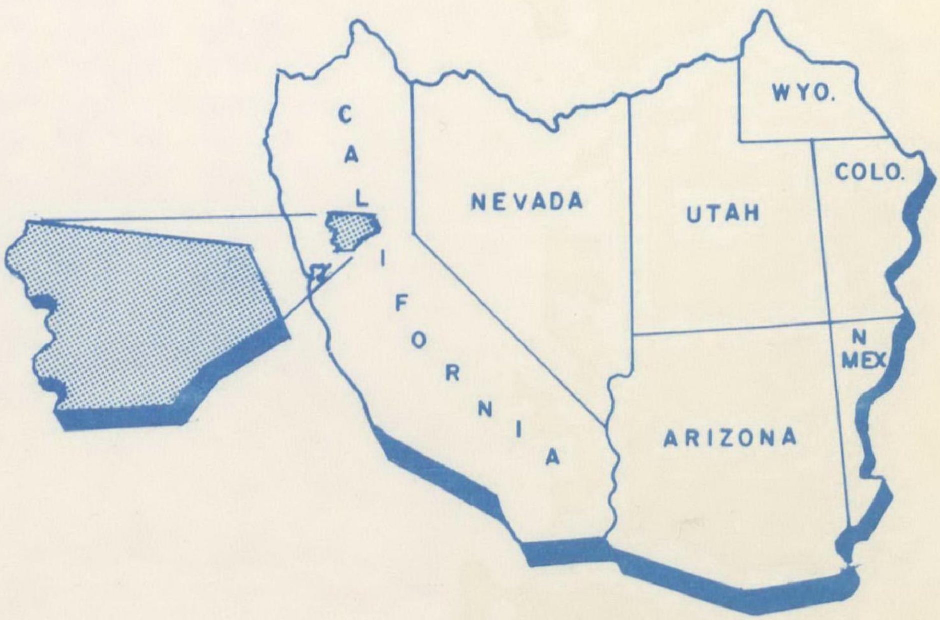
LOWER AMERICAN RIVER BASIN
CALIFORNIA

LOWER AMERICAN RIVER WATER QUALITY STUDY



U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION SAN FRANCISCO, CALIF.

CLEAN WATER

WATER QUALITY STUDY
LOWER AMERICAN RIVER
CALIFORNIA

ABSTRACT

Water quality problems in the Lower American River due to nutrient enrichment of surface waters by treated waste effluents are expected to become important during low-flow years starting in 1975. The operation of the Bureau of Reclamation's Auburn-Folsom South Unit as presently proposed is not expected to significantly influence these water quality conditions. Regulation of the flow of the Lower American River by altering the proposed method of operation of this unit could postpone the onset of such problems. Such action would be of temporary value, however, and the least costly long-term solution would require control of Lower American River water quality by diversion of future incremental waste flows to the Sacramento River and reuse of existing treated waste flows for parkland irrigation.

U. S. DEPARTMENT OF THE INTERIOR
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PACIFIC SOUTHWEST REGION
SAN FRANCISCO, CALIFORNIA

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I. INTRODUCTION

PURPOSE

The Auburn-Folsom South Unit, an authorized facility of the Bureau of Reclamation's Central Valley Project, is located on the American River near the city of Sacramento, California (see Figure 1 for location). Project water will be diverted into the Folsom South Canal to service areas along the east side of the Central Valley southward to the town of Escalon. The diversion will increase with time to meet growing demands for municipal, industrial, and agricultural water needs. Ultimately, 810,000 acre-feet will be diverted annually. This large diversion will have a significant impact on the hydrologic regimen of the river below the diversion structure, Nimbus Dam.

The purpose of the study described in this report is to determine the impact on water quality of the proposed diversions from the American River and the measures necessary to minimize resulting adverse effects.

SCOPE

The evaluation has been limited to that part of the American River where flows will be affected by the proposed diversions, a stretch of the river from Folsom Dam to its confluence with the Sacramento River near the city of Sacramento that has been designated the Lower American River for this study.

The study has been based on existing engineering and economic data and information from local, State, and Federal agencies. To provide additional data and information on the Lower American River, the Federal Water Pollution Control Administration (FWPCA) conducted chemical and biological studies on the river during the summer of 1967.

The study considered the needs for regulation of river flows to control water quality and the alternatives of advanced waste treatment and diversion of waste water from the river. The period of study used was 1975-2025 (50 years). Facilities were provided in this study on a schedule to meet increasing needs up to the 50-year design horizon with necessary replacements, maintenance, and operation of facilities for a 100-year project economic life.

A preliminary evaluation of the flow regulation needs of the American River was published in a 1963 report by the U. S. Public Health Service (1). With the subsequent authorization of the Auburn-Folsom South Unit, intense local interest has been expressed over the future flow conditions of the Lower American River, as it became apparent that these major developments in the basin could drastically alter the hydrologic regimen of the lower river and might induce significant changes in the stream environment. Therefore, reevaluation of the earlier USPHS report is needed to provide the basis for the Bureau's operation of these CVP units on the American River.

AUTHORITY

This study of the Lower American River has been made under the authority of and in accordance with the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.), and Executive Order 11288, dated July 2, 1966.

ACKNOWLEDGEMENT

The cooperation and assistance of the following Federal and State agencies and individuals added significantly to this study.

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Bureau of Outdoor Recreation
Department of the Interior
San Francisco, California

Central Valley Regional Water Quality Control Board
State of California
Sacramento, California

Department of Fish and Game
State of California
Sacramento, California

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II. SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

FINDINGS

1. The Bureau of Reclamation's American River developments for the Central Valley Project (CVP) consist of Auburn, Folsom, and Nimbus Dams and the Folsom South Canal. Folsom and Nimbus Dams were completed in 1955 and the other two facilities were authorized in 1965 for construction.

2. The watershed of the American River is composed of 1900 square miles of drainage area located in the Sierra Nevada northeast of Sacramento, California. From Folsom Dam to the confluence of the American with the Sacramento River, the local area draining to the Lower American River is 120 square miles, largely within the metropolitan Sacramento area.

3. The average annual runoff of the American River at Fair Oaks (below Nimbus Dam) is slightly more than 2,700,000 acre-feet. A large part of this annual flow occurs during the wet season, November through April.

4. The planned diversion of American River water into the Folsom South Canal will ultimately reach 810,000 acre-feet annually. This diversion will significantly alter the natural hydrologic regimen of the Lower American River below Nimbus Dam.

5. The economy of the study area is diversified, with important industrial, financial, commercial, transporation, governmental, and military establishments in the metropolitan area. Construction, service, trade, and agriculture are significant parts of the economy.

6. Domestic, industrial, and agricultural water supply of the study area is derived from the Sacramento River, American River, and the local ground-water basin.

7. The salmon, striped bass, trout, shad, and other fisheries are an important natural resource of the Lower American River. The American River Parkway, extending along both banks of the river up to Folsom Dam, provides major recreational opportunities to the metropolitan population of Sacramento.

8. Municipal and industrial wastes are treated and discharged to the Lower American River, to percolation ponds, or to the Sacramento River. At present, 18 sewage treatment plants of various sizes are located in the study area and 6 discharge to the American River.

9. The present mineral quality of the American River is excellent, containing low total dissolved solids and hardness. It is suitable for all domestic, industrial, and agricultural purposes. The quality of the ground water in the Lower American River Basin is also good. Water quality problems related to waste discharge in the Lower American River are minimal under present operational schedules of Folsom and Nimbus Dams.

