IV - WATERSHED CHARACTERISTICS

4-01 General Characteristics

Carbon Canyon Dam is located near the northern edge of Orange County, 4 miles east of the city of Brea, and approximately 12 miles north of the city of Santa Ana on Carbon Canyon Creek, a tributary of Coyote Creek. The drainage area above the dam is 19.3 square miles. The Puente and Chino Hills form the northern and eastern drainage divide of the watershed. The drainage divide on the west is formed by the ridge between the Tonner Canyon and Carbon Canyon watersheds. On the south, the drainage divide is formed by the ridge between Telegraph Canyon watershed and that of the Santa Ana River watershed. Carbon Canyon Creek flows generally southwest from the drainage divide for about 7.4 miles to the dam site, leaves the canyon mouth (becoming Carbon Canyon Channel), then flows south about 3.5 miles to Miller Basin, a flood retarding complex. At Miller Basin, the channel system divides into two channels: Carbon Canyon Diversion Channel, which flows south to the Santa Ana River; and Carbon Creek Channel, which flows west into Coyote Creek and on to the San Gabriel River. The average gradient of Carbon Canyon Creek is about 117 feet per mile above the dam site. The average gradient of Carbon Canyon and Carbon Creek Channels is about 55 feet per mile from the dam to the juncture with Coyote Creek. Telegraph Canyon Creek, the major tributary in the watershed above Carbon Canyon Dam, joins Carbon Canyon Creek within Carbon Canyon Reservoir.

4-02 Topography

Approximately 98% of the drainage area above Carbon Canyon Dam consists of steep, rugged terrain, dissected by deep, narrow ravines containing numerous watercourses tributary to Carbon Canyon and Telegraph Canyon Creeks. The remainder of the watershed consists of a relatively small valley fill area. Elevations in the mountains vary from 1781 feet at San Juan Hill (the highest point in the watershed) to about 403 feet at the dam site.

4-03 Geology and Soils

Carbon Canyon is located on the southwest side of the northwest-southeast trending Puente and Chino Hills, a structural block that has been uplifted as a wedge between the Whittier and Chino faults. The Puente and Chino Hills are composed of soft Tertiary sediments consisting of interbedded sandstones and siltstones with occasional beds of conglomerate. These rocks are covered by recently deposited alluvium in the stream channels and by patches of early Quaternary alluvium on lower elevation terraces. The tertiary bedrock has been folded and faulted into large anticlines and synclines by regional compression forces.

Carbon Canyon was formed by erosion of the uplifted relatively soft rocks of the Puente and Chino Hills. Downcutting of the canyon reached its maximum during the Pleistocene glaciation (approximately 10-20,000 years BP). Since then, the canyon has generally undergone a period of aggradation and contains approximately 100 feet of alluvium over the deepest sections of the canyon. The canyon floor at the dam is about 1000 feet wide and relatively flat except for a narrow wash which contains Carbon Canyon Creek. The slopes forming the canyon walls are moderate to steep. Immediately downstream of the dam, the canyon ends and the creek flows across the relatively flat alluvial fan surface of the coastal plain.

Soils in the mountains tend to be shallow, stony, and poorly-developed. Soil depths range from ten or more feet deep at the bases of steep slopes to a few inches near ridge crests. Soils tend to erode easily under raindrop impact, particularly when the watershed has suffered recently from the effects of wildfire.

4-04 Sediment

Sediment production within the Carbon Canyon watershed varies considerably, depending primarily on the terrain. In the lower sloped valley fill areas, sediment production is at a minimum. However, these areas comprise a very small part of the total drainage area above the dam and have historically served as storage sites for sediment transported by overbank flows during flood events. In the steep mountainous segment of the watershed sediment production can be quite high, particularly following periods in which wildfire impacts the watershed, and also following periods of high-intensity rainfall.

Reservoir surveys performed in March 1961 and September 1969 indicate a change in storage capacity at spillway crest from 7033 to 6615 ac-ft due to sediment inflow. This indicates a sediment yield for the watershed above Carbon Canyon Dam of 418 ac-ft for an 8.5 year period, or an average annual sediment yield of 2.54 ac-ft per square mile per year. This figure is generally consistent with that measured at reservoirs elsewhere in the area, but is somewhat higher than the 50-year sediment yield of 1.55 ac-ft per square mile per year originally allocated (1500 ac-ft over the 50 year economic life of the dam). The loss in storage capacity due to sediment deposition within Carbon Canyon Reservoir amounted to 6% of gross storage capacity as of September 1969.

