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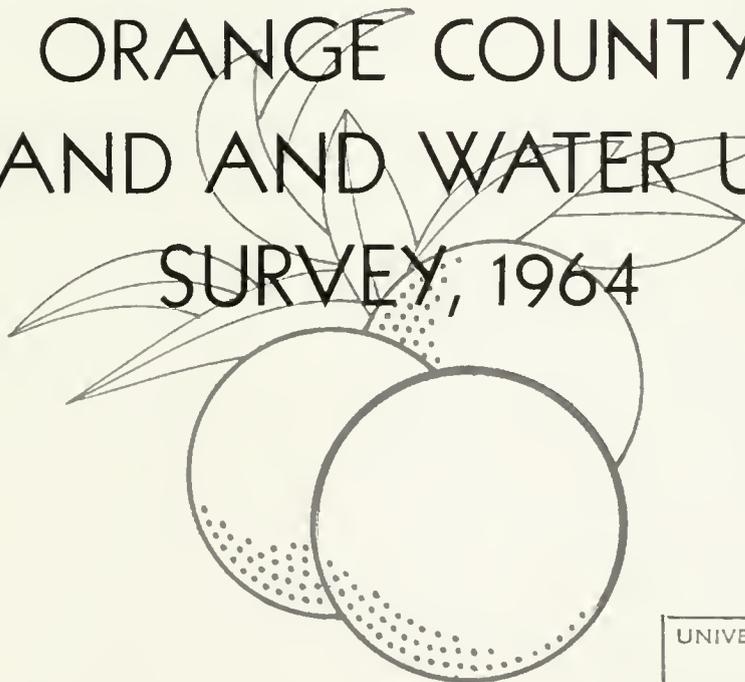
STATE OF CALIFORNIA
The Resources Agency

Department of Water Resources

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BULLETIN No. 70-64

ORANGE COUNTY
LAND AND WATER USE
SURVEY, 1964



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AUGUST 1967

RONALD REAGAN
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Director
Department of Water Resources

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The Santa Ana River
North from near Olive

SPENCE AIR PHOTOS

The river, which is the principal stream in Orange County, rises in the San Bernardino Mountains, a little more than 75 miles inland, and passes through portions of Riverside and San Bernardino Counties.

STATE OF CALIFORNIA
The Resources Agency
Department of Water Resources

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FOREWORD

In 1948, an intensive land and water use survey was conducted on a statewide basis. This information was published in State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California", June 1955. The 1948 survey also served as the basis for a more detailed report on the entire Santa Ana River drainage area. This was published as Department of Water Resources Bulletin No. 15, "Santa Ana River Investigation", February 1959.

To bring information on land and water use in the Santa Ana River drainage area up to date, the Department began a new survey in 1957 which resulted in the publication of two bulletins: Bulletin No. 70, "Orange County Land and Water Use Survey, 1957", and Bulletin No. 71, "Upper Santa Ana River Drainage Area Land and Water Use Survey, 1957".

This report, Bulletin No. 70-64, presents land and water use as of 1964 and updates data presented in Bulletin No. 70. Such updating of land and water use data has been carried on since 1957 for different areas throughout the Southern District as set forth in Sections 225, 226, and 232 of the California Water Code.

The Department of Water Resources expresses its thanks to the many farmers of the area without whose cooperation detailed crop mapping would not have been possible.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California

June 12, 1967

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State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

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ABSTRACT

Bulletin No. 70-64 reports that, in the Orange County study area, urban development has been rapidly increasing while the area devoted to agriculture has been declining. / The area of the report encompasses 825 square miles and includes most of Orange County and minor portions of Los Angeles, Riverside, and San Bernardino Counties. It consists of portions of three hydrologic units: Los Angeles-San Gabriel River, Santa Ana River, and San Juan. / Population in the Orange County portion of the survey increased from 516,000 in 1957 to 1,070,800 in 1964. / The gross urban-suburban area (in the entire study area) increased from 69,490 acres in 1957 to 140,590 acres in 1964. The gross agricultural area decreased from 101,920 acres in 1957 to 61,760 acres in 1964. / Net water use in the study area expanded from 244,000 acre-feet in 1957 to 305,400 acre-feet in 1964 -- a 25-percent increase. Urban-suburban net water use increased from 104,100 acre-feet in 1957 to 220,500 acre-feet in 1964, while agricultural net water use decreased from 139,900 acre-feet in 1957 to 84,900 acre-feet in 1964. / Foldout plates depict hydrologic units, subunits, subareas; water-bearing sediments; major water agencies; present land use; and change in land use between 1957 and 1964.

CHAPTER I. INTRODUCTION AND SUMMARY

A periodic survey of land and water use is necessary to provide information on present water requirements and to form the basis of predictions of future water requirements and the need for supplemental water supplies. This is particularly true in an area such as Orange County where the recent rapid growth of population and industry and the resulting decline in irrigated agricultural acreage have created drastic changes in the character and amount of demand for water.

Charting the land uses and water needs in areas such as this began in 1947 when the California Legislature directed the Department of Water Resources and its predecessor agencies to conduct a comprehensive investigation of the water resources of the entire State. Out of this investigation came The California Water Plan -- a master blueprint for management of California's water resources.

Since then, the Department has periodically updated its land and water use surveys to keep abreast of the changes taking place. For example, the investigation reported here, which was conducted in 1964, updates a similar survey made in 1957 in the same area.

Objectives and Scope of Investigation

The major objective of the program, of which this survey is a part, is to provide timely and reliable information on the availability, suitability, and use of land throughout the State for various kinds of water-using development.

The specific objectives of this survey were to develop information on present water use in the study area and to compare present water

use with historical use to determine water use trends. This information will then be used by the Department of Water Resources in continuing studies to compare values of present use with local and imported water supplies to ascertain the need for supplemental water.

This report contains data for Orange County and for small parts of Los Angeles, Riverside, and San Bernardino Counties. These minor areas outside of Orange County have been included because the boundaries of the hydrologic drainage areas extend beyond county lines. A general location map of the study area is presented in Figure 1.

Methods and procedures employed in this investigation are similar to those used in the 1957 survey. A detailed explanation of the classification of land use and conduct of the study is given in Appendix A, and an explanation of the unit value method for estimating net water use is given in Appendix B. For definitions of terms as used in this report, see Appendix C. For a list of references used in this report see Appendix D.

Summary of Findings

The investigation reported in this bulletin disclosed that in 1964, the land in the area of investigation was being put to these uses:

Gross urban and suburban area	140,590 acres
Gross irrigated agriculture area.	61,760 acres
Gross water service area.	202,350 acres

And this land was found to be using the following amounts of water:

Net urban and suburban water use	220,500 acre-feet
Net irrigated agriculture water use	84,900 acre-feet
Total net water use	305,400 acre-feet

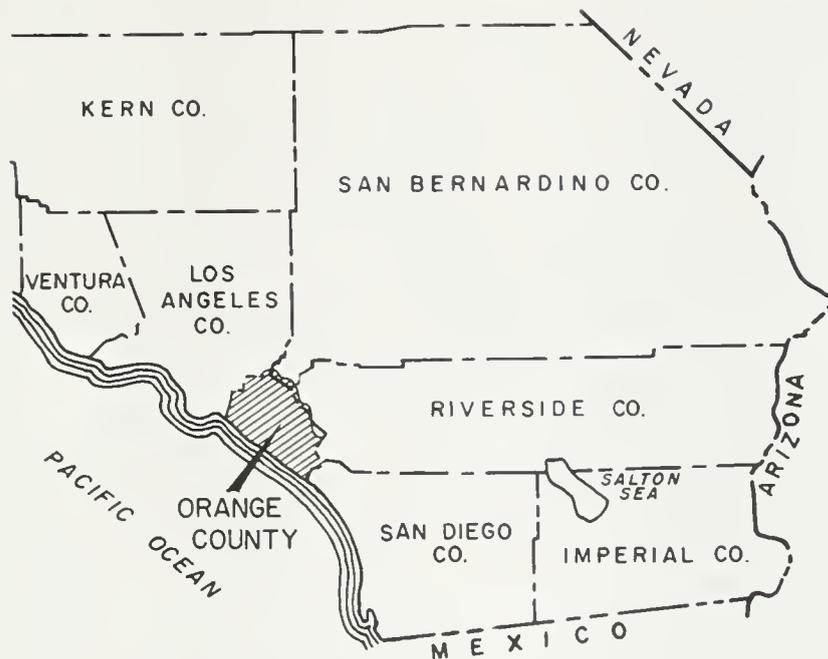


Figure 1. Location of Area of Investigation

The following findings result from the 1964 survey of the study area:

1. The population of Orange County has increased 108 percent since the 1957 survey (516,000 in 1957 to 1,070,800 in 1964).
2. The gross urban and suburban area within the area of investigation increased from 69,490 acres in 1957 to 140,590 acres in 1964, an increase of 71,100 acres, or 102 percent.

3. The gross irrigated agricultural area decreased from 101,920 acres in 1957 to 61,760 acres in 1964, a reduction of 40,160 acres, or about 39 percent.
4. The gross water service area increased from 171,410 acres in 1957 to 202,350 acres in 1964, an increase of 30,940 acres, or about 18 percent.
5. Eight major water agencies encompass 75 percent of the study area and provide service to 99 percent of the water service area.
6. Annual net water use for urban and suburban acreage increased 116,400 acre-feet between 1957 and 1964 -- from 104,100 to 220,500 acre-feet, or almost 112 percent.
7. Annual net water use on irrigated agricultural lands declined from 139,900 acre-feet to 84,900 acre-feet between 1957 and 1964, a decrease of 55,000 acre-feet, or about 39 percent.
8. Overall net water use increased about 61,400 acre-feet, or almost 25 percent, from 244,000 acre-feet in 1957 to 305,400 acre-feet in 1964.
9. The deliveries of water imported to Orange County from the Colorado River increased from 154,200 acre-feet in 1957 to 303,400 acre-feet in 1964.
10. The total seasonal net water use for Orange County by the year 2020 has been estimated to be 804,000 acre-feet. This means that nearly 650,500 acre-feet of water will have to be imported annually to this area in the future.

Conclusions

Based on the results of this investigation, it is concluded that:

1. The population within the study area will continue to increase within the foreseeable future.
2. Irrigated agricultural lands will continue to lose choice acreage to urban and suburban expansion, but a portion of this loss will be offset by new development of lands which previously have been in native vegetation or farmed under a nonirrigated condition.
3. Increasing reliance on importation has relieved, but not solved, the current overdraft conditions.
4. Orange County is undergoing very rapid changes. These changes will require continued periodic inventories of land use to serve as a foundation for future water resources planning and development.



Newport Bay

PACIFIC AIR INDUSTRIES

Newport Bay is one of the most intensively used small craft harbors in Southern California.

CHAPTER II. AREA OF INVESTIGATION

The Orange County study area comprises about 825 square miles. It is roughly rectangular in shape and extends some 37 miles parallel to the Pacific Ocean, with an inland depth of about 25 miles.

The study area is situated in a locale that encompasses many variations in topography, ranging from relatively level land along the coast to rugged mountains along the Santa Ana Range. A short drive through the county will carry one along scenic country roads that pass fields of stubble grain or undeveloped valleys where large oaks shade the highway. Going west, one may pass through a broad plain that stretches to the ocean. This plain is the scene of intense urban and agricultural activity. A highway along the coast takes one along beautiful beaches and unique cities that attract crowds of holiday and weekend visitors.

This flat coastal plain blends into the Coastal Plain of Los Angeles County on the northwest. The north and northeast boundary of the study area runs along the drainage divide of the Puente and Chino Hills. The eastern limits of the study area follow the rugged Santa Ana Mountains. The southeast boundary follows the Orange County and San Diego-Riverside county lines. This last stretch of the study area runs through very hilly and mountainous terrain. The southern boundary borders on the Pacific Ocean.

The internal features of the county are quite variable. The San Joaquin Hills, which are located just inland from Laguna Beach, and the Puente Hills attain elevations of about 1,200 feet and 1,800 feet, respectively. Both ranges are relatively smooth. The Santa Ana Mountains are more rugged and rise to an elevation of 5,700 feet.

