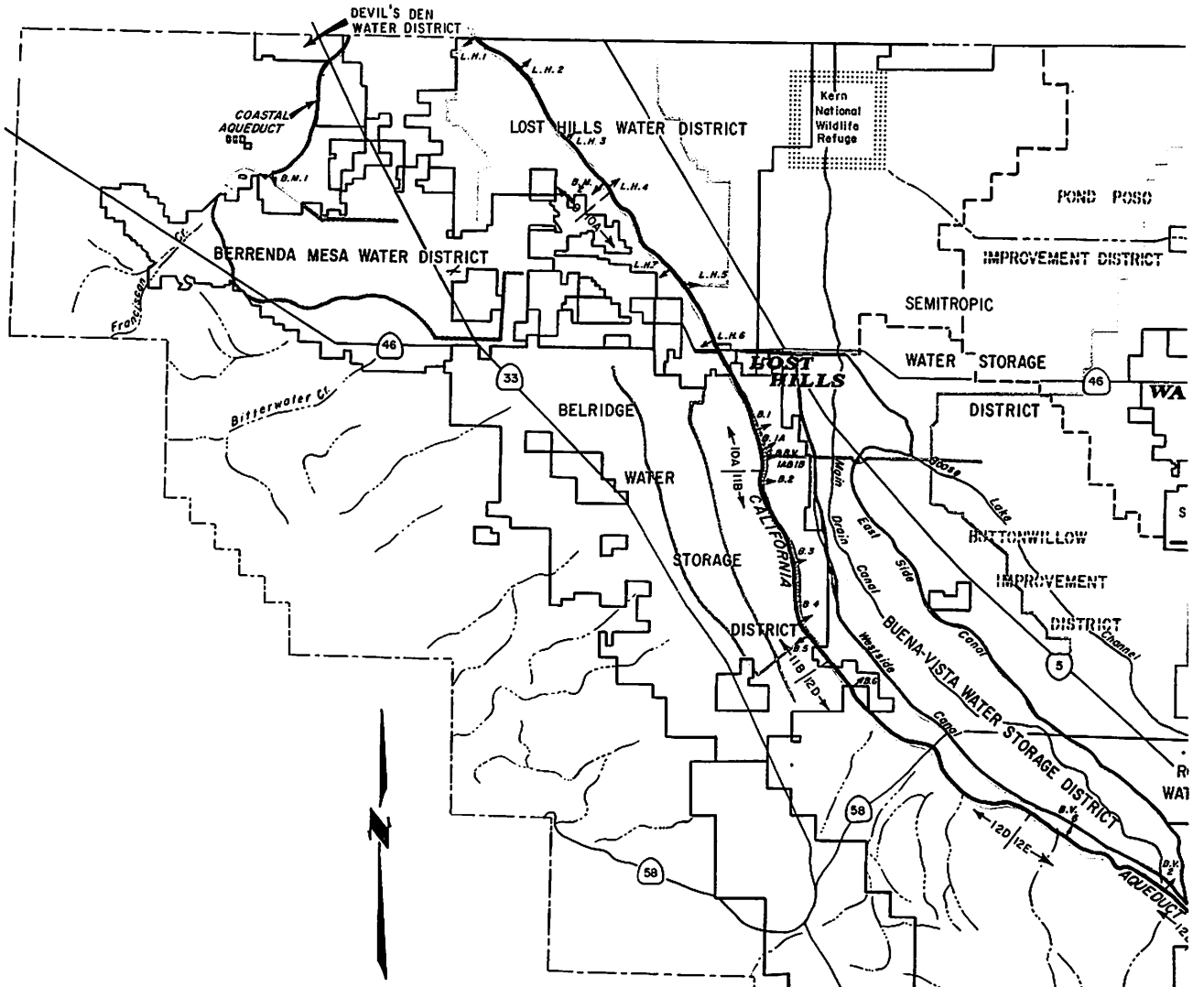
INDIAN WELLS VALLEY
GROUNDWATER SURFACE ELEVATION MAP
UNCONFINED WELLS
MARCH 1992