CONCLUSIONS

1. The study area population is predicted to increase from 585,000 to about 3, 230,000 by 2025. Sewage treatment plants discharging to the Lower American River presently serve a population of 131,000 but these facilities are expected to be enlarged to provide service to a population of 625,000 by 2025.

2. Under the proposed release schedule from Nimbus Dam, sewage effluent will form a significant portion of the river flow during summer conditions by the 2025 level of development. The total dissolved solids and hardness of the city of Sacramento water supply will be significantly increased by the sewage effluent; however, total dissolved solids concentrations will meet the U.S. Public Health Service Drinking Water Standards and the Regional Water Quality Control Board policy for the river.

3. The amount of sewage effluent discharged to the Lower American River is predicted to increase from the 1965 level of 12 mgd to about 80 mgd by 2025. The total BOD_5 load into the river will increase from 3,300 pounds per day to about 19,000 pounds per day in the same period.

4. Despite the reduction in stream flow by the proposed diversions from the river above Nimbus Dam, the projected organic waste loads will not in themselves significantly reduce dissolved oxygen levels in the American River.

5. The total annual nitrogen load reaching the Lower American River will increase from 1,100,000 to about 4,700,000 pounds by 2025. Over the same period, the annual phosphorus load will increase from 290,000 to about 1,260,000 pounds.

6. Algal growth potential (AGP) studies of river water demonstrated that increased percentages of sewage effluent in the river water will result in significant stimulation of algal growth.

7. Projected nutrient loading of the river combined with planned diversions will cause excessive aquatic growths which will result

in dissolved oxygen problems. Recommended nitrogen and phosphorus objectives will be exceeded during a significant part of each year by 2000.

8. The relationship between excessive aquatic growths in the river and its recreation potential indicates that recreation activities will be impaired by diminishing the river flow and expected nutrient loading by the year 2000. Present worth (1975)[a/] of this loss of potential recreation resource was determined to be $10.853 million over a 100-year evaluation period. The average annual value of the lost potential would be $505,000 over the same period.

9. The excessive stimulation of algae and rooted aquatic plants can be expected to cause severe nocturnal depression of dissolved oxygen. Such fluctuations will lower oxygen content below the minimum acceptable level for the river and cause impairment of the fishery. Detriments estimated to have a present worth of $8,423,000 will result from reductions in angler-use and commercial fishery income. This is equivalent to an annual detriment of $393,867 over a 100-year evaluation period.

10. Without the proposed project, the future nutrient load into the Lower American River will also cause excessive aquatic growths and dissolved oxygen problems. Maximum recommended nitrogen and phosphorus levels which result in minimum acceptable water quality will be exceeded during the dry summer months beginning under 1975 loading conditions and excessive concentrations are expected under the 2025 level of development. Thus, nutrient concentrations (nitrogen) would exceed the value included in the present policy of the Central Valley Regional Water Quality Control Board. However, adequate flow would be available during the winter and spring runoff period. Present worth (1975) of the loss of potential recreation use was estimated to be about $11.385 million over a 100-year evaluation period, and the average annual value would be $540,000 over the same period. Severe nocturnal depression of dissolved oxygen can be expected to cause fishery losses. These losses are of the same order of magnitude as those expected under project conditions. Thus, the impact of the future nutrient load on both recreation use and fishery use without the project is about the same as under project diversion conditions.

11. Various solutions to the expected water quality problems were examined, i.e. advanced waste treatment, control of waste

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a/ Present worth is computed to the base year, 1975.

constituient concentrations by regulating stream flows, diversion of waste flows to the Sacramento River, reuse of waste effluents for irrigation of park lands and combinations of one or more of these methods. Diversion of future incremental waste flows combined with maximum reuse of existing effluents for irrigation appears to be the most effective and least costly solution, having an equivalent annual cost of $296,000.

12. The diversion of water to irrigation service areas can have detrimental effects on the water quality of the Sacramento-San Joaquin Delta as a result of increased consumptive use of water and the generation of additional wastes in the return flows. These water quality detriments can be minimized by maintaining adequate circulation of water within the Delta and outflow to San Francisco Bay. It is necessary, therefore, that the Bureau of Reclamation operate the Auburn-Folsom South Unit in conjunction with all other units of the Central Valley Project and the State Department of Water Resources operate the State Water Project in a manner which will avoid deterioration of water quality in the Delta. Water quality levels to be maintained in the Delta have been established in accordance with the Federal Water Quality Act of 1965. These water quality standards provide the necessary operating criteria for the operation of the Central Valley Project.

RECOMMENDATIONS

1. The City of Sacramento, Sacramento County and other local agencies should take early action to develop a comprehensive sewerage plan for protecting water quality in the Lower American River. The diversion of future waste flows from the river and the reuse of secondary effluent from existing sewage treatment plants for irrigation of the American River Parkway should be examined in detail as a potential solution. The State Water Resources Control Board through the Central Valley Regional Water Quality Control Board should stimulate the development and implementation of a coordinated water quality management plan for the Lower American River. The findings of the State's San Francisco Bay-Delta Water Quality Control Program should provide useful guidance in developing such a plan.

2. The Bureau of Reclamation should coordinate with local and State agencies the schedule for the releases of water to the Lower American River as part of an optimum plan for the preservation of water quality in the river.

III. PROJECT DESCRIPTION

A description of major units of the Central Valley Project (CVP) located in or planned for the American River basin is helpful as background information for this study.

Auburn Dam, the farthest upstream structure, will be located near the confluence of the North Fork and Middle Fork of the American River (see Figure 1). It will provide flood control storage, hydroelectric power, irrigation, and municipal and industrial (M&I) water supplies. It will also include provisions to enhance fishery and wildlife resources, to prevent damage to these resources, and to develop recreational opportunities. The proposed Auburn Dam will be a thin-arch concrete structure located in Placer County near the city of Auburn, about 35 miles northeast of Sacramento, the state capital. A 2,300,000-acre-foot reservoir will be impounded behind the 690-foot-high dam located in a narrow canyon. The dam crest will extend 3,500 feet, the longest thin-arch dam in the world when completed.

At maximum level, the surface of the reservoir will provide about 10,000 acres of recreational water area. Under proposed operating schedules, a recreation and fishery pool of at least 600,000 acre-feet will be maintained, except during drought years when the minimum pool will be reduced if necessary to meet CVP demands.

Flood control storage of 450,000 acre-feet will be reserved for the peak winter and spring runoffs; this space will be used for conservation storage after the spring flood season. The reservoir will provide water for a 300,000-kw powerhouse, with future expansions to 750,000 kw and, in addition, will yield about 300,000 acre-feet of water annually for agricultural and M&I purposes.

Folsom and Nimbus Dams, located downstream from the Auburn Dam site, (see Figures 1 and 2), were completed in 1955 by the U.S. Army Corps of Engineers and the Bureau of Reclamation, respectively, for flood control, hydroelectric power generation, and water conservation purposes. These units are operated by the Bureau of Reclamation and conservation yields are utilized in the Central Valley Project. Nimbus Dam forms Lake Natoma, a regulation reservoir for hydroelectric power releases from Folsom Reservoir which will also serve as a diversion structure for the Folsom South Canal. Below Nimbus Dam, a fish hatchery, constructed under the Folsom Dam Project as a fishery mitigation measure, is funded by the Bureau of Reclamation and operated by the California Department of Fish and Game.