The Santa Ana River, the principal stream in Orange County, originates to the northeast in the San Bernardino Mountains a little more than 75 miles inland and passes through portions of Riverside and San Bernardino Counties. It enters Orange County by way of a 12-mile gorge between the Puente Hills and the Santa Ana Mountains, known as the Santa Ana Narrows, and flows in a southwesterly direction across the coastal plain to the Pacific Ocean.

Precipitation in Orange County varies widely both according to season and according to geography and generally occurs in the form of rainfall. Mean seasonal rainfall near the center of the county at the City of Santa Ana for the 30-year period 1934-1964 was 13.04 inches, and precipitation ranged from a maximum of 34.34 inches during the 1940-41 season to a minimum of 3.56 inches during the 1960-61 season. At Camp Silverado in the Santa Ana Mountains mean seasonal rainfall is 24.37 inches. The maximum recorded rainfall at this station was 48.73 inches during the 1940-41 season, while the minimum recorded rainfall was 10.78 inches during the 1960-61 season.

Generally the temperature range is small. At the City of Santa Ana the mean temperature is 62° F. with recorded extremes of 22° F. and 112° F. Killing frost and temperatures exceeding 110° F. are of infrequent occurrence. Loss of semitropical crops is usually prevented during heavy frosts by use of orchard heaters or wind machines.

Hydrologic Subdivisions

The Orange County Study area is divided into three major hydrologic units: Los Angeles-San Gabriel River, Santa Ana River, and San Juan. Because each takes in considerable territory outside this study area, any

reference to a unit in this report will refer to only that portion of the unit within the study area. Information on the remainder of the Los Angeles-San Gabriel River Unit may be found in Department of Water Resources Bulletin No. 24-60, "Coastal Los Angeles County Land and Water Use Survey, 1960". Additional data on the Santa Ana River unit may be found in Bulletin No. 71-64, "Upper Santa Ana River Land and Water Use Survey, 1964". The San Juan unit is another unit that extends into another study area. Information on the remainder of this unit may be obtained from Department of Water Resources Bulletin No. 102, "San Diego County Land and Water Use Survey, 1958".

Each hydrologic unit has been subdivided into subunits and, in some instances, into subareas. Subunits were found to be the most suitable subdivision to describe. Three of these -- Anaheim, San Juan, and San Mateo -- extend beyond the study area; therefore, any values of land use extracted from this report pertaining to these three subunits will not be a subunit total.

The names and areas of the hydrologic units and subunits are presented in Table 1. The location and configuration of the boundary has been delineated on Plate 1.

Anahaim Subunit

This subunit, which is a subdivision of the Los Angeles-San Gabriel River Hydrologic Unit, extends beyond the study area into Los Angeles and San Bernardino Counties. The part of the subunit within the study area is located in the northwestern part of Orange County and covers 79,840 acres, or 125 square miles. The northern limits of this partial subunit correspond with the Los Angeles county line. The southern

TABLE 1.
AREAS OF HYDROLOGIC UNITS AND SUBUNITS
IN THE STUDY AREA

In acres

Hydrologic subdivision	:	Area
<u>Los Angeles-San Gabriel River Unit</u>		
Anaheim Subunit		79,840*
<u>Santa Ana River Unit</u>		
Lower Santa Ana River Subunit		281,720
<u>San Juan Unit</u>		
Laguna Subunit		40,940
San Juan Subunit		101,310*
San Clemente Subunit		12,680
San Mateo Subunit		<u>11,600*</u>
	Subtotal	166,530
STUDY AREA TOTAL		528,090

*Subunits that extend into other study areas.

boundary is a drainage divide extending diagonally from Alamitos Bay northeast through Anaheim to another drainage divide in the Chino Hills.

Rolling hills form the northern part of this partial subunit. The hills level off to meet the coastal plain just north of Fullerton. The rest of this subunit is relatively level to the ocean. Elevations range from sea level on the coast to more than 1,700 feet near the county line. A number of canyons and gullies slice through the northern part of the partial subunit. Some form major thoroughfares where highways carry

large volumes of traffic. In particular, Brea and Carbon Canyons provide access to and from the Chino and Pomona areas, which are north of the study area.

Agriculture still exists in the more level parts, but urban development is rapidly encroaching on the once so plentiful farm land. Urban development is widespread and not restricted to any one metropolitan area. Rapidly growing cities such as Buena Park, Fullerton, and La Habra are located here, along with a large segment of Anaheim.

There are no perennial streams flowing through this partial subunit. All surface flow is to Coyote Creek, a tributary of the San Gabriel River, which passes through another portion of the hydrologic unit outside of the study area.

Lower Santa Ana River Subunit

The Lower Santa Ana River Hydrologic Subunit, which is a subdivision of the Santa Ana River Hydrologic Unit, covers all the central part of Orange County. It is rectangular in shape and oriented in a southwest-northeast direction. This important hydrologic subdivision of Orange County covers about 281,720 acres, or 440 square miles.

The wide, expansive coastal plain is the site of vast urban construction activity, spotted by intensively farmed agricultural land. East of the City of Santa Ana a considerable acreage of irrigated agriculture remains, including truck crops, oranges, and avocados.

The coastal plain extends inland about 15 miles where the land gently changes to rolling hills which rise to the steep slope of the Santa Ana Mountains. The inland limits of this subunit follow the drainage

divide of the Santa Ana Mountains which separates runoff between the Upper and Lower Santa Ana River Hydrologic Subunits. The southern or southeastern limit of this subunit extends toward the coast from Santiago Peak following the divide between the Lower Santa Ana River Subunit and the Laguna Subunit. This boundary closely parallels El Toro Road.

The Santa Ana River enters this subunit at Prado Dam and flows through the Santa Ana Narrows to the west side of the subunit. It then flows through the coastal plain in a southerly direction between the cities of Anaheim and Orange to the ocean just southeast of Huntington Beach. Santiago Creek, which is located in the northeast part of the subunit, flows into Irvine Lake. Below the lake, the creek continues on to meet the Santa Ana River just west of the City of Santa Ana.

The most populous cities in Orange County are located in this subunit. Anaheim, Santa Ana, and Garden Grove continue to be the hub of county activity. On the coast is Newport Bay, one of the most intensively used small craft harbors in Southern California. Military installations, such as the Marine Corps Air Station at El Toro and the U. S. Naval Weapons station at Seal Beach, are important to the economy of the study area.

Laguna Subunit

The Laguna Subunit is part of the San Juan Hydrologic Unit and is located in the southern part of Orange County, encompassing 40,940 acres, or about 64 square miles. The boundaries of the subunit follow drainage divides.

The topography is very rolling and steep, leveling off sharply on the coast to form steep palisades interspersed with scenic beaches.

Laguna Beach is the center of importance here, attracting throngs of tourists and vacationers from nearby metropolitan areas.

Agriculture is limited to the few level valleys in the upper reaches of Aliso Creek near the town of El Toro. Urban growth has occurred primarily along the coast between Dana Point and Laguna Beach.

San Juan Subunit

This subunit is also a subdivision of the San Juan Hydrologic unit. The subunit is bounded on the north by the rugged Santa Ana Mountains and on the west by the Laguna Subunit. The eastern side of the subunit borders on the San Clemente and San Mateo Subunits.

This hilly and mountainous area covers 101,310 acres, or 158 square miles. Major creeks in the area are San Juan, Canada Gobernadora, and Arroyo Trabuco.

Irrigated agriculture is restricted to the valleys and some rolling hills where avocados are successfully grown. Urban development is centered at San Juan Capistrano and Capistrano Beach.

San Clemente Subunit

This small subunit covers 12,680 acres which is almost 20 square miles. The subunit is also part of the San Juan Unit. It is situated east of Capistrano Beach and extends inland only about 6 miles. There are no major streams or creeks here.

Nearly all development, both urban and agricultural, remains confined to the coast. The coastal city of San Clemente attracts large crowds of tourists during the summer months.

San Mateo Subunit

The portion of this subunit in Orange County covers 11,600 acres, or about 18 square miles. It is a subdivision of the San Juan Unit. This partial subunit drains to San Mateo Creek which flows outside the study area. Most of the subunit falls within San Diego and Riverside Counties. There is very little urban development here and no irrigated agriculture. The subunit completes various land and water use values for Orange County.

Population

For many years Orange County has been one of the fastest growing areas in the nation. A feeling of this growth can be experienced when driving through the county. The aura of this dynamic growth is reflected in the gross changes of the landscape. New housing tracts are emerging everywhere. Roads are blocked for excavation, new sewers, water pipes, and gas lines. The road detour and construction signs are an indication of the progress being made in the county.

In 1940 the Bureau of Census estimated the population to be 130,760. By 1950 this value had increased to 216,224, an increase of 65 percent. Between 1950 and 1957, the year of the Department's last land and water use survey, the population had added 300,000 persons to reach a total of 516,000. This 139 percent increase of population in the county in seven years is continuing. Population figures in 1964 were estimated to be 1,070,800. This is an increase of 554,800, or 108 percent since 1957.

Table 2 lists the incorporated cities in Orange County with the census counts for 1940, 1950, 1960, and estimates by the Orange County Planning Commission for 1957 and 1964.



Urban Encroachment on
Citrus Groves near Anaheim

SPENCE AIR PHOTOS

*Orange County is rapidly losing agricultural lands to urban and
suburban development.*

The increases in population between 1957 and 1964 varied from city to city, ranging from 6 percent in Dairyland to 1,078 percent in Fountain Valley. In 1957 approximately 82 percent of the county residents lived within an incorporated city. By 1964 this value amounted to slightly more than 90 percent.

The study area includes small portions of Los Angeles County and Riverside County. The population of these portions can be considered negligible when compared to the population of Orange County; therefore, the population values and results discussed in this section reflect only the figures for Orange County.

Urban and Suburban Development

The study area is rapidly losing agricultural lands to urban and suburban development. Housing tracts have replaced a large portion of the important agricultural development.

The total urban-suburban area, which had amounted to 69,490 acres in 1957, covered 140,590 acres in 1964. This area is made up of a number of different types of land use, many of which are dependent on the others for support.

For example, construction of a residential tract causes new schools to be built. The neighborhood shopping center emerges to serve the family needs. Light industry moves into the area to take advantage of the labor. This interdependency grows and accumulates at faster and faster rates, pushing and prodding at city boundaries and causing expansion in all directions.

TABLE 2

POPULATION OF INCORPORATED CITIES IN ORANGE COUNTY

City	1940 census	1950 census	1957 ^a estimate	1960 census	1964 ^a estimate	Increase in percent 1957-1964
Anaheim	11,031	14,556	65,000	104,184	144,719	123
Brea	2,567	3,208 ^b	6,500	8,487	12,166	87
Buena Park	Uninc.	5,483 ^b	27,000	46,401	63,014	133
Costa Mesa	Uninc.	11,844 ^b	23,000	37,550	63,510	176
Cypress	Uninc.	Uninc.	1,700	1,753	12,583	640
Dairyland ^c	Uninc.	Uninc.	600	622	634	6
Fountain Valley	Uninc.	Uninc.	600	2,068	7,070	1,078
Fullerton	10,442	13,958 ^b	46,000	56,180	73,672	60
Garden Grove	Uninc.	3,762 ^b	58,500	84,238	113,698	94
Huntington Beach	3,738	5,237	12,300	11,492	59,734	386
Laguna Beach	4,460	6,661	8,500	9,288	11,031	30
La Habra	2,499	4,961	15,000	25,136	35,539	137
Los Alamitos	Uninc.	Uninc.	Uninc.	4,312	6,704	---
Newport Beach	4,438	12,120	21,200	26,564	34,582	63
Orange	7,901	10,027	20,000	26,444	61,083	205
Placentia	1,472	1,682	3,200	5,861	11,362	255
San Clemente	479	2,008	7,400	8,527	13,825	87
Santa Ana	31,921	45,533	71,200	100,350	130,272	83
Seal Beach	1,553	3,553	4,200	6,994	18,298	336
Stanton	Uninc.	Uninc.	4,600	11,163	17,819	287
Tustin	953	1,143 ^b	1,800	2,006	7,054	292
Westminster	Uninc.	3,131 ^b	14,200	25,750	48,355	240

a. Orange County Planning Commission estimate for July 1.

b. U. S. Census count of unincorporated communities, shown for comparative purposes.

c. Is now incorporated and called La Palma.