4-05 Climate

The climate of the drainage area above Carbon Canyon Dam is generally temperate-subtropical and semi-arid, with warm dry summers and mild, moist winters.

a. Temperature. Average daily minimum and maximum temperatures (degrees Fahrenheit) in the vicinity of Carbon Canyon Dam range from about 42 and 66, respectively, in winter to about 59 and 90 in summer. Average winter maxima are generally 3-4 degrees lower near the top of the drainage basin. All-time low and high extremes of temperature are about 22 and 113, respectively. The area does not experience significant periods of freezing temperatures.

Table 4-1, reprinted from the National Weather Service Climatography of the United States No. 20, is a climatic summary for Yorba Linda (National Weather Service Station No. 9847), located about 2 miles southeast of Carbon Canyon Dam at 33E53'N, 117E49'W, elev. 350 ft NGVD. This table lists, among other items, the mean daily maximum and minimum temperature and record highest and lowest temperature for each month of the year.

b. Precipitation. Plate 4-1 shows the mean seasonal precipitation over the drainage area above Carbon Canyon Dam. This element ranges from about 16 inches at the dam to about 19 inches in the hills at the upper left portion of the watershed, and averages about 17 inches. Nearly all precipitation occurs during the months of December through March, in the form of rain. Rainless periods of several months during the summer are common. Most precipitation in the drainage area results from general winter storms that are associated with extra-tropical cyclones of North Pacific origin.

Table 4-1 shows the mean and maximum monthly and annual precipitation, as well as the maximum daily precipitation for each month of the year, for the Yorba Linda station. Also listed in table 4-1 are the probabilities (from 5 to 95 percent) for each month of the year that the monthly total precipitation at Yorba Linda will be equal to or less than the indicated amounts. This table shows that there can be great year-to-year variability in annual, monthly, and daily precipitation.

Table 4-2 is a precipitation depth-duration-frequency tabulation for the station at Yorba Reservoir, located about one-half mile south of the Yorba Linda weather station (table 4-1) at 33E52'N, 117E49'W, elev. 320 feet NGVD. Table 4-3 is a precipitation depth-duration-frequency tabulation for Carbon Canyon Workman, located near the north end of the drainage basin at 33E57'N, 117E48'W, elev. 1175 feet NGVD. In these tables are listed the computed point-value precipitation depths at each station for durations ranging from 5 minutes to 24 hours, and for return periods from 2 to 100 years. Data for this table were obtained from the State of California Department of Water Resources publication, Rainfall Depth-Duration Frequency for California, revised November 1982. These California Water Resources data are similar to those obtained from the National Oceanic and Atmospheric Administration publication, NOAA Atlas 2.

c. Snow. Snow in southern California is relatively uncommon at elevations below 4000 feet and is extremely rare below 2000 feet. Although even the valley floor has experienced light snow on isolated occasions, snowfall and snowmelt are not significant hydrologic factors in the Carbon Canyon Dam watershed.

d. Evaporation. No formal studies of evaporation have been made in the Carbon Canyon watershed; since Carbon Canyon Reservoir is normally dry, with any impoundments generally lasting less than 24 hours, evaporation is not a major consideration at this site. Studies for nearby locations indicate that mean monthly evaporation ranges from about 3 inches in winter to almost 9 inches in summer (table 4-4). On days of very strong, dry Santa Ana winds, evaporation can be considerably greater than one inch.

e. Wind. The prevailing wind in the Carbon Canyon watershed is the sea breeze. This gentle onshore wind is normally strongest during late spring and summer afternoons, with speeds in the Carbon Canyon watershed typically 10 to

15 miles per hour.

The Santa Ana is a dry desert wind that blows from out of the northeast, most frequently during late fall and winter. The characteristic low humidity and strong gusts of Santa Ana winds (which can exceed 70 miles per hour at times) usually create very high fire hazards, but can also be instrumental in drying a saturated watershed, thus reducing the flood hazard from later events.

Rainstorm-related winds are the next most common type in southern California. Winds from the southeast ahead of an approaching 20-30 mph, with occasional gusts to more than 40 mph. West to northwest winds behind storms can sometimes exceed 35 mph, with higher gusts.