CONTOURED BY T. HASLEBACHER, JUNE 1992



scale 0 1 2 miles

CONTOURS OF GROUNDWATER ELEVATION IN FEET ABOVE SEA LEVEL



KERN COUNTY WATER AGENCY

WATER DISTRICT MAP

SHOWING

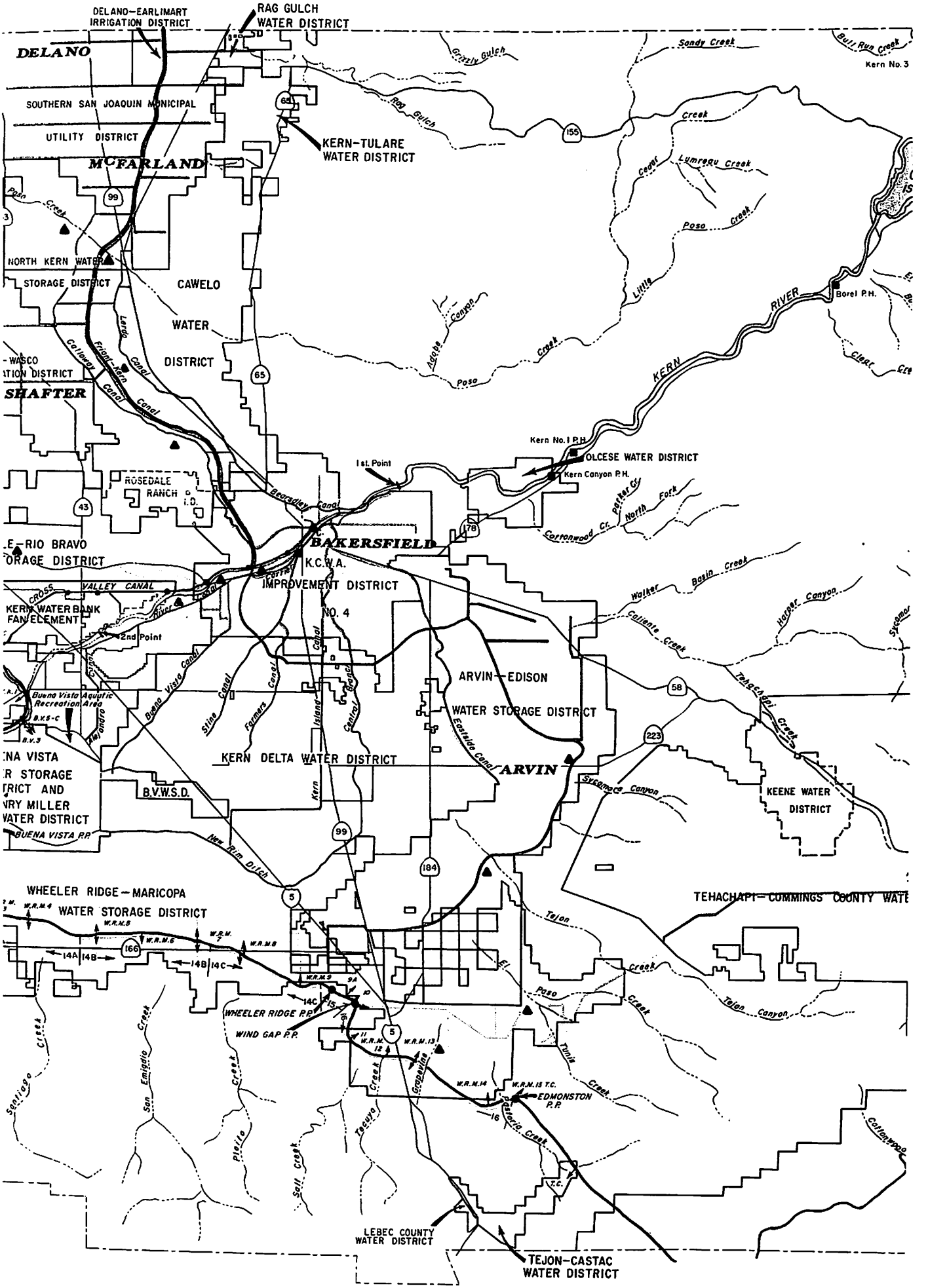
MAJOR SURFACE WATER SUPPLIES AND INTERMEDIATE TRANSMISSION FACILITIES