Single family residential units form about 85 percent of all existing dwelling units. Multiple units are rapidly replacing older single family residential development in the major cities. In 1964 there were 28,501 building permits authorized within the county. Of this total, 15,345 were for multiple units -- more than 53 percent.

Another phenomenon of competition for land area is the development of the condominium. This type of development resembles duplex or triplex residences set in a park-like atmosphere. Similar to this type of development is the retirement community. There are a number of these within the county -- some being cities in themselves, covering hundreds of acres.



SPENCE AIR PHOTOS

Industrial Complex near Buena Park

Light industry moves in to take advantage of the labor.

Industrial development has followed the fast pace set by the population influx. North American Aviation, Inc., with some 22,000 employees, is one of the largest of the approximately 1,400 manufacturing plants within the county. Other large industries are Hughes Aircraft Company, Beckman Instruments, Aeronutronic Division of Ford Motor Company, Douglas Aircraft Company, Nortronics, and Hunt Foods. Most of the manufacturing plants, however, would be classed as light industry.

Total expenditures by military installations increased from a little more than \$92 million in 1957 to slightly more than \$133 million in 1964. The U. S. Marine Corps Air Station at El Toro contributes almost \$96 million to this expenditure.

The assessed valuation of Orange County increased from \$793,634,290 during the 1956-57 period to \$1,820,385,734 during 1963-64. This 129 percent increase reflects the dynamic changes occurring in the county.

Agricultural Development

The first known agricultural development in the study area occurred in the vicinity of the mission San Juan Capistrano in 1776. Before 1900, the principal source of revenue was the raising of cattle pastured on native grasses and dry farm stubble. However, some irrigated agriculture, primarily truck crops and wine vineyards, did exist. Water for irrigation was obtained by diversions from the Santa Ana River and other streams, although shallow dug wells were developed during the latter part of the nineteenth century to provide firm supplies during the late summer and fall.

About the year 1900, the planting of orchards, primarily citrus, became common. The greatest influence on the expansion of agricultural

development was the introduction of the deep-well turbine pump. Use of ground water resulted in an increase of approximately 350 percent in agricultural acreage between 1904 and 1926. By 1948 there were 136,600 gross acres of irrigated agriculture in the study area. The principal crops were citrus, avocados, walnuts and other deciduous fruits, truck crops, and alfalfa. In 1957 the agricultural area was found to have decreased to 101,920 acres. The 1964 survey indicated even a greater decline in irrigated agriculture -- reaching 61,760 acres -- far below the 140,590 acres in urban and suburban development recorded in that same year.

The Orange County Department of Agriculture reported in the "Agricultural Crop Report, 1951" that, at peak development, citrus and avocado orchards covered as much as 84,000 acres. By 1957, only about 49,500 acres of orchards were productive, and by 1964 this figure had dropped to 26,730 acres.

Many of the citrus orchards that have been subdivided have been developed into estate-type ranches. Although much of the ranch is occupied by residences, there is still an appreciable area of bearing citrus trees that can be farmed on a commercial basis.

Citrus and avocados remain important to the economy of the county, but field crops have declined in value. There has been a shift to more intensive use of the land, growing and harvesting as many as three truck crops in a year on the same piece of land.

In recent years smog damage has been more prevalent. Nurseries appear to be the hardest hit, but almost all crops are affected to some degree. The smog problem will be a factor in deciding the type of agriculture that will exist in the future.



Agriculture in the Coastal Plain

SPENCE AIR PHOTOS

There has been a shift to more intensive use of the land, growing and harvesting as many as three truck crops in a year on the same piece of land.

The value of farm products in Orange County increased sharply from \$34 million in 1940 to almost \$94 million in 1945. The peak was reached in 1959 when production reached \$114 million. The total gross value of Orange County agricultural products for 1964 was almost \$98 million.

Water Supply

The two primary sources of water for the study area are ground water and imported water from the Colorado River through facilities of The Metropolitan Water District of Southern California. As previously mentioned, surface diversions from the Santa Ana River constituted the primary source of water supply for early irrigation enterprises. However, because of the erratic nature of this supply and the increased demands for irrigation and domestic water, this source became inadequate and wells were drilled to tap the underlying aquifers. As a result of the increased ground water development, large overdrafts developed in certain portions of Orange County.

The first published engineering evaluation of overdraft conditions was given in a report by the former Division of Water Resources, "Present Overdraft On, and Safe Yield from, the Ground Water of the Coastal Plain of Orange County", dated June 1, 1945. At that time the average annual overdraft on the coastal plain was estimated to be 12,000 acre-feet.

Overdraft conditions resulted in sea-water intrusion along the coast. In 1961 sea water had intruded some 3 to 4 miles inland, degrading approximately 6,700 acres. Saline waters have been moved seaward short distances in recent years as a result of pressures established by artificial recharge activities in the forebay area north of the City of Santa Ana.

In recognition of the inadequacy of local water supplies to meet the growing needs of the county, three cities -- Santa Ana, Fullerton and Anaheim -- became charter member agencies of The Metropolitan Water District of Southern California. Since the District's organization in 1928, two additional water service agencies, the Coastal Municipal Water District and the Orange County Municipal Water District have been formed and accepted into membership. The U. S. Marine Corps Air Station at El Toro also receives deliveries of Colorado River water from the Metropolitan Water District.

The Orange County Water District was created in 1933 and now encompasses most of the Coastal Plain of Orange County. The District overlaps the territory of previously mentioned water agencies and is responsible for spreading water for ground water recharge and for constructing salinity barriers along the coast.

Imported water was first delivered to Orange County in 1941 by the Metropolitan Water District through the Orange County feeder. This water, delivered through surface distribution facilities, has replaced water that otherwise would have been pumped. Beginning in 1949, imported water has also been used for recharge of the ground water basins by spreading in and adjacent to the streambed of the Santa Ana River. The net result of these operations has been a reduction in overdraft. During the 1956-57 season, 154,200 acre-feet of water was purchased by Orange County water agencies. This importation had increased in 1963-64 to 303,400 acre-feet. This represents an increase in deliveries of 97 percent.

Table 3 gives the historic seasonal deliveries of imported water. The boundaries of the major water agencies are shown on Plate 2.

TABLE 3

HISTORIC SEASONAL DELIVERIES OF IMPORTED WATER
TO THE STUDY AREA BY
THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

In acre-feet

Season ending September 30	Softened water	Unsoftened water	Total delivered
1940-41	1,500	--	1,500
41-42	800	--	800
42-43	700	--	700
43-44	4,300	--	4,300
44-45	9,200	--	9,200
1945-46	10,900	--	10,900
46-47	11,000	--	11,000
47-48	12,300	--	12,300
48-49	12,900	4,700	17,600
49-50	13,200	25,300	38,500
1950-51	15,000	28,500	43,500
51-52	17,500	38,200	55,700
52-53	18,600	28,900	47,500
53-54	22,000	61,000	83,000
54-55	26,500	52,400	78,900
1955-56	28,000	21,700	49,700
56-57	34,600	119,600	154,200
57-58	38,300	88,500	126,800
58-59	48,300	90,100	138,400
59-60	50,700	185,400	236,100
1960-61	59,400	172,000	231,400
61-62	53,100	242,300	295,400
62-63	61,700	232,900	294,600
63-64	77,400*	226,000	303,400

*Includes 33,200 acre-feet of filtered, nonsoftened water.

Sewage and Industrial Waste Disposal

In the early stages of urbanizing Orange County, sewage and industrial waste were disposed of through privately owned cesspools and septic tanks. In free ground water areas, percolation from these cesspools and septic tanks constituted an important source of replenishment to the underlying ground water basins. With increased urban and industrial development it became necessary, for public health and convenience, to construct extensive sewerage systems and treatment facilities with ocean disposal.

The County Sanitation Districts of Orange County operate and maintain two marine outfall lines. In addition, smaller marine outfall lines are operated by other agencies. These smaller agencies are in Seal Beach, Laguna Beach, South Laguna, Dana Point, and San Clemente.

The only major water reclamation plan that has been attempted in Orange County was undertaken by the Talbert Water District. It pioneered in using primary effluent for irrigation, but discontinued this because of odor and other nuisance problems and also because of the encroachment of urban development on agricultural lands. The Irvine Company is proceeding with plans to reclaim waste water produced within the projected University City. The service area includes the new University of California at Irvine and the proposed city surrounding it. Orange County Water District, in collaboration with the U. S. Public Health Service, is conducting research in reclaiming and injecting effluent through wells to create an underground barrier for control of sea-water intrusion.

During the 1956-57 season a total of 38,900 acre-feet of treated effluent was discharged to the ocean. By 1963-64 this figure had increased to 103,100 acre-feet, or 165 percent over a period of seven years.

Presented in Table 4 is a tabulation of estimated quantities of sewage and industrial waste discharged to the ocean from sewerage systems within the study area.

TABLE 4
 ESTIMATED DISCHARGE OF
 SEWAGE AND INDUSTRIAL WASTE TO
 THE OCEAN FROM THE STUDY AREA

Season ending September 30	:	Acre-feet
1940-41	:	9,400
41-42	:	9,500
42-43	:	10,300
43-44	:	11,000
44-45	:	12,000
1945-46	:	12,500
46-47	:	12,900
47-48	:	13,600
48-49	:	15,100
49-50	:	16,100
1950-51	:	17,800
51-52	:	19,600
52-53	:	20,900
53-54	:	23,100
54-55	:	27,500
1955-56	:	35,000
56-57	:	42,300
57-58	:	49,900
58-59	:	59,600
59-60	:	64,100
1960-61	:	71,300
61-62	:	86,500
62-63	:	95,300
63-64	:	103,100

CHAPTER III. LAND USE

The nature, location, and areal extent of land use within the Orange County study area were determined by a detailed survey conducted in 1964. For analysis and presentation, the various land uses were classified and grouped according to their water requirements. A detailed explanation of land use classification used in this report is presented in Appendix A. The classes of land use described are similar to those used in Bulletin No. 70 (the report on the 1957 survey). Irrigated fallow and idle lands were formerly placed in the nonirrigated agriculture category, but for this report, these lands have been considered part of the gross irrigated area.

Results of the Survey

Data from the 1964 land use survey are compiled in Table 5 by hydrologic units, subunits, and subareas. Land use by counties is shown in Table 6. Table 7 presents land use by selected major water agencies that serve the county. The subtotals in all the tables are in terms of net acreage (i.e., minus the streets, rights-of-way, and other nonwater-using sections within the particular land uses).

In 1964 the gross acreage requiring water service within the area of investigation was 202,350 acres. About 140,590 acres, or 69 percent of this area, was devoted to urban-suburban development. Gross irrigated agriculture totaled 61,760 acres accounting for the remaining 31 percent gross water service area.