PAGE NOT

AVAILABLE

DIGITALLY

The Folsom South Canal will divert water from Lake Natoma southward in a 67-mile concrete-lined canal to Lone Tree Creek near Escalon in San Joaquin County. Ultimately, the canal will divert 810,000 acre-feet of water annually for use on about 518,000 acres of farmland in Sacramento and San Joaquin Counties and for M&I water supply in the service area. Present plans schedule the diversion only from Nimbus Dam to the Folsom South Canal. The total diversion will be derived from the combined operation of the Auburn and Folsom Reservoirs.

The extension of the Folsom South Canal along the Sierra Nevada foothills of the San Joaquin Valley southward for about 325 miles to Bakersfield, California, is under investigation by the Bureau of Reclamation. An extension of the canal, called the East Side Canal, is planned to ultimately divert about 4,000,000 acre-feet annually from the Sacramento River through the Hood-Clay pump connection. A large portion of this Sacramento River water will be derived from the north coastal basins of California. Although the East Side Division of the CVP is currently under study, preliminary evaluations were so promising that authorization has been given to design the Folsom South Canal south of the Hood-Clay pump connection (see Figure 1) with capacity sufficient to accommodate the future flow requirements of the East Side Canal.

With the construction of the Auburn-Folsom South Unit of the CVP, the hydrologic regimen of the American River will be under almost complete control by man-made developments. Construction of this project has been approved and authorized by the U.S. Congress and preparation of final project plans are progressing under the direction of the Bureau of Reclamation.

IV. STUDY AREA DESCRIPTION

LOCATION AND BOUNDARIES

The Lower American River study area encompasses the drainage basin of the American River from Folsom Dam to the confluence with the Sacramento River near the city of Sacramento. The entire drainage basin of the American River comprises about 1,900 square miles of watershed (see Figure 1). That portion of the basin immediately tributary to the Lower American River below Folsom Dam contains only about 120 square miles (see Figure 2, a foldout in the rear of the report). Within the study area are several major drainage channels which flow parallel to the American River and discharge into the Sacramento River. These include the Natomas East Main Drainage Canal, Dry Creek (north), Magpie Creek, Arcade Creek, Cripple Creek, Morrison Creek, and Elder Creek. The study area is approximately the north half of Sacramento County, one of the more populous areas in California.

The principal community in the study area is the city of Sacramento, which is surrounded by many suburban communities that form its metropolitan area. Among these are Carmichael, Fair Oaks, and Rancho Cordova. Other large communities include Folsom, McClellan Air Force Base, and Mather Air Force Base.

The topography of the Lower American River is composed of rolling hills descending from the Lower Sierra Nevada and plains sloping westward from the city of Folsom to the valley flatlands near Sacramento. The terrain near Folsom and Nimbus Dams is broken by large areas of dredger tailings, the remains of extensive gold mining operations, composed of large boulders covered in some places with a thin mantle of top soil. Little progress has been made so far in reclaiming these tailing areas for useful purposes.

Aside from the tailings, the foothills have a moderate cover of woodland, principally oak trees, and a heavy cover of low scrub and grass. Dryland farming and livestock grazing are the principal agricultural activities of the Sierra foothills. Near Sacramento, the valley supports growths of oak and brush, while willow, cottonwood, and tules grow along and near the river and its tributary creeks. Agriculture in the area consists primarily of field and row crops, pasture, and fruit orchards.

GEOLOGY

The oldest rocks in the foothills, pre-Cretaceous, form the core of the Sierra Nevada. Tertiary and Quaternary formations, which are located under the flatlands near Sacramento, overlie the older rocks. Typical alluvial and marine sediments resting upon the base rocks are in some places up to 2,000 feet thick. The sediments form an extensive ground-water basin which extends toward the tidal waters of the Sacramento River Delta.

CLIMATE

Typical of the Central Valley of California, the climate of the Lower American River study area is one of cool winters and long, hot, dry summers. The annual average temperature is about 61°F with a mean daily minimum of 38°F in January and a mean daily maximum of 92° in July. Daily temperatures frequently exceed 100°F during the summer but the winters are generally mild, with temperatures rarely dropping below 20°F. Mean annual precipitation is about 17 inches. Approximately 85 percent of the normal rainfall occurs between November and April.

V. WATER RESOURCES OF THE STUDY AREA

SURFACE WATER

The average annual runoff of the American River for the 61-year period 1904-1965, has been slightly above 2,700,000 acre-feet at the Fair Oaks gaging station (2), which is situated a short distance downstream from Nimbus Dam. The lowest annual runoff past this point was 530,000 acre-feet, during the 1923-24 water year. A peak discharge of 180,000 cubic feet per second was recorded during the flood of November 1950 and an historic low discharge of 4 cfs was recorded in August 1924. During the most severe flood of recent times (December 1955), a peak discharge of 220,000 cfs into Folsom Reservoir was recorded. Fortunately, the ample storage space in the reservoir, which had just been placed in operation, contained the potentially damaging flows.

About 60 percent of the annual flow occurs during the rainy season, November through April, and this runoff period is extended by the spring snowmelt to about May. The monthly distribution of the historic annual flow of the American River from 1905-1954 is shown in Figure 3. The historic flow pattern has been markedly influenced by Folsom Dam and will be further modified by the proposed Auburn Dam and diversions into the Folsom South Canal.