4-06 <u>Storms and Floods</u>

a. Storm Types. General storms consist of one or more cyclonic disturbances, last a total of one to four or more days, and result in precipitation over large areas. Local thunderstorms result in intense precipitation over small areas for short periods of time, and may occur independently or in association with general storms. Tropical cyclones are infrequent, but occasionally occur in late summer. Snow seldom occurs over this drainage area. A description of storm types which may impact the project area follows:

(1) General Winter Storms. Most precipitation in southern California coastal drainages occurs during the cool season, primarily from November through early April, as mid-latitude cyclones from the northern Pacific Ocean move inland over the area. Most of these storms are the general winter type, characterized by hours of light-to-moderate precipitation, but with occasional heavy showers or thunderstorms embedded within the storm system.

(2) Local thunderstorms. Local thunderstorms can occur in southern California at any time of the year. They occur fairly frequently in the coastal areas in conjunction with general winter storms. They can also occur between early July and early October, when desert thunderstorms occasionally drift westward across the mountains into coastal areas, sometimes enhanced by moisture drifting northward from tropical storms off the west coast of Mexico. These local thunderstorms can at times result in very heavy rain for periods of one to three hours over small area, causing very rapid runoff from small drainages, such as the Carbon Canyon watershed.

(3) General Summer Storms. General summer storms in southern California are quite rare; but on occasion between mid-August and late October, a tropical storm from off the west coast of Mexico can drift far enough northward to bring rain, occasionally heavy, to southern California, sometimes with very heavy thunderstorms embedded. On very rare occasions, southern California has received light rain from general summer storms of non-tropical origin.

b. Floods. Information compiled from historical accounts, records of court cases, and statements of witnesses, indicate that large floods occurred in coastal southern California watersheds in 1811, 1815, 1825, 1851, 1852, 1859, 1860, 1862, and 1867. Available records since 1880 indicate that medium to large general floods occurred in February and March 1884, January 1886, December 1889, January 1890, February 1891, March 1905, March 1906, January 1910, March 1911, February 1914, January 1916, December 1921, April 1926, February 1927, January 1934, March 1938, January 1843, January and February 1969, February and March 1978, February 1980, February 1981, and March 1983. There was also a major tropical storm that occurred in September 1939, but no widespread flooding resulted in southern California from this event.

Brief summaries of the two floods producing the largest peak flows the Carbon Canyon Dam location (March 1938 and March 1983) and the December 1933-January 1934 flood, which was the basis for the standard project storm for Carbon Canyon Dam, follow:

(1) Storm and flood of 30 December 1933 - 2 January 1934. This storm caused the disastrous flood in the Glendale-Montrose-La Crescenta area of the Los Angeles River basin. Ground conditions were favorable to high runoff because of a fire in November 1933 that had burned over an area of 7.5 square miles of mountain area, and an antecedent storm that occurred in mid-December. Precipitation was general over a wide area. The ratio of valley precipitation to mountain precipitation was unusually high. Although the total storm rainfall and short-period intensities were not excessive, the 24-hour rates were the maximum of record at many stations. This storm was characterized by sharp bursts of rainfall. The depths of maximum 6-, 12-, 24-, and 48-hour precipitation at Mt. Wilson were estimated at 4.1, 7.8, 11.8, and 15.0 inches, respectively. The maximum 12-, 24-, and 48-hour total storm precipitation depths over the drainage area above Carbon Canyon Dam were estimated at 3.3, 5.9, and 6.9 inches, respectively. In the vicinity of the storm center, runoff was heavy in the foothills and valleys but only moderate in the mountains. For Carbon Canyon Creek, runoff was moderate; a peak discharge of 728 ft^3/s was recorded at the gauge on Rose Drive Bridge at Olinda.

This storm, transposed on the basis of mean annual precipitation and critically centered over the watershed above the Carbon Canyon Dam location, was used as the standard project storm in the design of Carbon Canyon Reservoir.

(2) Storm and Flood of 27 February-3 March 1938. The flood February-March 1938 was the most destructive of record on the Santa Ana River and many other streams in southern California, and its occurrence played a major role in the justification of the construction of Carbon Canyon Dam. The storm developed out of a series of low-latitude north Pacific disturbances, bringing several bands of intense rainfall to southern California during a 5-day period. The maximum 12-, 24-, and 48-hour total storm precipitation depths were estimated at 3.5, 4.8, and 9.5 inches, respectively, for the precipitation station at Carbon Canyon Summit, and 4.1, 5.8, and 10.5 inches, respectively, over the drainage area above the dam. The intense band of 1-2 March produced a peak flow of 1760 ft^3/s on Carbon Canyon Creek at the Golden

Avenue Bridge gauge (see table 4-5). This flow, combined with heavy runoff from Brea Creek and other tributaries, produced a very destructive flood on the Santa Ana River, Coyote Creek, and Carbon Canyon Creek.