Detailed information concerning the pattern of land use as determined from this survey is presented on Plate 3. Although the acreages of nonwater service areas within urban-suburban and irrigated

TABLE 5

LAND USE IN HYDROLOGIC UNITS, SUBUNITS, AND
In acres

Category and Class of Land Use	Los Angeles-San Gabriel River Unit			UNIT TOTAL	Santa Ana River Unit			UNIT TOTAL
	Anaheim Subunit				Lower Santa Ana River Subunit			
	Anaheim Subarea	La Habra Subarea	Yorba Linda Subarea		East Coastal Plain Subarea	Santiago Subarea	Santa Ana Narrows Subarea	

WATER SERVICE AREA

Urban and Suburban

Residential	12,570	3,610	1,930	18,110	35,450	230	340	36,020
Commercial	2,820	710	230	3,760	8,030	30	10	8,070
Industrial	900	140	90	1,130	1,670	0	0	1,670
Unsegregated urban and suburban area	<u>2,030</u>	<u>370</u>	<u>440</u>	<u>2,840</u>	<u>3,560</u>	<u>150</u>	<u>240</u>	<u>3,950</u>
Subtotals	18,320	4,830	2,690	25,840	48,710	410	590	49,710
Included Nonwater-service Area	<u>11,550</u>	<u>4,740</u>	<u>2,920</u>	<u>19,210</u>	<u>35,070</u>	<u>120</u>	<u>310</u>	<u>35,500</u>
Gross Urban and Suburban Area	29,870	9,570	5,610	45,050	83,780	530	900	85,210

Irrigated Agriculture

Alfalfa	0	0	0	0	230	0	0	230
Pasture	640	30	10	680	420	10	30	460
Citrus and subtropical	1,950	650	2,590	5,190	17,070	60	1,760	18,890
Truck crops	1,110	220	50	1,380	19,570	0	60	19,630
Field crops	650	10	10	670	2,810	0	0	2,810
Deciduous fruits and nuts	*	0	10	10	490	0	0	490
Small grains	<u>10</u>	<u>0</u>	<u>0</u>	<u>10</u>	<u>0</u>	<u>0</u>	<u>120</u>	<u>120</u>
Subtotals	4,360	910	2,670	7,940	40,590	70	1,970	42,630
Fallow	230	30	0	260	1,070	0	0	1,070
Included Nonwater-Service Area	<u>1,220</u>	<u>340</u>	<u>210</u>	<u>1,770</u>	<u>4,020</u>	<u>20</u>	<u>150</u>	<u>4,190</u>
Gross Irrigated Agriculture	<u>5,810</u>	<u>1,280</u>	<u>2,880</u>	<u>9,970</u>	<u>45,680</u>	<u>90</u>	<u>2,120</u>	<u>47,890</u>
GROSS WATER SERVICE AREA	35,680	10,850	8,490	55,020	129,460	620	3,020	133,100

NONWATER-SERVICE AREA

Nonirrigated Agriculture	330	430	490	1,250	4,410	60	60	4,530
Native Vegetation	4,100	1,560	2,700	8,360	21,880	2,980	4,700	29,560
Unclassified	<u>260</u>	<u>1,100</u>	<u>13,850</u>	<u>15,210</u>	<u>38,920</u>	<u>50,730</u>	<u>24,880</u>	<u>114,530</u>
GROSS NONWATER-SERVICE AREA	<u>4,690</u>	<u>3,090</u>	<u>17,040</u>	<u>24,820</u>	<u>65,210</u>	<u>53,770</u>	<u>29,640</u>	<u>148,620</u>
TOTALS	40,370	13,940	25,530	79,840	194,670	54,390	37,660	281,720

*Less than 5 acres

SUBAREAS OF THE ORANGE COUNTY AREA, 1964

San Juan Unit								UNIT TOTAL	TOTAL INVESTIGATION AREA
Laguna Subunit				SUBUNIT	San Juan	San Clemente	San Mateo		
San Joaquin Subarea	Laguna Subarea	Aliso Subarea	Dana Point Subarea	TOTAL	Subunit	Subunit	Subunit		
340	700	480	440	1,960	940	1,350	10	4,260	58,390
30	120	50	60	260	160	270	10	700	12,530
0	0	10	0	10	30	10	0	50	2,850
<u>10</u>	<u>10</u>	<u>150</u>	<u>100</u>	<u>270</u>	<u>200</u>	<u>200</u>	<u>0</u>	<u>670</u>	<u>7,460</u>
380	830	690	600	2,500	1,330	1,830	20	5,680	81,230
<u>100</u>	<u>360</u>	<u>1,020</u>	<u>420</u>	<u>1,900</u>	<u>1,380</u>	<u>1,280</u>	<u>90</u>	<u>4,650</u>	<u>59,360</u>
480	1,190	1,710	1,020	4,400	2,710	3,110	110	10,330	140,590
0	0	0	0	0	220	0	0	220	450
0	0	130	0	130	30	40	0	200	1,340
0	20	790	0	810	1,840	0	0	2,650	26,730
0	0	20	0	20	450	0	0	470	21,480
0	0	0	0	0	20	0	0	20	3,500
0	0	0	0	0	0	0	0	0	500
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>130</u>
0	20	940	0	960	2,560	40	0	3,560	54,130
0	0	10	0	10	30	0	0	40	1,370
<u>0</u>	<u>*</u>	<u>60</u>	<u>0</u>	<u>60</u>	<u>240</u>	<u>*</u>	<u>0</u>	<u>300</u>	<u>6,260</u>
<u>0</u>	<u>20</u>	<u>1,010</u>	<u>0</u>	<u>1,030</u>	<u>2,830</u>	<u>40</u>	<u>0</u>	<u>3,900</u>	<u>61,760</u>
480	1,210	2,720	1,020	5,430	5,540	3,150	110	14,230	202,350
0	0	650	0	650	1,690	0	0	2,340	8,120
0	430	1,800	170	2,400	11,990	10	680	15,080	53,000
<u>3,930</u>	<u>5,690</u>	<u>17,730</u>	<u>5,110</u>	<u>32,460</u>	<u>82,090</u>	<u>9,520</u>	<u>10,810</u>	<u>134,880</u>	<u>264,620</u>
<u>3,930</u>	<u>6,120</u>	<u>20,180</u>	<u>5,280</u>	<u>35,510</u>	<u>95,770</u>	<u>9,530</u>	<u>11,490</u>	<u>152,300</u>	<u>325,740</u>
4,410	7,330	22,900	6,300	40,940	101,310	12,680	11,600	166,530	528,090

agricultural categories are shown individually in Table 5, they were not differentiated on the plate. Also omitted from the plate were developed nonwater service lands, such as nonirrigated agriculture, and undeveloped nonwater service lands, such as native vegetation. The boundaries of major water agencies are shown in detail on Plate 2. In Table 7, the eight agencies listed to the left of The Metropolitan Water District of Southern California are all members of it; their totals are given in the Metropolitan Water District column. About 397,000 acres, or 75 percent of the study area, lie within these eight major water service districts. These same districts include more than 99 percent (201,120 acres) of the gross water service area (202,350 acres).

Changes in Land Use

Changes in land use within the study area are indicated in Table 8 which lists land use data obtained during both the 1957 and 1964 surveys. The locations of these land use changes have been delineated on Plate 4. During the period between these surveys the gross urban and suburban area increased from 69,490 acres to 140,590 acres, an increase of 102 percent. Gross irrigated agricultural area was reduced by 40,160 acres, from 101,920 acres to 61,760 acres, a drop of 39 percent. The total gross water service area increased from 171,410 acres in 1957 to 202,350 acres in 1964, an 18 percent-increase.

Residential area increased from 27,960 acres in 1957 to 58,390 acres in 1964, a gain of 109 percent. Commercial lands gained by 244 percent, increasing from 3,640 acres in 1957 to 12,530 acres in 1964. The area in industry increased from 1,450 acres in 1957 to 2,850 acres in 1964,

TABLE 6
 LAND USE BY COUNTIES IN THE ORANGE
 COUNTY AREA, 1964
 In acres

Category and Class of Land Use	Orange	Los Angeles	Riverside	San Bernardino	TOTAL
WATER SERVICE AREA					
Urban and Suburban					
Residential	58,260	0	50	80	58,390
Commercial	12,510	0	0	20	12,530
Industrial	2,850	0	0	0	2,850
Unsegregated urban and suburban area	<u>7,280</u>	<u>0</u>	<u>30</u>	<u>150</u>	<u>7,460</u>
Subtotals	80,900	0	80	250	81,230
Included Nonwater-Service Area	<u>59,240</u>	<u>0</u>	<u>60</u>	<u>60</u>	<u>59,360</u>
Gross Urban and Suburban Area	140,140	0	140	310	140,590
Irrigated Agriculture					
Alfalfa	450	0	0	0	450
Pasture	1,340	0	0	0	1,340
Citrus and subtropical	26,630	0	30	70	26,730
Truck crops	21,480	0	0	0	21,480
Field crops	3,500	0	0	0	3,500
Deciduous fruits and nuts	500	0	0	0	500
Small grains	<u>130</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>130</u>
Subtotals	54,030	0	30	70	54,130
Fallow	1,370	0	0	0	1,370
Included Nonwater-Service area	<u>6,240</u>	<u>0</u>	<u>10</u>	<u>10</u>	<u>6,260</u>
Gross Irrigated Agriculture	<u>61,640</u>	<u>0</u>	<u>40</u>	<u>80</u>	<u>61,760</u>
GROSS WATER SERVICE AREA	201,780	0	180	390	202,350
NONWATER-SERVICE AREA					
Nonirrigated Agriculture	8,120	0	0	0	8,120
Native Vegetation	51,070	0	1,510	420	53,000
Unclassified	<u>246,800</u>	<u>970</u>	<u>4,740</u>	<u>12,110</u>	<u>264,620</u>
GROSS NONWATER-SERVICE AREA	<u>305,990</u>	<u>970</u>	<u>6,250</u>	<u>12,530</u>	<u>325,740</u>
TOTALS	507,770	970	6,430	12,920	528,090

TABLE 7

LAND USE IN MAJOR WATER AGENCIES
In acres

Category and Class of Land Use	Coastal Municipal Water District	Chino Basin Municipal Water District	Orange County Municipal Water District	Pomona Valley Municipal Water District
WATER SERVICE AREA				
Urban and Suburban				
Residential	6,860	80	43,070	0
Commercial	1,830	10	8,630	0
Industrial	290	0	2,000	0
Unsegregated urban and suburban area	<u>500</u>	<u>140</u>	<u>6,180</u>	<u>0</u>
Subtotals	9,480	230	59,880	0
Included Nonwater-Service Area	<u>5,340</u>	<u>60</u>	<u>46,660</u>	<u>0</u>
Gross Urban and Suburban Area	14,820	290	106,540	0
Irrigated Agriculture				
Alfalfa	0	0	230	0
Pasture	60	0	1,270	0
Citrus and subtropical	170	70	25,690	0
Truck crops	90	0	21,290	0
Field crops	10	0	3,380	0
Deciduous fruits and nuts	0	0	500	0
Small grains	<u>0</u>	<u>0</u>	<u>130</u>	<u>0</u>
Subtotals	330	70	52,490	0
Fallow	0	0	1,320	0
Included Nonwater-Service Area	<u>100</u>	<u>20</u>	<u>5,760</u>	<u>0</u>
Gross Irrigated Agriculture	<u>430</u>	<u>90</u>	<u>59,570</u>	<u>0</u>
GROSS WATER SERVICE AREA	15,250	380	166,110	0
NONWATER-SERVICE AREA				
Nonirrigated Agriculture	730	0	5,380	0
Native Vegetation	1,190	390	37,980	0
Unclassified	<u>15,850</u>	<u>12,170</u>	<u>114,520</u>	<u>950</u>
GROSS NONWATER-SERVICE AREA	<u>17,770</u>	<u>12,560</u>	<u>157,880</u>	<u>950</u>
TOTALS	33,020	12,940	323,990	950

*Less than five acres

**Agency formed primarily to spread water; its territory overlaps that of other agencies.

OF THE ORANGE COUNTY AREA, 1964

Western Municipal Water District of Riverside County	City of Santa Ana	City of Anaheim	City of Fullerton	Metropolitan Water District of Southern California	Orange County** Water District
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80	3,260	1,320	3,420	58,090	48,090
10	1,000	380	650	12,510	10,410
0	130	190	230	2,840	2,490
<u>30</u>	<u>120</u>	<u>80</u>	<u>340</u>	<u>7,390</u>	<u>5,380</u>
120	4,510	1,970	4,640	80,830	66,370
<u>80</u>	<u>1,780</u>	<u>880</u>	<u>4,100</u>	<u>58,900</u>	<u>46,660</u>
200	6,290	2,850	8,740	139,730	113,030
0	0	0	0	230	210
0	0	0	0	1,330	1,030
30	340	60	340	26,700	21,500
0	50	0	10	21,440	19,480
0	*	0	110	3,500	3,230
0	0	0	0	500	500
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>130</u>	<u>10</u>
30	390	60	460	53,830	45,960
0	0	0	0	1,320	1,230
<u>10</u>	<u>40</u>	<u>*</u>	<u>310</u>	<u>6,240</u>	<u>5,310</u>
<u>40</u>	<u>430</u>	<u>60</u>	<u>770</u>	<u>61,390</u>	<u>52,500</u>
240	6,720	2,910	9,510	201,120	165,530
0	0	0	400	6,510	3,220
1,510	20	10	820	41,920	21,580
<u>3,940</u>	<u>10</u>	<u>0</u>	<u>10</u>	<u>147,450</u>	<u>10,780</u>
<u>5,450</u>	<u>30</u>	<u>10</u>	<u>1,230</u>	<u>195,880</u>	<u>35,580</u>
5,690	6,750	2,920	10,740	397,000	201,110

amounting to an increase of about 96 percent. In the unsegregated urban and suburban category, which includes such land use types as dairies, farmsteads, livestock ranches, parks, cemeteries, and golf courses, land use increased from 6,090 acres in 1957 to 7,460 acres in 1964 -- a total increase of 22 percent.