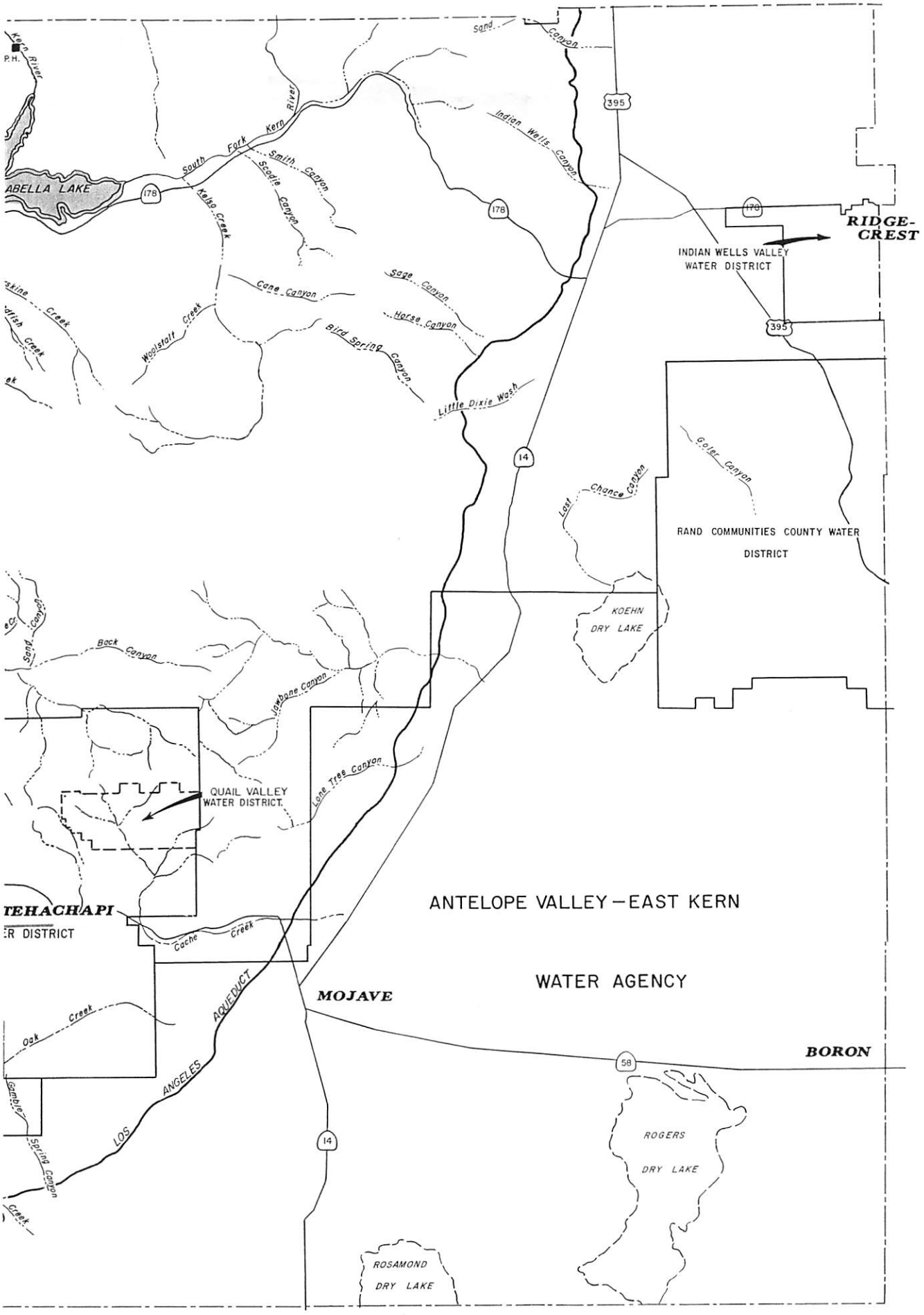
LEGEND

- KCWA MEMBER UNIT BOUNDARIES
- NON-MEMBER UNIT BOUNDARIES
- CENTRAL VALLEY PROJECT — FRIANT KERN CANAL
- KERN RIVER
- STATE WATER PROJECT
- ▲ ESTABLISHED GROUNDWATER REPLENISHMENT SITES