(3) Storm and Flood of 28 February-3 March 1983. A low-latitude Pacific storm reminiscent of the major event exactly 45 years earlier in 1938 moved into southern California at the end of February and first of March 1983, with 5-8 inches of rain over portions of Orange County. The heaviest rainfall occurred with the passage of a strong occluded cold front during the late morning of 1 March, with peak intensities well in excess of 1 inch per hour.

The peak inflow of 1837 ft^3/s at Carbon Canyon Reservoir occurred on 1 March 1983.

c. Flood Damages. Damages resulting from floods on Carbon Canyon Creek prior to the construction of the dam and channel improvements were relatively severe. Most damages occurred in the highly developed overflow area in and near Anaheim. The March 1938 flood moved houses off their foundations, tore up paved streets, and caused damages estimated at $600,000 (1938 dollars). Since the completion of the dam in 1961, along with the downstream channel improvements, minimal damage has resulted from severe storm events. The more recent storm of March 1983 is comparable in severity to the March 1938 storm. Without the protection of the dam and channel improvements, tremendous damage would have resulted in this highly developed area.

4-07 Runoff Characteristics

Runoff from the watershed is characterized by high flood peaks of short duration that result from high-intensity rainfall on the Puente and Chino Hills. Flood hydrographs are typically of less than 12 hours duration and are almost always less than 48 hours duration. Inflow rates drop rapidly between storms, and inflow during the dry summer season is usually less than 10 cfs. Long-term average inflow to Carbon Canyon Dam for the period 1960 through 1987 is 753 acre-feet per year (or 1.04 ft^3/s).

Table 4-5 lists the historic peak discharges for gauges at, or downstream of, Carbon Canyon Dam site for the period 1931 through 1961. Table 4-6 lists annual maximum peak inflow, outflow, and storage at Carbon Canyon Dam from 1962 through 1985. The greater Orange County basin area has historically experienced long-term wet and dry periods. Plate 4-2 illustrates the historic regional response of flood peaks from the 1870's to the 1970's for the southern California area.

In general, antecedent precipitation is a prerequisite for the occurrence of large floods. With substantial antecedent precipitation resulting from a series of winter storms, precipitation loss rates may decrease to as low as 0.15 inch per hour by the climax of a major storm. The unit graph for the watershed above Carbon Canyon Dam is shown on Plate 4-3.

4-08 Water Quality

Because Carbon Canyon Reservoir is strictly a flood-control project that rarely impounds water for more than 24 hours, it has no appreciable effect on water quality. The nature of the storm runoff entering the reservoir is generally of good quality considering the location of the watershed in the highly developed southern California area. This is probably because of the mostly undeveloped nature of the watershed upstream of the dam. Outflow from Carbon Canyon Reservoir may be used for groundwater recharge purposes at several sites downstream of the dam.

4-09 Channel and Floodway Characteristics

Characteristics of the Carbon Canyon Channel downstream from Carbon Canyon Dam vary throughout its length (pl. 3-1). The segment extending from the dam downstream to the Miller Basin Complex begins as a rectangular concrete-lined open channel with a capacity of 1000 ft^3/s. At Alta Vista Golf Course, the Channel is unlined and of unknown capacity. From the golf course downstream to Miller Basin, the channel is concrete-lined and trapezoidal, with a capacity of 1730 ft^3/s. Carbon Canyon Diversion Channel, extending from Miller Basin to the Santa Ana River, is unlined, trapezoidal, and varies in capacity from 2275 to 2800 ft^3/s. Carbon Creek Channel, after leaving Miller basin, varies from an unlined trapezoidal channel with a capacity of 470 ft^3/s, to a concrete-lined rectangular channel with a capacity of 3100 ft^3/s, transitions through various cross sectional shapes and capacities, and ends up joining Coyote Creek as an unlined trapezoidal channel with capacity of 2100 ft^3/s. All capacities given above are shown on plate 3-1.

4-10 Upstream Structures

There are no significant impoundment structures upstream of Carbon Canyon Reservoir.