A great deal of the residential growth between 1957 and 1964 occurred on what had been irrigated agricultural land; this accounted for most of the 39-percent loss in that category. New construction is also spreading to nonirrigated agricultural lands as well as raw brush lands. Valley lands are most vulnerable to development, although hilltops are being leveled by heavy equipment and are being developed.

The comparatively small percentage increase in development of the unsegregated urban and suburban area is caused by a shift rather than a loss of dairies and feedlots. The dairy industry has shifted from the older, established dairy-producing areas to more rural areas of the county. Because the dairy owner can no longer afford a large pasture area connected to his farm, he has reduced his operation to a milking shed, processing house, and holding pens. Instead of pasture to roam in, the dairy cows are now kept in what resembles a feedlot where they eat imported hay. This dairy feedlot operation may be expected to continue to develop in the more rural areas of the county where less expensive land can be obtained.

New golf courses are being constructed in many areas of the county. Their appearance is most noticeable adjacent to the large city-like developments such as the condominium and the retirement city.

TABLE 8

COMPARISON OF 1957 AND 1964 LAND USE
IN THE ORANGE COUNTY AREA
In acres

Category and Class of Land Use	1957	1964	Percent Change
WATER SERVICE AREA			
Urban and Suburban			
Residential	27,960	58,390	109
Commercial	3,640	12,530	244
Industrial	1,450	2,850	96
Unsegregated urban and suburban area	<u>6,090</u>	<u>7,460</u>	22
Subtotals	39,140	81,230	108
Included Nonwater-Service Area	<u>30,350</u>	<u>59,360</u>	96
Gross Urban and Suburban Area	69,490	140,590	102
Irrigated Agriculture			
Alfalfa	2,450	450	-82
Pasture	4,070	1,340	-67
Citrus and subtropical	48,470	26,730	-45
Truck crops	20,330	21,480	6
Field crops	19,670	3,500	-82
Deciduous fruits and nuts	1,060	500	-53
Small grains	<u>770</u>	<u>130</u>	-83
Subtotals	96,820	54,130	-44
Fallow	*	1,370	- -
Included Nonwater-Service Area	<u>5,100</u>	<u>6,260</u>	23
Gross Irrigated Agriculture	<u>101,920</u>	<u>61,760</u>	-39
GROSS WATER SERVICE AREA	171,410	202,350	18
NONWATER-SERVICE AREA			
Nonirrigated Agriculture	45,980	8,120	-82
Native Vegetation	26,860	53,000	97
Unclassified	<u>283,840</u>	<u>264,620</u>	-7
GROSS NONWATER-SERVICE AREA	<u>356,680</u>	<u>325,740</u>	-9
TOTALS	528,090	528,090	

*Value Distributed Between Truck Crops and Nonirrigated Agriculture

As has been pointed out, a large part of the 39-percent decrease in agriculture can be attributed to urban development. Citrus and sub-tropical fruits suffered the greatest numerical loss, declining 45 percent, from 48,470 acres in 1957 to 26,730 acres in 1964. Field crops declined from 19,670 acres in 1957 to 3,500 acres in 1964. This 82-percent loss may actually be the result of the lower economic value of field crops and a shift to more intensive farming. Many acres of field crops formerly in



Leisure World near El Toro

SPENCE AIR PHOTOS

There are a number of retirement communities within the county – some being cities in themselves, covering hundreds of acres.

dry beans and other low income crops are now planted in truck crops. Pasture land declined about 67 percent, dropping from 4,070 acres to 1,340 acres. This too may be due to a lower economic value of the pasture land which has resulted in the changeover to a feedlot operation in the dairy industry. The only increase recorded in crop acreage within the county was experienced in truck crops, where the area increased from 20,330 acres to 21,480 acres. This amounts to a 6-percent increase since 1957.



College and Shopping Center
Development in Santa Ana

PACIFIC AIR INDUSTRIES

From 1957 to 1964, commercial lands gained by 244 percent.

CHAPTER IV. WATER USE

To estimate the 1964 level of water use, the land use data reported in Chapter III were used with the unit values assigned to the various types of water use (as described in Appendix B). The results of this computation are presented in this chapter plus a comparison of these estimates with those from the 1957 survey. In addition, this indicated demand is compared with the estimated water supply.

Estimates of 1964 Net Water Use

The level of net water use in Orange County under 1964 conditions of development and under average precipitation and climatic conditions was estimated by applying mean seasonal unit values of consumptive use of applied water or, in some cases, total applied water to the net areas of each type of land use.

In water service areas overlying or tributary to free ground water basins, it was assumed that all applied water in excess of consumptive use requirements, except the portions of sewage and industrial waste exported from the area, returns to ground water storage and is available for reuse. The net water use for such an area was **estimated** to be the sum of the consumptive use of applied water plus sewage export. The inland or forebay area of Orange County was treated in **this manner**.

Recent studies by the Department have indicated that there is some deep percolation occurring in areas overlying confined ground water basins. The quantities and rates of recharge are not yet known. Therefore for this report, as in Bulletin No. 70, it has been assumed that deep percolation is limited and that net water use for these areas was considered to be equal to the total applied water. This method of calculating net water use was used in the coastal

part of the county because it overlies a pressure area where deep percolation is limited (pressure and forebay areas shown on Plate 1). Furthermore, some of the ground water basins underlying the coastal area are contaminated by oil brines or sea water. It is reasonable to assume that percolating water would be degraded in quality so that it could not be reused.

Details of the method used to estimate net water use are given in Appendix B, plus a brief discussion of unit water use. Unit values of water use for the study area are in Table 13 in Appendix B.

The estimated levels of mean seasonal net water use in Orange County, for 1964 conditions, are presented in Table 9. For comparison, values estimated for 1957 conditions are also given.

As indicated in the first part of this chapter, the unit values used to derive the net water use represent the needs of the various types of water-using developments under average conditions of precipitation and climate. The actual net water use for a specific year may have differed from the estimated values reported here because of deviations from the mean, but the estimates presented indicate the general level of water use.

Mean annual precipitation recorded at climatological stations in Anaheim, Newport Beach, and San Clemente over a 30-year period (1930-1961) were 13.76, 11.99, and 12.27 inches, respectively. During both water years 1956-57 and 1963-64, the average precipitation was 67 percent of the 30-year mean precipitation for these stations. Therefore, although the estimates of levels of net water use shown in Table 9 are probably on the low side as compared to actual water use, the difference between estimates for the two years shown is considered to be a good estimate of the change in water use during the period.

TABLE 9

ESTIMATED LEVELS OF NET WATER USE IN THE STUDY AREA
FOR CONDITIONS OF DEVELOPMENT IN 1957 AND 1964

In acre-feet

Development	1957	1964	Change
Irrigated lands	139,900	84,900	- 55,000
Urban-suburban lands	<u>104,100</u>	<u>220,500</u>	<u>+116,400</u>
TOTAL	244,000	305,400	+ 61,400

Net water use data presented in this report reflect the changes in land use that were given in Chapter III. The estimated seasonal net water use for 1964 was 305,400 acre-feet -- this was an increase of 25 percent, or 61,400 acre-feet, above that of 1957. Urban-suburban water use increased by 116,400 acre-feet, almost 112 percent, while water use by irrigated agriculture decreased 55,000 acre-feet, or 39 percent.

TABLE 10

COMPARISON OF NET WATER USE AND
SUPPLEMENTAL REQUIREMENTS IN THE STUDY AREA

In acre-feet

Date of survey	Net water use	Safe yield* of local supplies	Supplemental water requirements	Historic imports**
1957	244,000	153,500	90,500	154,200
1964	305,400	153,500	151,900	303,400
1990	591,000	153,500	437,500	--
2020	804,000	153,500	650,500	--

*From Bulletin No. 78, Appendix D.

**From The Metropolitan Water District of Southern California.

Comparison with Water Supply

As was pointed out earlier, the water supply for the study area comes from local ground water and imports from the Colorado River. The approximate mean annual safe yield of the local supply as is shown in Table 10, has been estimated in earlier studies of the Department to be 153,500 acre-feet. Included in Table 10 is the forecast net water use for the years 1990 and 2020 as derived from current Department studies.



Changes in Land Use, Looking
North from near Garden Grove

SPEENCE AIR PHOTOS

For many years Orange County has been one of the fastest growing areas in the nation. (Same scene in two photos – above: 1956; on facing page: 1963.)

The export of sewage has been included in the net water use value in those areas overlying the forebay. Department records show that this was about 25,200 acre-feet in 1957. By 1964, it had reached 48,500 acre-feet. The imported water shown in Table 10 does not include that imported to the Los Angeles-San Gabriel Unit from adjacent ground water basins in Los Angeles County. These imports are small when compared to that imported through The Metropolitan Water District of Southern California.



SPENCE AIR PHOTOS

By the year 2020, the estimated total seasonal net water use for Orange County, as derived from current Department studies, will be on the order of 804,000 acre-feet. Of this, 650,500 acre-feet will have to be obtained by importing supplies. The expected increase in net water use between the present and the year 2020 will result largely from the development of land currently not receiving water service.

In the development of estimates of future requirements for water, particularly for urban areas, the value of the requirement can vary, depending upon the assumption made, particularly with respect to the disposition of sewage. The estimated requirement for the year 2020, presented above, was based on the assumption that additional facilities will be constructed to export sewage from the study area.

Experience has indicated that, as areas approach a high degree of urbanization, aesthetic conditions force the disposal of sewage to the ocean. It is recognized that the collection and central disposal of sewage is required in many areas to avoid public health problems and that the export of a certain amount of sewage, together with various industrial wastes, is necessary to maintain salt balance in ground water bodies. The derivation of the volume of such waste that is required to prevent adverse salt balance is beyond the scope of this investigation. However, the foregoing estimates of future net water use illustrate the extent to which the development of facilities for reclamation and local use of waste waters and for ocean disposal of sewage can affect water needs. It is, therefore, indicated that any such estimates may be subject to considerable modification, depending upon the ultimate sewerage system developed for the drainage area.

Regardless of the degree of development of facilities for ocean disposal of sewage in Orange County, estimates of net water use presented above indicate that a large increase in the volume of water imported to the area will be required to meet forecast demands.

To help meet this demand, The Metropolitan Water District of Southern California has contracted with the California Department of Water Resources to purchase over 2,000,000 acre-feet of water from the State Water Project. The State Water Project is expected to meet the area's supplemental water needs until 1990. Deliveries are to begin in 1971 and a portion of this water will be sold through the Metropolitan Water District to its member agencies in Orange County.

Demands for water after 1990 will require further implementation of the California Water Plan to convey additional supplemental water to Southern California, plus increased emphasis on the reclamation of waste water and sea-water desalination.

Appendix A

CLASSIFICATION OF LAND USE
AND
CONDUCT OF THE STUDY

Appendix A

CLASSIFICATION OF LAND USE AND CONDUCT OF THE STUDY

For analysis and presentation, the various land uses are grouped into two major categories under water service areas: (1) urban and suburban, and (2) irrigated agriculture; and into three major categories under nonwater service areas: (1) nonirrigated agriculture, (2) native vegetation, and (3) unclassified. Each of the two categories under water service areas includes several classes of land use. The classes include a number of types of land use -- all types within a class requiring similar unit amounts of water.

The major categories, classes, and types of land use in the classification are listed in Table 11.

In delineating land use types in the field, no attempt was made to exclude such items as streets, roads, railroad and powerline rights-of-way, and other essentially nonwater-using lands occurring within the surveyed areas. Later in the office, these land uses were extracted from overall land use totals by applying to each major land use class a percentage value appropriate for that class. The amounts extracted from gross land use totals were then classified as "included nonwater service area".

During this survey, a brief study was made to reevaluate the reduction factors for residential and commercial land use classes. The appropriate percentage reduction factors for the major classes of land use are presented in Table 12.