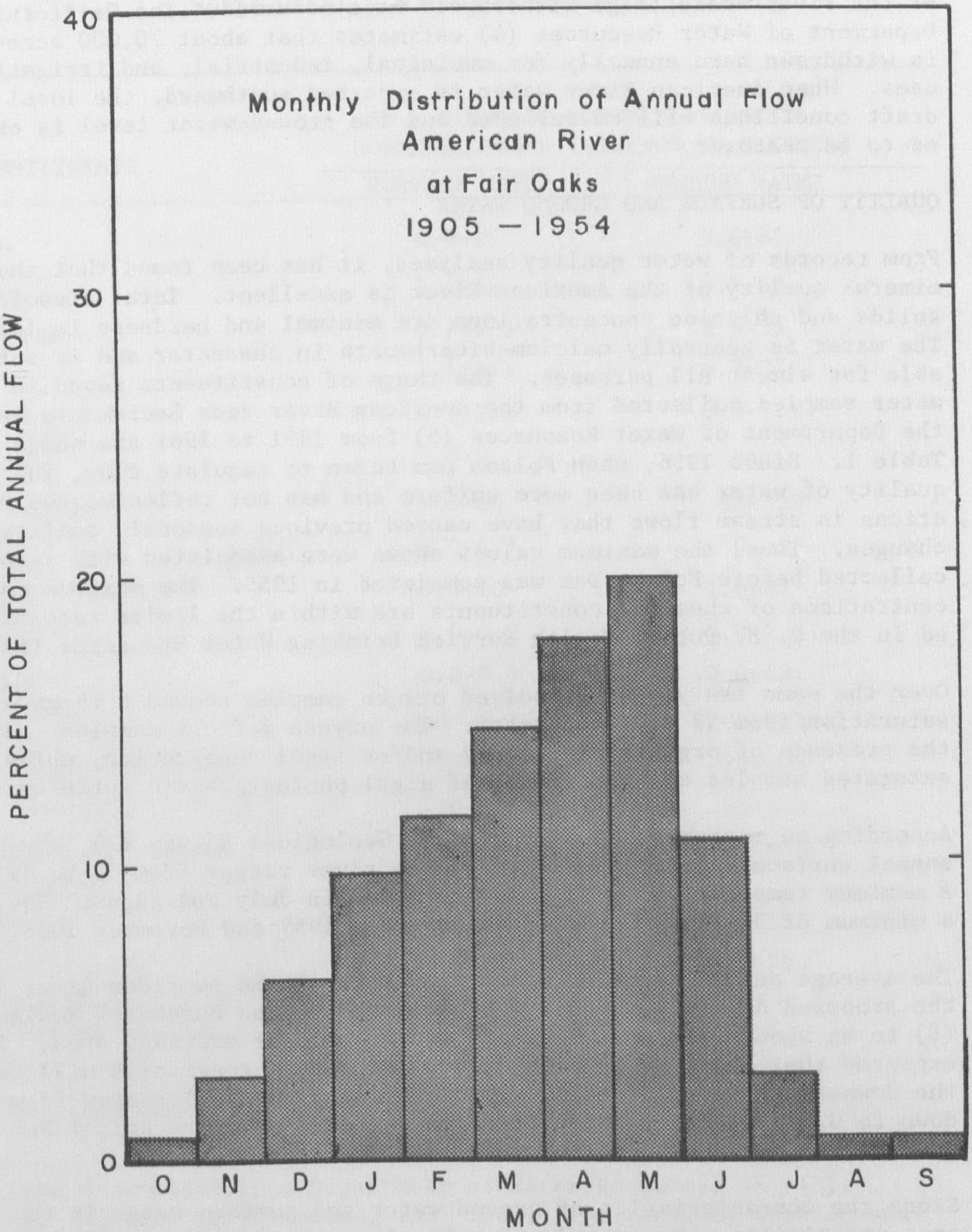
GROUND WATER

The extensive alluvial sand, gravel, and clay deposits lying between the foothills and the Sacramento River form an important ground-water basin which is fed by precipitation and surface runoff in the American River and tributary streams.

In the gravel deposits along the banks of the river, the ground-water table is contiguous with the water in the river. During periods of high runoff, the river feeds these gravel deposits. When stream flow is low, the process is reversed.

In the alluvial deposits near the Sacramento and American Rivers, the water table lies within 10 feet of the ground surface, while near the foothills of Folsom, the ground-water table lies about 100 feet below the surface. The general ground-water movement is southwest towards the Sacramento River and the Sacramento River Delta. The U. S. Geological Survey (3) estimates the total storage capacity of the entire alluvial fill on the north and south sides of the river near Sacramento to be about 3,600,000 acre-feet.

In recent years, the extensive use of ground water in the study area has caused a general lowering of the water table, notably in areas south



LOWER AMERICAN RIVER STUDY

MONTHLY DISTRIBUTION OF ANNUAL FLOW
(Historical)

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Figure 3

of the river where large withdrawals have occurred. The California Deparment of Water Resources (4) estimates that about 70,000 acre-feet is withdrawn here annually for municipal, industrial, and irrigation uses. When American River water is exported southward, the local overdraft conditions will be relieved and the ground-water level is expected to be restored.

QUALITY OF SURFACE AND GROUND WATER

From records of water quality analyses, it has been found that the mineral quality of the American River is excellent. Total dissolved solids and chloride concentrations are minimal and hardness is low. The water is generally calcium-bicarbonate in character and is suitable for almost all purposes. The range of constituents found in water samples collected from the American River near Sacramento by the Department of Water Resources (5) from 1951 to 1961 are shown in Table 1. Since 1956, when Folsom Dam began to regulate flow, the quality of water has been more uniform and has not reflected the variations in stream flows that have caused previous seasonal quality changes. Thus, the maximum values shown were associated with samples collected before Folsom Dam was completed in 1955. The maximum concentrations of chemical constituents are within the limits recommended in the U. S. Public Health Service Drinking Water Standards (6).

Over the same ten years, dissolved oxygen samples showed a range of saturation from 59 to 124 percent. The oxygen deficit samples indicate the presence of organic pollutants and/or algal respiration, while the saturated samples are the result of algal photosynthetic activity.

According to measurements of the U. S. Geological Survey (7), the mean annual surface water temperature of the river varies from 55 to 59°F. A maximum temperature of 81°F was recorded in July and August 1954, and a minimum of 32°F was recorded in November 1957 and November 1958.

The average annual sediment production rate of the American River above the proposed Auburn Reservoir was estimated by the Bureau of Reclamation (8) to be about 0.38 acre-feet per square mile of drainage area. It is expected that settling in both Auburn and Folsom reservoirs will reduce the downstream sediment load. Turbidity samples (JCU) ranged from 140 down to 0. The higher turbidities were recorded before Folsom Dam was built.

Since the characteristics of ground water and surface water in the study area are similar, the ground water is also considered excellent for all purposes. Generally, its mineral concentration is higher than that of the surface water. The range of constituents found in 200 samples of well water collected by the Department of Water Resources (4) from 1952 to 1963 is shown also in Table 1. The maximum concentrations are generally

TABLE 1 - WATER QUALITY LOWER AMERICAN RIVER BASIN a/

CONSTITUENTS	RANGE OF CONCENTRATIONS b/ CONCENTRATIONS (MINIMUM TO MAXIMUM)	
	SURFACE WATER	GROUND WATER
Silica	6.9-15	5.6-84
Calcium	3.4-12	6.2-63
Magnesium	0.7-5.5	0.5-36
Sodium	1.1-5.1	4.7-27
Potassium	0.1-1.3	0.0-7.3
Carbonate	0-0	---
Bicarbonate	16-54	38-322
Sulfate	0.0-4.7	0-35
Chloride	0.0-10	1.0-87
Fluoride	0.0-0.2	0.0-2.8
Nitrate	0.0-0.9	0.0-48
Boron	0.00-0.17	0.00-0.22
Total Dissolved Solids	17-91	73-405
Total Hardness (as $CaCO_3$)	10-50	23-288
Specific Conductance (Michromhos at 25°C)	24-129	94-658
pH units	6.7-8.3	6.2-8.5
Temperature, °F	41-81	51-72
Dissolved Oxygen	5.3-14.2	---
Percent Saturation	59-124	---
Turbidity (JCU)	0-140	---
Coliform (MPN/100 ml)	6-700,000	---

a/ Data from California Department of Water Resources (4) (5):
1. Surface water record, 1951-1961, from Sampling Station near the H Street Bridge, Sacramento, California
2. Ground water record, 1952-1963. Analysis from about 200 wells on south side of the Lower American River.

b/ Concentration expressed in mg/liter unless noted otherwise.

associated with the few wells located near waste effluent percolation ponds. These well waters are not typical and do not reflect the generally excellent ground-water quality of the area. The chemical constituents of almost all well waters are within the limits recommended in the U. S. Public Health Service Drinking Water Standards (6).

VI. ECONOMY

PAST AND PRESENT

The economy of the study area is diversified. Industrial, financial, commercial, State and Federal government, and military establishments center in or near the city of Sacramento, supported by agricultural activity in the surrounding farmlands. Three major military installations are located near Sacramento: McClellan Air Force Base, 10 miles northeast, Mather Air Force Base, about 12 miles east, and the U. S. Army Signal Depot, at the southeastern boundary of the city. Employing over 45,000 civilians and 12,000 assigned military personnel, these installations contribute significantly to the local economy.