4-11 Downstream Structures

Numerous flood retarding basins exist along Carbon Canyon Creek below Carbon Canyon Dam (pl. 2-6). These basins are Miller, Placentia, Raymond, and Gilbert, in downstream order. These basins are occasionally used to infiltrate water; however, their main purpose is to reduce floodflows in the area downstream from Carbon Canyon Dam. Miller Basin Complex is approximately 3.5 miles downstream of the dam at the confluence of Carbon Canyon Channel and Atwood Channel. It consists of a small stilling basin, retarding basin, desilting basin, and flow diversion structure. Flows entering Miller Basin Complex first run through the stilling basin, then into the desilting basin where a set of overflow weirs split flows between Carbon Canyon Diversion Channel (diverting flows to the Santa Ana River) and the Miller Retarding Basin. The capacity of the stilling basin is 44 ac-ft, while the capacity of the retarding basin is 340 ac-ft. The weir separating the stilling basin from the desilting basin is small and nearly covered by sediment and vegetation. The desilting basin has two weirs which serve different purposes. The low-level weir at the south end of the basin acts to restrict and divert flows to the Santa Ana River via the Carbon Canyon Diversion Channel. This weir has a capacity of about 3200 ft^3/s. There is also a weir at the west end of the desilting basin at a higher elevation above which flows enter Miller Retarding Basin. The capacity of this weir is about 6000 ft^3/s. There is also an emergency spillway at the west and which empties into a ditch. This ditch eventually leads back into Carbon Creek, which flows toward Coyote Creek. Thus inflow to Miller Basin may be, when necessary or desired, split between the Carbon Canyon Diversion Channel and Carbon Creek Channel, and passed into the lower Santa Ana or San Gabriel Rivers, respectively. See plate 2-6 for a schematic of the flood retarding facilities downstream.

4-12 <u>Economic Data</u>

a. Population. Orange County has been one of the fastest growing areas in the nation since the end of World War II. The watershed of Carbon Canyon Dam is contained in the Chino Hills area of northeastern Orange County. The downstream floodplain runs through the cities of Brea, Placentia, Fullerton, Yorba Linda, and Anaheim. The State of California, Department of Finance, Population Research Unit estimates population as of January 1989 for these cities as:

Brea	33,500
Placentia	41,650
Fullerton	111,700
Yorba Linda	47,900
Anaheim	244,300

b. Agriculture. The floodplain below the dam was once primarily citrus groves. The postwar era has brought increasing urbanization to the area, virtually replacing all agriculture. Today, a small nursery and a small plot of citrus groves continue in the flood plain.

c. Industry. The explosive growth in population has been accompanied by corresponding growth in industry and commerce. Just north of the dam, within the watershed boundary but not in the reservoir, are oil fields. Housing is available further upstream from the dam but extensive development is limited by the steep topography of the Chino Hills. Chino Hills State Park and Carbon Canyon Regional Park are the extent of recreational development within the watershed. Below Carbon Canyon Dam, the downstream floodplain contains numerous industrial/business parks. Located within the floodplain is an ammonia chemical plant, scheduled to close in the early 1990's. Otherwise most of the manufacturing is light industry that specializes in highly technical fields, especially aerospace and electronics. Research and development, banks, and food processing firms have rapidly expanded into the floodplain over the past decade. The floodplain area is heavily residential and supports general office and commercial development. The California State University at Fullerton lies 3 miles southwest of the dam.

d. Flood Damages. Since completion of the project, cumulative flood damages prevented through fiscal year 1988 for Carbon Canyon Dam and channel have been estimated to be $205,569,000.

TABLE 4-1 CLIMATOLOGICAL SUMMARY AT YORBA LINDA, CA

PERIOD: 1951-80
ELEVATION: 350 FT

TEMPERATURE (F)

	MEANS			EXTREMES						MEAN NUMBER OF DAYS				DEGREE DAYS	
										MAX		MIN			
	* DAILY MAXIMUM	* DAILY MINIMUM	* MONTHLY	RECORD HIGHEST	YEAR	DAY	RECORD LOWEST	YEAR	DAY	90 AND ABOVE	32 AND BELOW	32 AND BELOW	0 AND BELOW	* HEATING BASE 65	* COOLING BASE 65
JAN	67.3	42.4	54.9	91+	76	17	23	60	2	0	0	2	0	320	7
FEB	69.3	43.1	56.2	92+	77	15	27+	56	17	0	0	1	0	253	7
MAR	70.4	43.6	57.0	93+	59	12	29	51	2	0	0	1	0	256	8
APR	73.7	46.0	59.9	99	66	15	32+	56	2	1	0	0	0	179	26
MAY	76.7	50.9	63.8	104+	79	13	38+	60	5	2	0	0	0	84	47
JUN	81.8	54.5	68.2	111+	73	20	41+	53	3	5	0	0	0	26	122
JUL	88.8	58.2	73.5	110+	57	4	46+	53	2	13	0	0	0	0	264
AUG	89.2	59.0	74.1	108+	56	23	46	51	7	14	0	0	0	0	282
SEP	87.4	56.7	72.0	114+	55	1	43+	54	21	11	0	0	0	0	215
OCT	81.4	52.0	66.7	109+	58	16	30+	71	29	6	0	0	0	55	108
NOV	74.2	46.1	60.1	100+	76	4	29+	79	21	1	0	0	0	172	25
DEC	68.9	42.3	55.6	99+	58	3	22+	68	21	0	0	1	0	299	7
YEAR	77.4	49.6	63.5	114	SEP 55	1	22	DEC 68	21	53	0	5	0	1644	1118