TABLE 11

MAJOR CATEGORIES, CLASSES, AND TYPES OF LAND USE FOR
WATER SERVICE AND NONWATER SERVICE AREAS

Category and class of land use	:	Types of land use
<u>WATER SERVICE AREA</u>		
<u>Urban and Suburban Category</u>		
Residential		Single- and multiple-family houses and apartments, trailer parks, and residential subdivisions under construction at time of survey.
Commercial		All classes of commercial enterprises, including strip commercial and downtown commercial areas, schools, hospitals, churches, and motels.
Industrial		All classes of industrial land use involving manufacturing, processing, packaging, but excluding extractive (oil, sand, and gravel), storage, and distribution facilities.
Unsegregated urban and suburban		Dairies, farmsteads, livestock ranches, parks, cemeteries, and golf courses.
Included nonwater service		Oilfields, tank farms, vacant lots, quarries, gravel pits, warehouses, storage yards, railroad rights-of-way, public streets, landing strips of airfields, and miscellaneous paved areas.
<u>Irrigated Agriculture Category</u>		
Alfalfa		Alfalfa raised for hay, seed, or pasture.
Pasture		Irrigated grasses and legumes, other than alfalfa, used for livestock forage.
Citrus and subtropical		Oranges, lemons, grapefruit, avocados, olives, and miscellaneous subtropical fruits.
Truck crops		Vegetables of all varieties, melons, flower seed, and nursery crops.
Field crops		Sugar beets, corn, cotton, flax, and sorghums.
Deciduous fruits and nuts		All varieties of deciduous fruits and nuts.
Small grain		Barley, wheat, and oats.
Fallow		Land tilled between crops.
Included nonwater service		Public highways and roads, farm access roads, canals, and other inclusions not devoted to crop production, including irrigated idle and abandoned lands.
<u>NONWATER SERVICE AREA</u>		
<u>Nonirrigated Agriculture Category</u>		
		All varieties of dry-farmed crops, including pasture, nonirrigated fallow, and idle, that overlie defined ground water basins.
<u>Native Vegetation Category</u>		
		Native grasses, brush, and trees, including phreatophytes, that overlie defined ground water basins.
<u>Unclassified Category</u>		
		Bare ground, including river washes, beaches, and water surfaces, that overlie defined ground water basins; nonirrigated agriculture and native vegetation not overlying defined ground water basins.

TABLE 12
FACTORS FOR REDUCTION OF
GROSS AREAS TO NET AREAS

Land use	:	Percent deducted
	:	from gross area
Residential		22
Residential (low density)		10
Commercial		20
Schools		15
Industrial, manufacturing		25
Parks, cemeteries, and golf courses		15
Farmsteads, livestock ranches, and dairies		10
Irrigated agriculture		5

The net acreage values used in the tables summarizing land use represent the gross acreage values minus those portions of the gross values that have been deducted for these included nonwater-service areas.

Mapping of land use in Orange County was carried out by field crews who delineated the various land use types on recent aerial photographs. In the office, these field delineations were projected onto reproducible prints of U. S. Geological Survey quadrangle maps at a scale of 1:24,000. These maps served as area control maps insuring the accuracy of the succeeding process, while the reproducible prints served as masters for reproducing land use delineations on vellum prints. The individual areas of land use types were cut from the vellum prints and weighed, and these weights were converted into total acreages of individual land use types. These various land use types were grouped according to their

water requirements. Then, appropriate unit values of water use were employed to estimate net water use.

Land use data collected by the Department of Water Resources are processed by machine techniques, which permit the evaluation of this data in terms of a sizable number of hydrologic, geographic, or political subdivisions. The tabulations in the main body of this report give land use within the boundaries that are thought to be the most generally useful.

For a critical hydrologic analysis, determining and compiling the types of land use -- both developed and undeveloped -- for the entire area of the hydrologic unit would be desirable. This would permit a comprehensive analysis and evaluation of the various levels of water use for the entire area. However, the additional expense incurred in making such a complete compilation is not felt to be warranted at present; therefore, only those areas that are underlain by water-bearing material are mapped in their entirety. In those areas that are not underlain by water-bearing material, only types of land use requiring applied water are mapped. All other types of land use in areas not underlain by water-bearing material are tabulated in a category called "unclassified".

Appendix B

UNIT VALUE METHOD FOR
ESTIMATING NET WATER USE

Appendix B

UNIT VALUE METHOD FOR ESTIMATING NET WATER USE

Where none of the applied water is available for reuse, the net water use is determined by measuring the total applied water. On the other hand, in areas where a portion of the applied water becomes available for reuse, it is not possible to measure the volume of return flow of reusable water. The net water use in these areas must be determined in another manner; therefore, an indirect method is used.

In the indirect method employed in this investigation, estimates of net water use are obtained by multiplying the areas of the various classes of water-using developments by appropriate average values of consumptive use of applied water. These unit values of consumptive use reflect average conditions of precipitation and the normal practices associated with urban water distribution and with irrigated agriculture.

When using this method for determining net water use, the unit values of consumptive use of water must be clearly correlated with the appropriate land use classes or types (see Appendix A). This is especially critical for residential, industrial, and commercial water uses.

During this investigation, urban and suburban unit values of consumptive use of applied water derived in State Water Resources Board's Bulletin No. 2 and Department of Water Resources' Bulletin No. 70 were reviewed and were found to be the best available. A complete discussion of the techniques employed in the derivation of units of water use is contained in Bulletin No. 2; therefore, only a general description of those procedures is given here.

TABLE 13

ESTIMATED MEAN SEASONAL UNIT VALUES OF DELIVERY AND
CONSUMPTIVE USE OF APPLIED WATER ON URBAN-SUBURBAN
AND IRRIGATED LANDS IN THE ORANGE COUNTY AREA

In feet of depth

Land use type	Hydrologic Unit			
	Los Angeles-San Gabriel		San Juan	
	River and Santa Ana River			
	C.U.A.W.*	Delivery	C.U.A.W.*	Delivery
<u>Urban-Suburban Lands</u>				
Residential				
Single	1.3	2.6	1.3	2.8
Estate	.9	2.0	.9	2.2
Multiple	.3	4.5	.3	5.0
Recreational	.2	0.4	.2	0.4
Farmstead	.8	1.8	.8	1.8
Commercial				
Strip	.4	3.4	.4	4.0
Downtown	1.1	10.2	1.1	--
Industrial, manufacturing	1.4	10.8	1.4	10.8
Schools	.4	0.9	.4	1.1
Parks, cemeteries, and golf courses	2.4	3.4	2.5	3.6
Dairies	1.0	1.9	1.0	--
Livestock and poultry ranches	.6	1.3	.6	1.3
<u>Irrigated Lands</u>				
Alfalfa	2.4	3.4	2.4	3.4
Pasture	2.4	3.4	2.5	3.6
Deciduous fruits and nuts	1.7	2.4	1.5	2.1
Citrus and subtropical fruit	1.3	1.9	1.4	2.0
Truck crops	1.3	1.8	1.4	2.0
Field crops	1.3	1.9	1.3	1.9
Small grains	.7	1.0	.4	0.6

*Consumptive use of applied water.

Mean seasonal unit values of consumptive use of applied water on urban and suburban lands were estimated for Bulletin No. 2 on the

basis of a sampling procedure in which an inventory was made of measured water deliveries to study areas representative of each class or type of land use. For residential and commercial areas, study areas consisting of single blocks devoted entirely to one type of land use were selected. To compute the unit values of water use, an allowance for the applied water that is disposed of as sewage and is returned to the ground water body was deducted, and the remainder was divided by the net sampled area. Unit seasonal values of consumptive use of applied water by irrigated crops were derived by a method developed for the U. S. Department of Agriculture by Harry F. Blaney and Wayne D. Criddle.

The mean seasonal unit values of consumptive use and delivery of water so determined, shown in Table 13, along with sewage export, were utilized to compute net water use in all forebay areas where excesses of consumptive use are available for reuse through deep percolation.

In the coastal pressure areas of the county, net water use was estimated by applying unit values of delivery to the net areas of land use. The applied water or delivery figure is used in any area where deep percolation is restricted and recharge of the ground water basin is assumed to be negligible.

It should be pointed out that, in the derivation of the net water use for any given year, the volume of applied water required is based on the assumption that the precipitation for the season was equal to the long-time mean. However, the use of applied water will actually be somewhat larger or smaller in individual years, varying inversely with the amount of rainfall. A similar effect occurs with urban use; however, the use of precipitation by residential, commercial, and industrial

classifications is relatively small. Therefore, variations of rainfall from year to year have a lesser effect upon the use of applied water by these land use classes than by irrigated lands. Despite the possibility of these variations, the procedures used in this survey are considered by the Department to be the best available, resulting in reasonable values of current levels of water use.

Appendix C

DEFINITION OF TERMS

Appendix C

DEFINITION OF TERMS

Annual - The 12-month period from January 1 of a given year through December 31 of the same year, also called the "calendar year".

Applied Water - Water delivered to a farmer's headgate, in the case of irrigation use, or to an individual's meter (or its equivalent), in the case of urban use. Applied water does not include direct precipitation. Man applies water to satisfy the requirement for consumptive use in excess of the amount supplied from natural sources. However, as a practical matter, the quantity of water applied is usually in excess of the consumptive use of applied water and that portion of the water applied to any use that is not consumed or irrecoverably lost remains a part of the water supply.

Average - An arithmetical average relating to a period other than a mean period.

The California Water Plan - A master plan to guide and coordinate the planning and construction by all agencies of works required for the control, protection, conservation, and distribution of California's water resources for the benefit of all areas of the State and for all beneficial purposes.

Confined Ground Water - A body of ground water that is immediately overlain by material sufficiently impervious to sever free hydraulic connection with overlying water and that is acted upon by pressure caused by the difference in head between the intake, or forebay area, and the discharge area of the confined water body.

Consumptive Use of Water - Water from any source consumed by vegetative growth in transpiration and building plant tissue, also water evaporated from adjacent soil, from water surface, and from foliage. It also refers to water similarly consumed or evaporated by urban and nonvegetative types of land use.

Forebay Area - An area that consists of unconfined ground water where hydraulic continuity with the ground surface generally exists and that is located so as to provide a supply of ground water by subsurface flow to a body of confined ground water.

Free Ground Water - A body of ground water not immediately overlain by impervious materials.

Gross Area - An area of land use, as mapped in the field, which includes the acreage of streets, roads, railroad and powerline rights-of-way, and other essentially nonwater-using lands.

Ground Water Overdraft - The annual net extraction of water from a ground water basin in excess of safe yield.

Hydrologic Unit* - In this bulletin, a classification embracing one of the following two topographic characteristics, both of which are defined by surface drainage divides:

- a. In general, the total watershed area, including water-bearing and nonwater-bearing formations, such as the total drainage to the Santa Ana River.

*The areal designation system, i.e., categorizing areas into units, subunits and subareas, is designed to separate data according to areas of hydrologic significance. The system, as developed, does not differentiate between water-bearing formations and nonwater-bearing tributary areas, although land use, as inventoried, does differentiate between such boundaries.

- b. In coastal areas, two or more small contiguous watersheds having similar hydrologic characteristics and water supply problems, each watershed being directly tributary to the ocean and all watersheds emanating from one mountain body located immediately adjacent to the ocean.

Hydrologic Subunit* - In this bulletin, a major logical subdivision of a hydrologic unit, including water-bearing and nonwater-bearing formations, best typified by a major tributary of a stream, a major valley, or a plain along a stream containing one or more ground water basins and having closely related geologic, hydrologic, and topographic characteristics.

Hydrologic Subarea* - In this bulletin, a logical subdivision of a hydrologic subunit which may include either water-bearing or nonwater-bearing formations or both. Where possible, a hydrologic subarea includes one known ground water basin and its tributary area; the ground water basin comprising the water-bearing deposits of the subarea. In areas which are essentially nonwater bearing, the subarea division was based only on surface drainage conditions, and such factors as locations of gaging stations were given due consideration.

Irrecoverable Losses - Such items as disposal or seepage of unconsumed water to bodies of unsuitable quality, including the ocean, and disposal or seepage of unconsumed water in such a manner as to be uneconomical to recapture for use. These irrecoverable losses are incidental to consumptive use of water.

*See Footnote on preceding page.

Irrigation Efficiency - The ratio of consumptive use of applied irrigation water to the total amount of water applied, expressed as a percentage.

Mean - An arithmetical average relating to a mean period.

Mean Period - A period chosen to represent conditions of water supply and climate over a long series of years. For the current investigation, the mean precipitation period embraces the 50 seasons from 1897-98 through 1946-47.