Sacramento is the financial, commercial, wholesale distribution, and government center of Sacramento Valley. In recent years, industrial developments have gained importance. The large rocket and missile research and manufacturing firms established in the early 1950's have made major contributions to industrial growth and they in turn have attracted many allied subcontracting firms to the area. Employment in the rocket and missile industry alone was at one time more than 20,000, although personnel have been reduced because of completion of major missile contracts. Product diversification by the missile firms is expected to reverse the decline. Because of highly productive agriculture in the valley, the food processing industry has always been a strong element in the economy. The processing of a wide variety of agricultural crops produced from the rich farmlands has employed a peak of nearly 7,000 workers.

Following closely the rapid growth of the state, the Sacramento area has also grown steadily. Major factors contributing to this expansion include a large supply of labor, expanding markets, excellent transportation (including a deep-water channel for ocean-going vessels), a ready supply of raw materials, and an abundant supply of inexpensive water.

Although many acres of farmland have been converted to commercial-residential developments in recent years, agriculture is expected to remain an important industry of the area. It is estimated that there are more than 225,000 acres of land in Sacramento County used for farming, a large part of which lies outside the study area in the Delta and the Cosumnes River basin. The most important crops are corn, tomatoes, hops, alfalfa, sugar beets, and pears; cattle and sheep raising are also important agricultural enterprises. The cash value of all farm products sold in Sacramento County during 1964 (9) was about $65,916,000.

A recent review of economic progress in Sacramento County shows that growth of industrial and commercial-residential developments has made the greatest impact. The 1959 employment distribution is shown in Table 2. As indicated, military and government activities account for the largest employment (over 30 percent), followed by manufacturing and retail trade. Although Table 2 shows employment for the whole county, only a small portion (about 7,000) of this total is located outside the study area.

FUTURE

The national trend toward sprawling metropolitan centers has also been illustrated by the growth of Sacramento. The continuous expansion of industry and associated residential development in Sacramento is expected to outpace California's rate of growth, which is projected to exceed the national average. Studies made by Sacramento County in 1965 and 1967 (11) predicted concentrated industrial and residential growth to the south and east of the city, and residential developments in regions to the north and east of the Sacramento and American rivers. Since the Delta area of the county will remain primarily agricultural oriented,population growth there will be less spectacular.

To evaluate the waste load from the study area, projections of county and study area populations have been made to the year 2025 (see Table 3). For the same period, the tributary population contributing waste to the Lower American River is also shown. This population follows closely the predictions made by a recent sewerage survey (12) for a master plan of the study area. It should be noted that the city of Sacramento, a large populous area situated north of the American River, and a large area south of the city are served by treatment plants that discharge effluents into the Sacramento River rather than into the American River. Also, in areas southeast of the city, existing sewage treatment plants discharge effluents into creeks that are tributary to the delta. Thus, the population contributing waste loads to the American River constitutes only a portion of the total study area population.

TABLE 2 - EMPLOYMENT DISTRIBUTION, 1959 SACRAMENTO COUNTY [a]

	EMPLOYED	
	NUMBER	PERCENT
Government		
Civilian	44,800	24.2
Military	12,615	6.9
Retail Trade	23,000	12.4
Wholesale Trade	6,800	3.7
Manufacturing	24,300	13.2
Finance, Insurance, Real Estate	5,650	3.1
Transportation and Utilities	12,000	6.5
Contract Construction	11,000	5.8
Schools and Hospitals	13,400	7.3
Services	12,200	6.6
Agriculture	6,000	3.3
Mining and Agricultural Services	750	0.5
Self-employment	12,000	6.5
Total	184,515	100.0

a/ U. S. Bureau of Census, 1960 (10).

TABLE 3 - POPULATION PROJECTIONS LOWER AMERICAN RIVER BASIN

	1965	1975	2000	2025
Sacramento County	600,000	800,000	1,969,000	3,400,000
Study Area	585,000	780,000	1,920,000	3,230,000
Areas Tributary to Lower American River[a/]	131,000	225,000	450,000	625,000

a/ Areas discharging to sewage treatment plants with outfalls on the Lower American River.

VII. WATER REQUIREMENTS - MUNICIPAL, INDUSTRIAL, AGRICULTURAL, FISHERY, AND RECREATION

PAST AND PRESENT WATER USES

Municipal and industrial water supplies are derived from the ground water and surface waters of the Sacramento River and the American River. The city of Sacramento has two filtration plants with a total capacity of 100 mgd drawing water from the Sacramento River. To meet the needs of the city, these plants are supplemented by numerous wells and by the addition in 1964 of a new 70 mgd filtration plant that diverts water from the Lower American River at River Mile 7.6 (see Figure 2). Outside the city numerous private and public water agencies obtain water from both ground and surface water sources to serve the remainder of the study area such as Rio Linda, Fair Oaks, Citrus Heights, and Rancho Cordova. The Carmichael Irrigation District also draws surface water from the Lower American River to supplement well water for municipal, industrial, and agricultural purposes.

As might be expected in the hot, dry Sacramento Valley, the present per capita water use (270 gpd) in the study area exceeds the average of the state and the nation. The annual municipal use is about 177,000 acre-feet. Of this amount, only about 50,000 acre-feet are withdrawn from the Lower American River, mainly by the city of Sacramento, and the remainder is derived from the ground-water system, the Sacramento River, and minor diversions from the American River above Folsom Reservoir.

Irrigation water is used extensively for a variety of field crops, row crops, and orchards. Within the study area, three irrigation districts (Citrus Heights, Fair Oaks, and Carmichael) have been organized to serve agricultural lands. In addition to these organized water groups, many farmers operate individual well and distribution systems to meet their local needs. For the area south and southeast of Sacramento, the Department of Water Resources (4) estimates an annual withdrawal of about 70,000 acre-feet from wells, mainly for agricultural purposes. Because ground water north and northeast of the city is less available, agriculture is supported principally by surface diversions from the Sacramento River and from the American River above Folsom Dam. It is estimated that about 120,000 acre-feet are used annually for agriculture in the north and northeast areas.

Within the drainage basin of the Lower American River, agricultural water use is limited to an estimated 5,000 acre-feet annually diverted by the Carmichael Irrigation District near Carmichael. Other diversions are made by farmers, but these are small and are diminishing as agricultural land is transferred to urban development. Thus, although the total water consumed annually for agriculture in the entire study area is about 190,000 acre-feet, only a little more than 5,000 acre-feet is withdrawn from the Lower American River. In addition to the above consumptive water uses, the Lower American River supports important fisheries and intensive recreational uses.