PRECIPITATION TOTALS (INCHES)

	* MEAN	* GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR	DAY	SNOW MEAN	SNOW MAXIMUM MONTHLY	SNOW YEAR	MEAN NUMBER OF DAYS .10 OR MORE	.50 OR MORE	1.00 OR MORE
JAN	3.58	12.58	69	5.20	56	26	.0	.0		5	2	1
FEB	2.78	11.69	80	3.01	69	24	.0	.0		4	2	1
MAR	2.30	6.98	78	2.90	68	08	.0	.0		4	1	1
APR	1.15	5.21	58	1.64	58	01	.0	.0		3	1	0
MAY	.27	2.42	77	1.38	77	08	.0	.0		1	0	0
JUN	.05	.51	76	.51	76	10	.0	.0		0	0	0
JUL	.02	.29	68	.22	68	27	.0	.0		0	0	0
AUG	.15	2.61	77	2.41	77	17	.0	.0		0	0	0
SEP	.29	2.37	76	1.40	76	10	.0	.0		1	0	0
OCT	.23	1.96	57	.94	79	20	.0	.0		1	0	0
NOV	1.57	7.33	65	2.40	67	19	.0	.0		2	1	1
DEC	2.07	6.91	66	3.15	51	29	.0	.0		3	1	1
YEAR	14.46	12.58	JAN 69	5.20	JAN 56	26	.0	.0		24	8	5

*FROM 1951-80 NORMALS

ESTIMATED VALUE BASED ON DATA FROM SURROUNDING STATIONS

+ ALSO ON EARLIER DATES.

DEGREE DAYS TO SELECTED BASE TEMPERATURES (F)

BASE	HEATING DEGREE DAYS												
BELOW	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
65	320	253	256	179	84	26	0	0	0	55	172	299	1644
60	187	138	132	86	19	0	0	0	0	12	80	168	822
57	126	88	79	46	6	0	0	0	0	0	41	110	496
55	92	60	51	27	0	0	0	0	0	0	23	78	331
50	30	16	11	6	0	0	0	0	0	0	0	22	85

BASE	COOLING DEGREE DAYS												
ABOVE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
55	89	94	113	174	273	396	574	592	510	363	176	96	3450
57	61	66	79	133	216	336	512	530	450	305	134	66	2888
60	29	31	39	83	137	250	419	437	360	220	83	31	2119
65	7	7	8	26	47	122	264	282	215	108	25	7	1118
70	0	0	0	6	7	41	118	145	93	36	5	0	451

DERIVED FROM THE 1951-80 MONTHLY NORMALS

PROBABILITY THAT THE MONTHLY PRECIPITATION WILL BE EQUAL TO OR LESS THAN THE INDICATED PRECIPITATION AMOUNT

MONTHLY PRECIPITATION (INCHES)

PROBABILITY LEVELS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
.05	.00	.00	.00	.00	.00	.00	**	.00	.00	.00	.00	.00
.10	.22	.04	.00	.00	.00	.00	**	.00	.00	.00	.02	.00
.20	.77	.29	.49	.06	.00	.00	**	.00	.00	.00	.15	.17
.30	1.31	.62	.88	.25	.01	.00	**	.00	.00	.00	.34	.47
.40	1.91	1.06	1.28	.46	.05	.00	**	.00	.00	.00	.59	.83
.50	2.59	1.61	1.73	.72	.10	.00	**	.00	.00	.03	.90	1.27
.60	3.41	2.32	2.25	1.02	.18	.01	**	.00	.01	.12	1.30	1.80
.70	4.42	3.26	2.89	1.42	.29	.03	**	.00	.12	.24	1.83	2.51
.80	5.83	4.64	3.75	1.97	.46	.07	**	.01	.38	.42	2.62	3.51
.90	8.20	7.08	5.19	2.90	.78	.16	**	.35	.98	.72	4.02	5.21
.95	10.53	9.58	6.60	3.84	1.11	.25	**	.86	1.67	1.03	5.45	6.93