Net Area - An area of land use less the area in streets, road, railroad and powerline rights-of-way, and other essentially nonwater-using lands.

Net Water Use - That portion of applied water which is consumptively utilized for beneficial purposes or otherwise irrecoverably lost. It does not include that portion of the applied water which is subject to possible reuse.

Overdraft - The annual net extraction of water from a ground water basin in excess of safe ground water yield.

Pressure Area - A ground surface area underlain by an aquifer containing confined ground water.

Primary Effluent - Waste water that has gone through the primary treatment process. Primary treatment removes a portion of the settleable, suspended, and floating matter from domestic or industrial waste by screening, skimming, sedimentation, or other physical means.

Safe Yield - The average annual net amount of water that could be beneficially extracted from a ground water basin over an indefinitely

long period of years under a particular set of physical conditions affecting supply to and disposal from the ground water basin, without causing a net lowering of ground water levels during the period.

Seasonal - Any 12-month period other than the calendar year.

Water Use - In the broadest sense, includes all uses of water by nature or by man, whether consumptive or nonconsumptive, as well as irrecoverable losses of water incidental to such employment. It is synonymous with "water utilization".

Appendix D

REPORTS ON RELATED INVESTIGATIONS
AND OTHER REFERENCES

Appendix D

REPORTS ON RELATED INVESTIGATIONS AND OTHER REFERENCES

There are three very important reports which are related to this bulletin:

California State Water Resources Board, "Water Utilization and Requirements of California", Bulletin No. 2, June 1955. This bulletin was written in preparation of The California Water Plan and contains information on land and water use for the entire State. The land use data is based on a survey made in 1948.

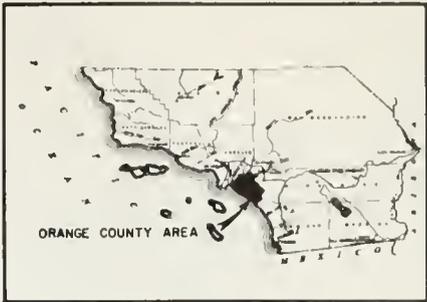
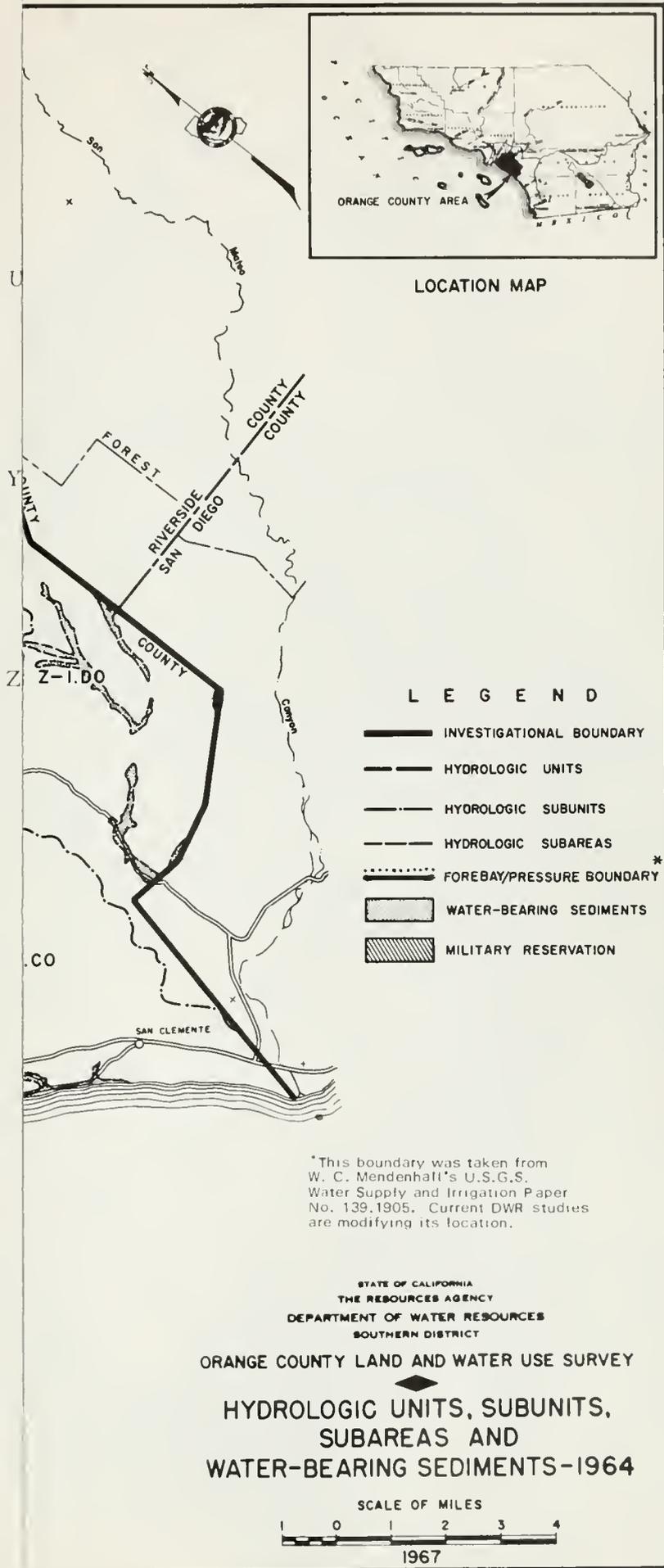
California Department of Water Resources, "Santa Ana River Investigation", Bulletin No. 15, February 1959. Hydrology of the entire Santa Ana River drainage area was the subject of this report. It contains an inventory of surface and underground water resources along with estimates of ultimate water utilization and requirements. Like Bulletin No. 2, this report is based on the 1948 land use survey.

California Department of Water Resources, "Orange County Land and Water Use Survey, 1957", Bulletin No. 70, January 1959. This report sets the pattern which Bulletin No. 70-64 follows. Land and water use data are based on a 1957 survey. The results of the 1957 bulletin have been used extensively in the present report for comparison.

Other references which were helpful throughout the course of this study are presented below:

Bank of America National Trust and Savings Association. "Focus on Orange County." No date

- California Department of Public Works, Division of Water Resources.
"Present Overdraft on, and Safe Yield from, the Ground Water of
the Coastal Plain of Orange County." June 1945.
- . "South Coastal Basin Investigation, Overdraft on Groundwater
Basins." Bulletin No. 53. 1947.
- California Department of Water Resources. "Investigation of Alternative
Aqueduct Systems to Serve Southern California", Appendix D. "Economic
Demand for Imported Water." Bulletin No. 78, Appendix D. March 1960.
- . "Upper Santa Ana River Drainage Area Land and Water Use Survey,
1957." Bulletin No. 71. May 1960.
- . "San Diego County Land and Water Use Survey, 1958." Bulletin
No. 102. August 1963.
- . "Coastal Los Angeles County Land and Water Use Survey, 1960",
Bulletin No. 24-60. March 1964.
- . "Santa Ana Gap Salinity Barrier." Bulletin No. 147-1, Preliminary
Edition. November 1965.
- . "Upper Santa Ana River Drainage Area Land and Water Use Survey,
1964", Bulletin No. 71-64. July 1966.
- Lowry and Associates, and Engineering-Science, Inc. "Waste Water Disposal
and Reclamation for the County of Orange, California 1966-2000."
July 1966.
- Orange County Department of Agriculture, "Agricultural Crop Report, 1951".
- Orange County Planning Department. "Orange County Progress Report."
Volume 3, Supplement No. 5. March 1966.
- Orange County Water District. "Inspection Tour of Water Spreading and
Conservation Facilities-Sea Water Intrusion Areas Within Orange
County Water District." July 17, 1963.



LOCATION MAP

L E G E N D

-  INVESTIGATIONAL BOUNDARY
-  HYDROLOGIC UNITS
-  HYDROLOGIC SUBUNITS
-  HYDROLOGIC SUBAREAS
-  FOREBAY/PRESSURE BOUNDARY *
-  WATER-BEARING SEDIMENTS
-  MILITARY RESERVATION

*This boundary was taken from W. C. Mendenhall's U.S.G.S. Water Supply and Irrigation Paper No. 139, 1905. Current DWR studies are modifying its location.

STATE OF CALIFORNIA
 THE RESOURCES AGENCY
 DEPARTMENT OF WATER RESOURCES
 SOUTHERN DISTRICT

ORANGE COUNTY LAND AND WATER USE SURVEY
 ◆
 HYDROLOGIC UNITS, SUBUNITS,
 SUBAREAS AND
 WATER-BEARING SEDIMENTS-1964



AREAL DESIGNATIONS
HYDROLOGIC UNITS, SUBUNITS, AND SUBAREAS

- U-0.00 Los Angeles Drainage Province
 - U-5.00 Los Angeles-San Gabriel River Hydrologic Unit
 - U-5.F0 Anaheim Hydrologic Subunit
 - U-5.F1 Anaheim Hydrologic Subarea
 - U-5.F2 La Habra Hydrologic Subarea
 - U-5.F3 Yorba Linda Hydrologic Subarea
- Y-0.00 Santa Ana Drainage Province
 - Y-1.00 Santa Ana River Hydrologic Unit
 - Y-1.A0 Lower Santa Ana River Hydrologic Subunit
 - Y-1.A1 East Coastal Plain Hydrologic Subarea
 - Y-1.A2 Santiago Hydrologic Subarea
 - Y-1.A3 Santa Ana Narrows Hydrologic Subarea
- Z-0.00 San Diego Drainage Province
 - Z-1.00 San Juan Hydrologic Unit
 - Z-1.A0 Laguna Hydrologic Subunit
 - Z-1.A1 San Joaquin Hydrologic Subarea
 - Z-1.A2 Laguna Hydrologic Subarea
 - Z-1.A3 Aliso Hydrologic Subarea
 - Z-1.A4 Dana Point Hydrologic Subarea
 - Z-1.B0 San Juan Hydrologic Subunit
 - Z-1.C0 San Clemente Hydrologic Subunit
 - Z-1.D0 San Mateo Hydrologic Subunit



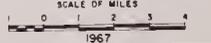
LOCATION MAP

LEGEND

- INVESTIGATIONAL BOUNDARY
- HYDROLOGIC UNITS
- HYDROLOGIC SUBUNITS
- HYDROLOGIC SUBAREAS
- FOREBAY/PRESSURE BOUNDARIES
- WATER-BEARING SEDIMENTS
- MILITARY RESERVATION

* This boundary was taken from
W. C. Mendonça's U.S.G.S.
Water Supply and Irrigation Paper
No. 139 1905. Current DWR studies
are modifying its location.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
ORANGE COUNTY LAND AND WATER USE SURVEY
HYDROLOGIC UNITS, SUBUNITS,
SUBAREAS AND
WATER-BEARING SEDIMENTS-1964



**AREAL DESIGNATIONS
HYDROLOGIC UNITS, SUBUNITS, AND SUBAREAS**

- U-0.00 Los Angeles Drainage Province
 - U-5.00 Los Angeles-San Gabriel River Hydrologic Unit
 - U-5.F0 Anaheim Hydrologic Subunit
 - U-5.F1 Anaheim Hydrologic Subarea
 - U-5.F2 La Habra Hydrologic Subarea
 - U-5.F3 Yorba Linda Hydrologic Subarea
- Y-0.00 Santa Ana Drainage Province
 - Y-1.00 Santa Ana River Hydrologic Unit
 - Y-1.A0 Lower Santa Ana River Hydrologic Subunit
 - Y-1.A1 East Coastal Plain Hydrologic Subarea
 - Y-1.A2 Santiago Hydrologic Subarea
 - Y-1.A3 Santa Ana Narrows Hydrologic Subarea
- Z-0.00 San Diego Drainage Province
 - Z-1.00 San Juan Hydrologic Unit
 - Z-1.A0 Laguna Hydrologic Subunit
 - Z-1.A1 San Joaquin Hydrologic Subarea
 - Z-1.A2 Laguna Hydrologic Subarea
 - Z-1.A3 Aliso Hydrologic Subarea
 - Z-1.A4 Dana Point Hydrologic Subarea
 - Z-1.B0 San Juan Hydrologic Subunit
 - Z-1.C0 San Clemente Hydrologic Subunit
 - Z-1.D0 San Mateo Hydrologic Subunit