FUTURE WATER USES

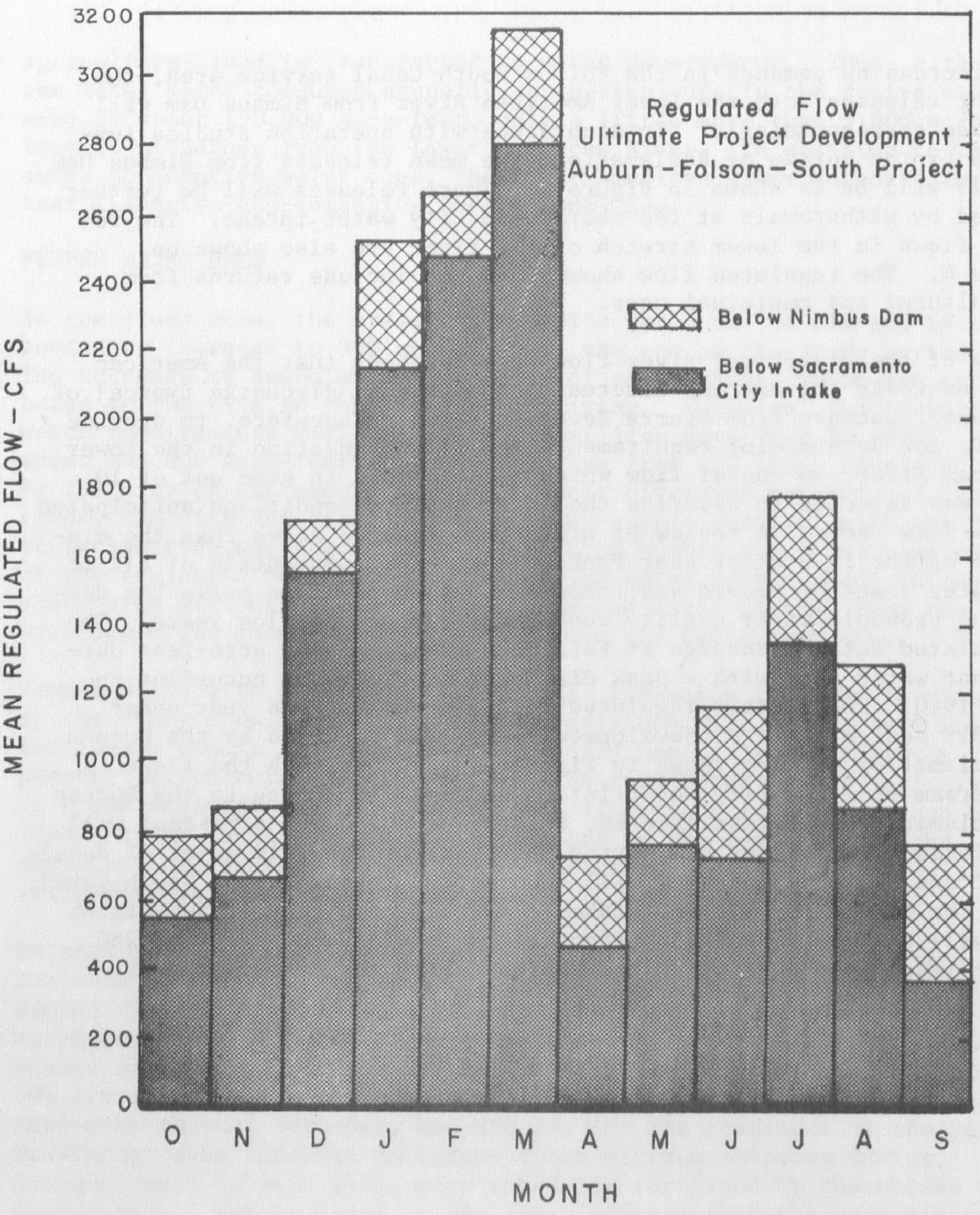
In the study area, the present per capita water use of 270 gpd is expected to increase to 300 gpd by 2025, the end of the study period. The increase is based on an extension of past trends, which are attributed to the rise in the standard of living. Municipal and industrial water requirements will be about 1.18 million acre-feet by 2025. Only about 245,000 acre-feet will be withdrawn from the Lower American River by the city of Sacramento. To meet their diversion schedule of the river, the city has entered into a water-supply contract with the Bureau of Reclamation who regulates releases from Nimbus Dam. The remainder of the projected municipal and industrial water supply needs in the study area will be obtained from the ground-water basins, from the American River above Folsom Dam, and from the Sacramento River.

Commensurate with commercial-residential expansion into the farmlands of the study area, less agricultural water use will be needed. The Sacramento County Planning Department (11) has projected that the present agricultural enterprises will be supplanted almost entirely by commercial-residential developments of metropolitan Sacramento by 2025. Minor farming activities remaining in the foothills to the northeast and boundary areas to the southeast will be supplied with irrigation water from Folsom Reservoir.

To meet requirements for a fishery in the Lower American River and the State of California fish hatchery located immediately downstream from Nimbus Dam, minimum releases from Lake Natoma are maintained under an agreement between the California Department of Fish and Game and the Bureau of Reclamation. It was agreed to maintain a minimum flow of 500 cfs in the Lower American River during the salmon spawning season, September through December, and 250 cfs for the remainder of the year. Provisions were included to reduce these minimum releases during drought years in accordance with schedules furnished by the Bureau of Reclamation. Future plans in the area indicate that the recreational uses of the river will expand and will be an important use of the river water. Under the project the important fisheries will be maintained to provide recreation to a large metropolitan population and for commercial purposes

With increasing demands in the Folsom South Canal service area, the present releases into the Lower American River from Nimbus Dam will decrease correspondingly. In accordance with operation studies furnished by the Bureau of Reclamation, the mean releases from Nimbus Dam by 2019 will be as shown in Figure 4. These releases will be further reduced by withdrawals at the Sacramento City water intake. The reduced flows in the lower stretch of the river are also shown on Figure 4. The regulated flow shown does not include returns from agricultural and municipal uses.

Review of the historical river flow records shows that the American River exhibits the extreme fluctuations in annual discharge typical of the runoff pattern from Sierra Nevada streams. Therefore, to provide a basis for determining requirements for flow regulation in the Lower American River, an annual flow which was exceeded in nine out of 10 years was selected to describe the water quality conditions anticipated in low-flow years. A review of historical records shows that the discharge of the 1939 water year ranked at the 10th percentile of all of the water years of record and therefore was chosen as a basis for describing probable water quality conditions during low-flow years. The unregulated total discharge at Fair Oaks was 1,086,000 acre-feet during that water year, with a peak discharge of 5,203 cfs occurring in April 1940. The monthly regulated releases during this year under the 2019 design state of development have been computed by the Bureau of Reclamation and are shown in Figure 5, together with the flows downstream from the city water intake system. According to the Bureau of Reclamation operation studies, a total of 1,250,000 acre-feet will be released from Nimbus Dam during this year at the 2019 level of development and 810,000 acre-feet will be diverted to the Folsom South Canal. Below the city water system intake, a monthly mean flow of 500 cfs or less will be experienced 75 percent of the months and a flow of 250 cfs or less in 25 percent of the months during the base-flow year.