THESE VALUES WERE DETERMINED FROM THE INCOMPLETE GAMMA DISTRIBUTION.
** STATISTICS NOT COMPUTED BECAUSE LESS THAN SIX YEARS OUT OF THIRTY HAD MEASUREABLE PRECIPITATION

Table 4-2

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE FOR THE STATION AT YORBA RESERVOIR 163

Station NO. BSN ORDER SUB	Station Name	ELEV	SEC	TWP	RNG	LOT	BWM	LATITUDE	LONGITUDE	COUNTY CODE
U05 9847 21	Yorba Reservoir 163	320	34	03S	09W	C	S	33.872	117.81	30

Maximum Precipitation for Indicated Duration; M-Minutes, H-Hours, F-Fiscal

Return Period in Years	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	F-YR
2	N/A	0.22	0.26	0.36	0.50	.65	.81	1.16	1.63	2.12	13.04
5	N/A	0.32	0.39	0.53	0.73	.97	1.19	1.72	2.40	3.12	18.36
10	N/A	0.39	0.47	0.64	0.89	1.17	1.45	2.08	2.91	3.78	21.73
20	N/A	0.45	0.54	0.75	1.03	1.36	1.68	2.42	3.39	4.40	24.82
25	N/A	0.47	0.57	0.78	1.08	1.42	1.76	2.52	3.54	4.60	25.78
40	N/A	0.51	0.62	0.85	1.17	1.54	1.91	2.74	3.84	4.99	27.75
50	N/A	0.53	0.64	0.88	1.21	1.60	1.98	2.84	3.99	5.18	28.67
100	N/A	0.59	0.71	0.97	1.35	1.78	2.20	3.16	4.42	5.75	31.44

Source: State of California, Department of Water Resources, Rainfall-Depth-Duration-Frequency for California, November 1982

Table 4-3

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE
FOR THE STATION AT CARBON CANYON WORKMAN

Station NO. BSN ORDER SUB	Station Name	ELEV	SEC	TWP	RNG	LOT	BWM	LATITUDE	LONGITUDE	COUNTY CODE
UDS 1520 00	Carbon Canyon Workman	1175		025	09W		S	33.95	117.80	36

Maximum Precipitation for Indicated Duration; M-Minutes, H-Hours, C-Calendar

Return Period in Years	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	C-YR
2	0.14	0.20	0.28	0.40	0.51	0.74	0.92	1.36	1.88	2.42	14.19
5	0.21	0.31	0.42	0.60	0.77	1.11	1.39	2.06	2.83	3.65	20.02
10	0.26	0.37	0.51	0.73	0.94	1.36	1.69	2.51	3.45	4.45	23.72
20	0.30	0.44	0.59	0.85	1.10	1.59	1.98	2.93	4.04	5.21	27.11
25	0.31	0.46	0.62	0.89	1.14	1.66	2.07	3.07	4.22	5.44	28.16
40	0.34	0.50	0.67	0.97	1.25	1.81	2.25	3.34	4.60	5.93	30.32
50	0.35	0.52	0.70	1.01	1.29	1.88	2.34	3.47	4.77	6.16	31.33
100	0.39	0.57	0.78	1.12	1.44	2.09	2.60	3.86	5.31	6.85	34.37

Source: State of California, Department of Water Resources, Rainfall Depth-Duration-Frequency for California, November 1982

Table 4-4

EVAPORATION STATIONS IN THE VICINITY OF CARBON CANYON RESERVOIR

OCEMA NO.	STATION NAME	LATITUDE (Degrees-Minutes-Seconds)	LONGITUDE (Degrees-Minutes-Seconds)	ELEVATION (ft)	RECORD from-to
126	Fullerton Airport	33-52-23	117-58-24	96	1/35 6/77
174	Atwood	33-51-48	117-50-30	240	4/70 6/77

MONTHLY EVAPORATION

(inches)

Fullerton Airport (42 year mean)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
4.92	3.57	2.69	2.74	3.04	4.41	5.43	5.57	7.20	8.69	7.98	6.67

Atwood (7 year mean)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
4.93	3.35	3.02	2.73	3.20	4.64	5.71	5.88	7.19	8.76	8.27	6.31

Average Annual Evaporation: Fullerton 62.91", Atwood 63.99"

Note: Each evaporation station consists of a Weather Bureau Class A Pan. Readings are adjusted for observed rainfall to yield net evaporation.
Reservoir evaporation may be estimated by multiplying measured pan evaporation by a pan coefficient ranging from 0.6 to 0.8.