4 0 4 8 12 MILES
SCALE

MAP PREPARED BY KERN COUNTY WATER AGENCY JULY 1977
Revised October 1991


DELANO–EARLIMART IRRIGATION DISTRICT
RAG GULCH WATER DISTRICT
DELANO
SOUTHERN SAN JOAQUIN MUNICIPAL UTILITY DISTRICT
KERN–TULARE WATER DISTRICT
McFARLAND
NORTH KERN WATER STORAGE DISTRICT
CAWELO WATER DISTRICT
SHAFTER
WASCO IRRIGATION DISTRICT
ROSEDALE RANCH I.D.
E-RIO BRAVO ORAGE DISTRICT
BAKERSFIELD
K.C.W.A. IMPROVEMENT DISTRICT NO. 4
KERN WATER BANK FAN ELEMENT
CROSS VALLEY CANAL
Buena Vista Aquatic Recreation Area
NA VISTA R STORAGE TRICT AND RY MILLER VATER DISTRICT
BUENA VISTA P.P.
B.V.W.S.D.
KERN DELTA WATER DISTRICT
ARVIN–EDISON WATER STORAGE DISTRICT
ARVIN
OLCESE WATER DISTRICT
Kern No. 1 P.H.
Kern Canyon P.H.
Borel P.H.
KERN RIVER
1st Point
2nd Point
Beardsley Canal
Friant-Kern Canal
Cottonwood Cr.
Panther Cr.
North Fork
Walker Basin Creek
Caliente Creek
Tehachapi Creek
Sycamore Canyon
KEENE WATER DISTRICT
TEHACHAPI–CUMMINGS COUNTY WATER
WHEELER RIDGE–MARICOPA WATER STORAGE DISTRICT
WHEELER RIDGE P.P.
WIND GAP P.P.
EDMONSTON P.P.
LEBEC COUNTY WATER DISTRICT
TEJON–CASTAC WATER DISTRICT
New Rim Ditch
Grapevine Creek
Tejon Creek
Tejon Canyon
Tunis Creek
Oso Creek
Caliente Creek
Bull Run Creek
Kern No. 3
Sandy Creek
Grizzly Gulch
Rag Gulch
Cedar Creek
Lumreau Creek
Poso Creek
Little Poso Creek
Agate Canyon
Pasa Creek
Lerdo Canal
Calloway Canal
Shine Canal
Farmers Canal
Island Canal
Central Canal
Eastside Canal
Kern Island Canal
Buena Vista Canal
Alejandro Canal
Santiago Creek
San Emigdio Creek
Pleito Creek
Salt Creek
Tecuya Creek
Caliente Creek
Cottonwood
99
65
43
178
58
223
184
166
5


Kern River
P.H.
ABELLA LAKE
South Fork Kern River
Smith Canyon
Scodie Canyon
Kelso Creek
Cane Canyon
Woolstalt Creek
Bird Spring Canyon
Sage Canyon
Horse Canyon
Little Dixie Wash
Indian Wells Canyon
Sand Canyon
178
395
14
58
INDIAN WELLS VALLEY WATER DISTRICT
RIDGE-CREST
RAND COMMUNITIES COUNTY WATER DISTRICT
Goler Canyon
Last Chance Canyon
KOEHN DRY LAKE
Back Canyon
Jawbone Canyon
Lone Tree Canyon
QUAIL VALLEY WATER DISTRICT
TEHACHAPI
ER DISTRICT
Cache Creek
Oak Creek
Gamble
Spring Canyon
LOS ANGELES AQUEDUCT
ANTELOPE VALLEY – EAST KERN
WATER AGENCY
MOJAVE
BORON
ROGERS DRY LAKE
ROSAMOND DRY LAKE