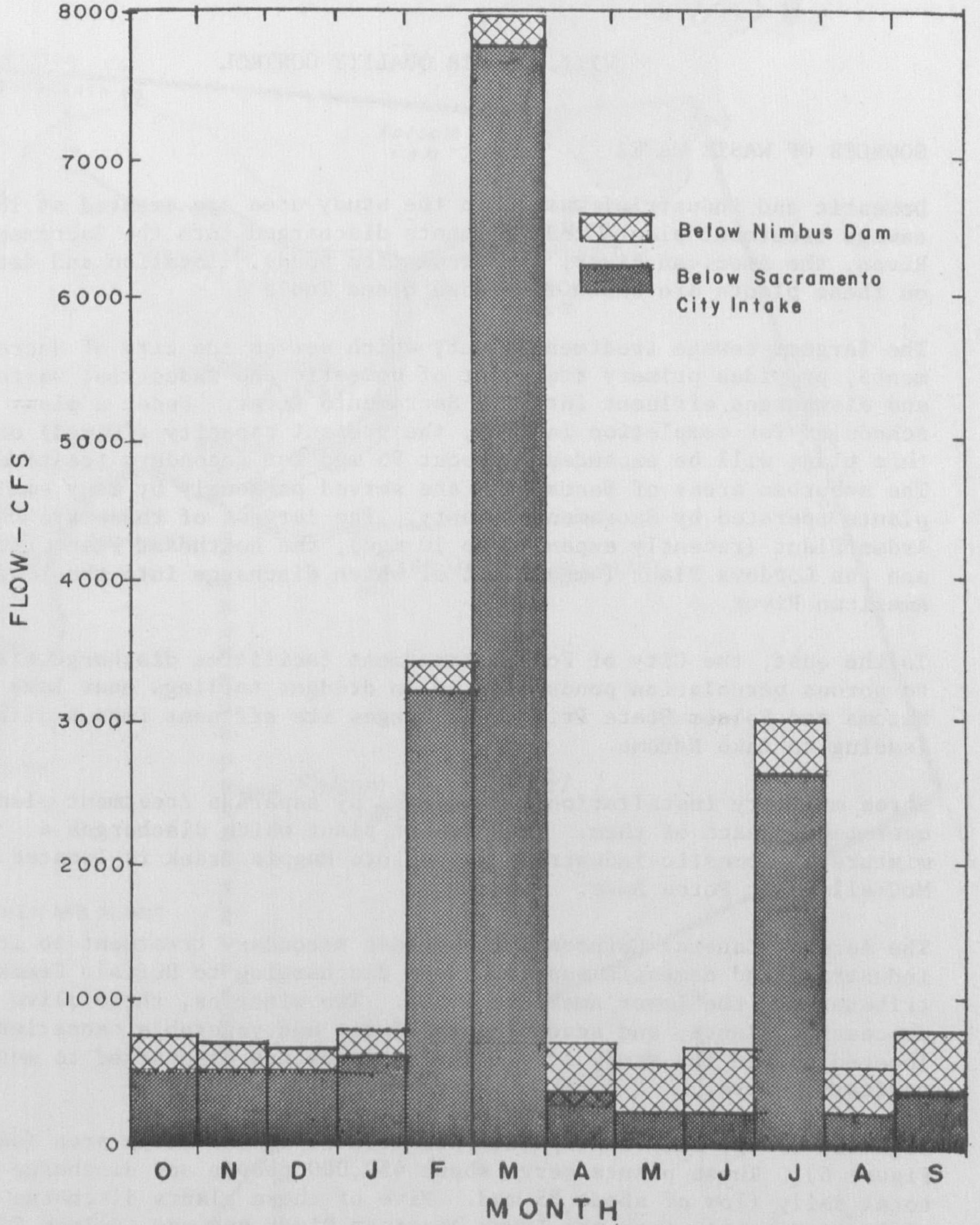


LOWER AMERICAN RIVER STUDY

MEAN REGULATED FLOW

DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION SAN FRANCISCO, CALIF.

Figure 4



Base flow is annual flow exceeded in 90 percent of record and is represented by the 1939 water year.

LOWER AMERICAN RIVER STUDY

BASE FLOW

ULTIMATE LEVEL OF DEVELOPMENT

LOWER AMERICAN RIVER

DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION SAN FRANCISCO CALIF.

Figure 5

VIII. WATER QUALITY CONTROL

SOURCES OF WASTE WATER

Domestic and industrial wastes in the study area are treated at 18 sewage treatment plants and effluents discharged into the Sacramento River, the American River, or percolation ponds. Location and data on these plants are shown in Figure 6 and Table 4.

The largest sewage treatment plant, which serves the city of Sacramento, provides primary treatment of domestic and industrial wastes and discharges effluent into the Sacramento River. Under a plan scheduled for completion in 1969, the present capacity (70 mgd) of this plant will be expanded to about 95 mgd for secondary treatment. The suburban areas of Sacramento are served presently by many smaller plants operated by Sacramento County. The largest of these are the Arden Plant (recently expanded to 10 mgd), the Northeast Plant (10mgd), and the Cordova Plant (4mgd), all of which discharge into the Lower American River.

To the east, the City of Folsom treatment facilities discharge effluent to porous percolation ponds located in dredger tailings near Lake Natoma and Folsom State Prison discharges its effluent into a ditch leading to Lake Natoma.

Three military installations are served by separate treatment plants operated by each of them. The largest plant which discharges a mixture of domestic-industrial waste into Magpie Creek is located at McClellan Air Force Base.

The Aerojet-General Corporation provides secondary treatment to its industrial and domestic wastes before discharging to Buffalo Creek, a tributary of the Lower American River. Two wineries, three olive processing plants, and several large fruit and vegetable canneries are located within the study area. Their wastes are discharged to municipal sanitary sewers.

Eighteen sewage treatment plants are located in the study area (see Figure 6). These plants serve about 450,000 people and discharge a total daily flow of about 85 mgd. Five of these plants discharge effluent directly into the Lower American River and one (Folsom City) discharges effluent into porous percolation beds near the south bank of the American River. Thus, the present (1968) total discharge into the flowing waters of the Lower American River is slightly greater than 12 mgd. The remaining 73 mgd from the study area is discharged to the Sacramento River, to its tributaries, or to percolation ponds or beds.

PAGE NOT

AVAILABLE

DIGITALLY

TABLE 4 - WASTE TREATMENT FACILITIES LOWER AMERICAN RIVER
1969

PLANT NO.	LOCATION	TYPE OF TREATMENT [a/]	DESIGN FLOW (mgd)	DISCHARGE POINT
1.	Natomas Sanitation District	S	3.50	Natomas E. Canal
2.	Rio Linda Co. Water District	S	0.50	Dry Creek
3.	McClellan Air Force Base	S	2.00	Magpie Creek
4.	Highland Estates	S	0.55	Dry Creek
5.	County Sanitary Dist. No. 6	S	3.34	Magpie Creek
6.	Arden W.Q. Control Plant	S	10.00	American River
7.	Northeast W.Q.Control Plant	S	10.00	American River
8.	Arden Gold S. M. District	S	0.25	Dredger Tailings Pond
9.	Folsom State Prison	S	0.85	American River
10.	City of Folsom	S	0.46	Dredger Tailings Pond
11.	Aerojet-General Corporation	S	0.33	Buffalo Creek
12.	Cordova W.Q. Control Plant	S	4.00	American River
13.	Mather Air Force Base	S	1.50	Morrison Creek
14.	Manlove S. M. District	S	1.25	Morrison Creek
15.	U. S. Army Signal Depot	S	1.25	Morrison Creek
16.	City of Sacramento	P	70.00	Sacramento River
17.	Meadowview Plant	S	0.22	Sacramento River
18.	Central W. Q. Control Plant	S	10.00	Sacramento River

a/ S = Secondary treatment

P = Primary treatment

It is estimated that about 15 percent of the study area population is served by septic tanks and leaching fields which do not contribute any liquid waste directly to surface waters.