Table 4-5

MAXIMUM RECORDED PEAK DISCHARGES, STREAM GAUGING STATIONS, CARBON CANYON DAM AND CARBON CANYON CREEK

Water Year	Carbon Creek at Olinda*** (Drainage Area = 19.1 mi^2) USGS #11075730		Carbon Creek near Yorba Linda (Drainage Area = 20.4 mi^2) USGS #11075740	
	Peak Discharge (ft^3/s)	Date	Peak Discharge (ft^3/s)	Date
1931-32	279	8 February	....	....
1932-33	186	29 January	....	....
1933-34	728	1 January	....	....
1934-35	102	7 March	....	....
1935-36	330	12 February	....	....
1936-37	No record	....	....	....
1937-38	1760	2 March	....	....
	(Gauge Discontinued)		....	....
1949-50	....	....	1.0	6 February
1950-51	....	....	2.3	13 November
1951-52	....	....	616	18 January
1952-53	....	....	25	15 November
1953-54	....	....	180	25 January
1954-55	....	....	24	18 January
1955-56	....	....	776	26 January
1956-57	....	....	22	1 February
1957-58	....	....	935	3 April
1958-59	....	....	32	11 February
1959-60	....	....	50	1 February
1960-61	....	....	8.4	26 January
			(Gauge Discontinued)	

***Gauge at Rose Drive bridge, drainage area 19.1 mi^2, from water year 1932 to 1935; and at Golden Avenue bridge, drainage area 20.0 mi^2 from 1935 to 1938.

TABLE 4-6

ANNUAL MAXIMUM WATER SURFACE ELEVATION, STORAGE, INFLOW, AND OUTFLOW
AT CARBON CANYON DAM

WATER YEAR OCT - SEP	MAX WATER SURFACE ELEVATION	MAXIMUM STORAGE (AC-FT)	DATE	MAXIMUM INFLOW (CFS)	DATE	MAXIMUM OUTFLOW (CFS)	DATE
1961 - 1962	409.77	56.7	FEB 19	109	JAN 20	90	JAN 20
1962 - 1963	407.14	21.5	FEB 10	33	FEB 10	1	MAR 17
1963 - 1964	406.25	13.2	NOV 20	38	NOV 20	16	NOV 21
1964 - 1965	408.75	42.1	APR 10	29	APR 09	9	APR 02
1965 - 1966	412.00	94.6	NOV 23	180	NOV 23	122	JAN 03
1966 - 1967	419.35	312.7	DEC 07	349	JAN 24	71	DEC 06
1967 - 1968	415.63	180.3	MAR 08	587	MAR 08	35	FEB 01
1968 - 1969	429.05	891.7	FEB 26	425	JAN 25	518	FEB 25
1969 - 1970	408.89	20.3	MAR 05	98	MAR 05	5	MAR 06
1970 - 1971	409.66	28.9	DEC 21	67	DEC 21	9	DEC 23
1971 - 1972	410.15	34.9	DEC 27	62	DEC 27	0	
1972 - 1973	414.40	105.7	FEB 12	171	FEB 11	27	FEB 08
1973 - 1974	413.99	97.4	JAN 08	96	JAN 07	20	MAR 04
1974 - 1975	411.68	57.0	MAR 09	120	DEC 04	20	DEC 29
1975 - 1976	409.61	28.3	FEB 09	116	MAR 01	0	
1976 - 1977	411.10	48.0	JAN 07	59	JAN 03	14	MAR 30
1977 - 1978	429.30	718.4	MAR 04	1029	MAR 04	415	FEB 10
1978 - 1979	422.45	361.8	JAN 31	638	JAN 30	250	FEB 01
1979 - 1980	426.80	572.7	FEB 16	1122	FEB 17	504	FEB 11
1980 - 1981	420.75	292.1	MAR 01	1206	MAR 01	512	MAR 01
1981 - 1982	418.12	199.4	MAR 17	181	MAR 17	95	MAR 17
1982 - 1983	430.90	821.5	MAR 01	1727	MAR 02	703	MAR 01
1983 - 1984	403.00	0		0		0	
1984 - 1985	415.30	124.7	FEB 11	17	NOV 24	17	NOV 24
1985 - 1986	421.40	318.0	FEB 15	1153	FEB 14	221	FEB 15
1986 - 1987	417.09	169.0	JAN 04	---		---	
1987 - 1988	406.79	4.9	DEC 18	---		---	
1988 - 1989	411.21	49.7	JAN 06	---		---	