- LEGEND**
- INVESTIGATIONAL BOUNDARY
 - HYDROLOGIC UNITS
 - HYDROLOGIC SUBUNITS
 - ORANGE COUNTY WATER DIST
 - CITY OF ANAHEIM
 - CITY OF FULLERTON
 - CITY OF SANTA ANA
 - COASTAL MUNICIPAL WATER DISTRICT
 - ORANGE COUNTY MUNICIPAL WATER DISTRICT
 - POMONA VALLEY MUNICIPAL WATER DISTRICT
 - CHINO BASIN MUNICIPAL WATER DISTRICT
 - WESTERN MUNICIPAL WATER DISTRICT OF RIVERSIDE COUNTY
 - MILITARY RESERVATION

STATE OF CALIFORNIA
 THE RESOURCES AGENCY
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 SOUTHERN DISTRICT
 ORANGE COUNTY LAND AND WATER USE SURVEY
 MAJOR WATER AGENCIES AND
 HYDROLOGIC SUBUNITS IN
 ORANGE COUNTY AREA - 1964

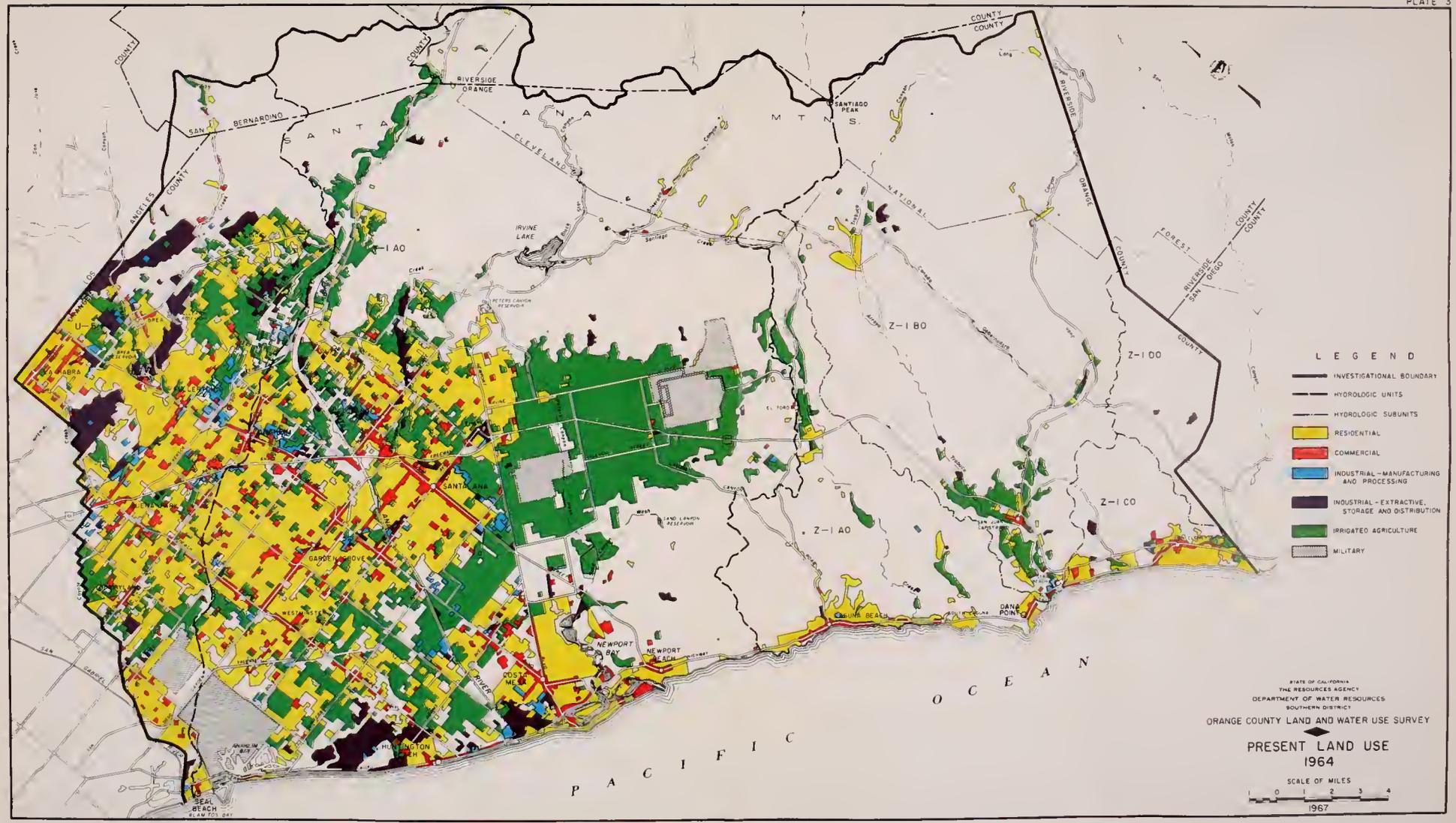
SCALE OF MILES
 0 1 2 3 4
 1967

**AREAL DESIGNATIONS
HYDROLOGIC UNITS, SUBUNITS, AND SUBAREAS**

- U-0.00 Los Angeles Drainage Province
 - U-5.00 Los Angeles-San Gabriel River Hydrologic Unit
 - U-5.F0 Anaheim Hydrologic Subunit
 - U-5.F1 Anaheim Hydrologic Subarea
 - U-5.F2 La Habra Hydrologic Subarea
 - U-5.F3 Yorba Linda Hydrologic Subarea

- Y-0.00 Santa Ana Drainage Province
 - Y-1.00 Santa Ana River Hydrologic Unit
 - Y-1.A0 Lower Santa Ana River Hydrologic Subunit
 - Y-1.A1 East Coastal Plain Hydrologic Subarea
 - Y-1.A2 Santiago Hydrologic Subarea
 - Y-1.A3 Santa Ana Narrows Hydrologic Subarea

- Z-0.00 San Diego Drainage Province
 - Z-1.00 San Juan Hydrologic Unit
 - Z-1.A0 Laguna Hydrologic Subunit
 - Z-1.A1 San Joaquin Hydrologic Subarea
 - Z-1.A2 Laguna Hydrologic Subarea
 - Z-1.A3 Aliso Hydrologic Subarea
 - Z-1.A4 Dana Point Hydrologic Subarea
 - Z-1.B0 San Juan Hydrologic Subunit
 - Z-1.C0 San Clemente Hydrologic Subunit
 - Z-1.D0 San Mateo Hydrologic Subunit



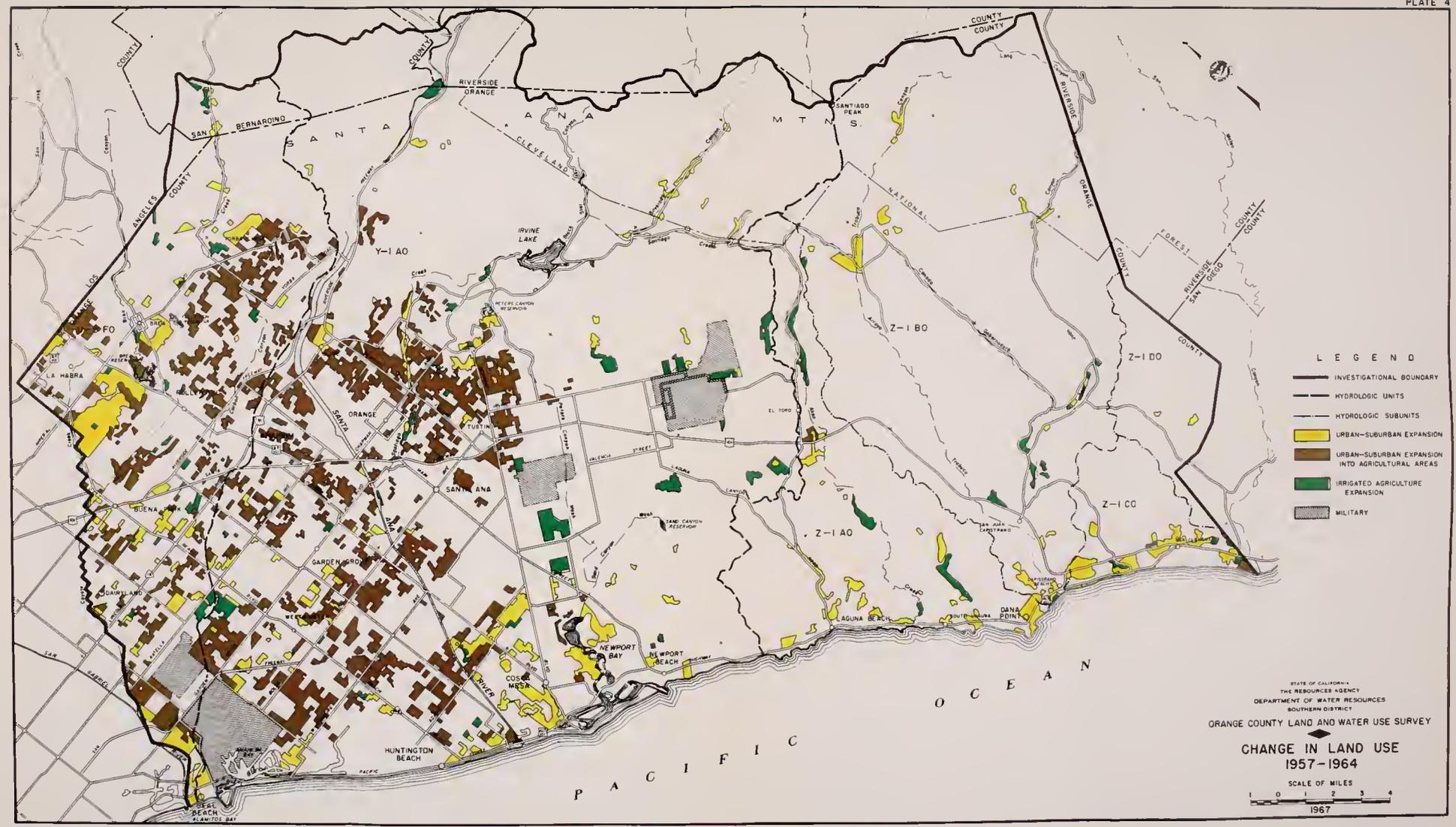
LEGEND

- INVESTIGATIONAL BOUNDARY
- HYDROLOGIC UNITS
- HYDROLOGIC SUBUNITS
- RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL - MANUFACTURING AND PROCESSING
- INDUSTRIAL - EXTRACTIVE, STORAGE AND DISTRIBUTION
- IRRIGATED AGRICULTURE
- MILITARY

STATE OF CALIFORNIA
 THE RESOURCES AGENCY
 DEPARTMENT OF WATER RESOURCES
 SOUTHERN DISTRICT
 ORANGE COUNTY LAND AND WATER USE SURVEY
**PRESENT LAND USE
 1964**
 SCALE OF MILES
 0 1 2 3 4
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**AREAL DESIGNATIONS
HYDROLOGIC UNITS, SUBUNITS, AND SUBAREAS**

- U-0.00 Los Angeles Drainage Province
 - U-5.00 Los Angeles-San Gabriel River Hydrologic Unit
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 - U-5.F1 Anaheim Hydrologic Subarea
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 - Y-1.A0 Lower Santa Ana River Hydrologic Subunit
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 - Z-1.A0 Laguna Hydrologic Subunit
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 - Z-1.A3 Aliso Hydrologic Subarea
 - Z-1.A4 Dana Point Hydrologic Subarea
 - Z-1.B0 San Juan Hydrologic Subunit
 - Z-1.C0 San Clemente Hydrologic Subunit
 - Z-1.D0 San Mateo Hydrologic Subunit



LEGEND

- INVESTIGATIONAL BOUNDARY
- HYDROLOGIC UNITS
- HYDROLOGIC SUBUNITS
- URBAN-SUBURBAN EXPANSION
- URBAN-SUBURBAN EXPANSION INTO AGRICULTURAL AREAS
- IRRIGATED AGRICULTURE EXPANSION
- MILITARY

STATE OF CALIFORNIA
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ORANGE COUNTY LAND AND WATER USE SURVEY

**CHANGE IN LAND USE
1957-1964**

SCALE OF MILES
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