Future waste loads are expected to be increased by the expanding commercial-residential populations of the metropolitan Sacramento area. A preliminary study in 1959 by DeWante-Stowell (12), consultants for Sacramento County, included recommendations for expansion of existing treatment facilities and construction of new treatment plants. The master plan for the locations of treatment facilities is shown on Figure 6.

Under the sewerage master plan, the entire study area will be served by seven large central treatment plans and five small treatment plants. For economy many existing smaller plants will be taken out of service and their collection areas will be served by the more efficient large central plants that exist or planned for the future. The trend toward central plants serving large areas will result in considerable economy in capital investment and maintenance, replacement, and operation costs. In a report (13) prepared for the California Department of Public Health, the Aerojet-General Corporation analyzed waste management systems, using systems analysis techniques. With the Sacramento metropolitan area as a model, the Aerojet study stressed the point that significant economies could be achieved by constructing large master collection systems with central treatment plants rather than a diversity of smaller plants located throughout the service area.

Under the 2025 plan of development, the sewerage system of the study area will serve a population of 3,230,000. It is estimated that the total volume of effluent from sewage treatment plants serving this population will be about 405 mgd. However, under the Master Plan, only five plants treating less than 20 percent of the basin effluent will discharge to the Lower American River basin. Four of these will discharge effluent to surface waters of the river, while the Folsom City plant will continue to discharge to percolation ponds near Lake Natoma.

The future waste loads from these five plants were determined and are presented in Table 5. As indicated, the total 5-day BOD load discharged to the river will increase from about 3,300 pounds per day to about 19,000 pounds per day in 2025.

To evaluate these loads, an average reduction of 85 percent of BOD by secondary treatment processes was assumed. Greater BOD reduction can be achieved by modern sewage treatment plants but allowance must be made for organic loads from the local surface drainage systems which will

TABLE 5 - PROJECTED WASTE LOADING LOWER AMERICAN RIVER

TREATMENT PLANT	1965 FLOW mgd	1965 BOD_5 lb/day	1975 FLOW mgd	1975 BOD_5 lb/day	2000 FLOW mgd	2000 BOD_5 lb/day	2025 FLOW mgd	2025 BOD_5 lb/day
Arden	4.0	1270	5.5	1485	7.5	2150	13.5	3240
Cordova	2.0	508	3.0	810	5.0	1425	8.8	2130
Northeast	5.0	1270	10.0	2700	24.0	6850	40.8	9780
Aerojet-General Corporation	0.3	76	0.5	135	2.0	670	3.8	900
Folsom City	0.5	130	3.0	810	6.5	1850	11.2	2700
Folsom State a/ Prison	0.5	89	0.7	135	---	---	---	---
Total	12.3	3343	22.7	6075	45.0	12945	78.1	18750

a/ State Prison waste will be discharged to Folsom City system by year 2000 be treated. Even during the hot, dry summer months, numerous drains were observed with running water, mainly from irrigation return to the river. Significant organic loads can be brought into the river by these return flows from residential lawns and agricultural land. By selecting an 85 percent reduction in organic load to the treatment plants, liberal allowance is thereby given to these untreated drainage wastes, thus reflecting more closely the organic load on the river.

WATER QUALITY REQUIREMENTS

Recognition of the many beneficial uses of Lower American River water is a prerequisite to establishing water quality objectives. The Lower American River is a vital source of irrigation and M&I water. The city of Sacramento withdraws large quantities of M&I water from the Lower American River. This withdrawal is predicted to increase to meet demands of future populations. In addition, the Carmichael Irrigation District diverts river water for M&I use and irrigation to supplement their existing ground-water supply. Other small diversions for water supplies and irrigation needs are made by irrigation districts and individual farmers.

The Lower American River is a natural spawning area for the king salmon, which provides a river sport fishery and supports an ocean sport fishery that accounted for an estimated 16,000 angler days in 1966 and a large commercial harvest. Rainbow trout and steelhead are also commonly found there, along with a warm water fishery composed of nearly 40 species (14,15). The anadromous striped bass and the American shad are numerous and very popular with anglers. The California Department of Fish and Game (15), reports that about 76,000 angler days were spent on the river in 1966. Besides the fishery, the Lower American River provides a natural environment for a variety of recreational use, including swimming, wading, water skiing, scuba diving, and boating.

Other recreational attractions include sunbathing, picnicking, hiking, bird watching, camping, sightseeing, and aesthetic enjoyment of the river environment. Preliminary estimates by the U. S. Bureau of Outdoor Recreation (16) indicates that annual recreational use of the Lower American River will increase from a 1973 level of about 2,000,000 recreation-days to about 14,600,000 by 2019. In recognition of the fact that the Lower American River is an important natural asset to the Sacramento metropolitan area, a master plan, as proposed by the County Park and Recreation Department has been approved by the County Board of Supervisors (11). The plan involves both public and private developments needed to provide recreational facilities for the growing metropolitan population, including amusement centers, golf courses, swimming beaches, marinas, recreation lakes, and nature areas.

Recognizing the value of the river, the Central Valley Regional Water Quality Control Board (RWQCB) has adopted water quality standards to regulate waste discharges and to control water quality. In 1959, Resolutions No. 59-108 and No. 59-109 were adopted by the Regional Board to provide for the preservation of the water quality of the river from Folsom Dam to its confluence with the Sacramento River. To update these standards, the Board adopted a water quality control policy, Resolution No. 68-21, for the Lower American River (Folsom Dam to the Sacramento River) in September 1967.

The latest water quality policy adopted by the Regional Board contains several water quality provisions that should be particularly emphasized in the evaluation of quality control practices. The most important of these are cited here:

Para. 9. "Bacteriological quality of the River as measured in terms of most probable number densities of fecal and standard coliform per 100 milliliters shall be maintained at levels which do not exceed historical values."

Para. 13. "The dissolved oxygen concentration in the American River shall be maintained above:

A. 7.0 mg/l in Lake Natoma and in the reach from Nimbus Dam to Watt Avenue Bridge.

B. 5.0 mg/l in the reach from Watt Avenue Bridge to the Sacramento River."

Para. 14. "Total nitrogen content of the River waters shall be maintained below 1.0 mg/l."

Para. 15. "The total dissolved solids concentration of the River shall not exceed 125 mg/l."

Para. 17. "Concentrations of dissolved nutrients shall be maintained at levels below those which may cause undesirable algal densities, slime or bacteriological growth, or other undesirable biological growth."

It should be noted that the dissolved oxygen concentration levels indicated in the Regional Board's policy are minimum levels. In accordance with recent studies (17), a mean dissolved oxygen level of 9.0 mg/l is recommended for salmon spawning areas below Nimbus Dam. Although this level is higher than the minimum recommended by the RWQCB, the 9 mg/l DO level is considered a desirable goal to maintain, because transient field conditions are expected to induce uncontrollable factors that will cause oxygen levels to fluctuate (18). The lower 7.0 mg/l level recommended by the Regional Board is a minimum and is thus compatible with the mean of 9 mg/l suggested above. Similarly, a higher mean dissolved oxygen level of 7.0 mg/l is recommended for the lower reach of the river, in addition to the 5.0 mg/l minimum specified by the Regional Board.

Sewage-borne nutrients such as nitrogen and phosphorus stimulate the growth of algae and other aquatic plants. Widespread plant growths often interfere with water uses (19), curtailing or even eliminating swimming, boating, water skiing, and sometimes fishing; imparting tastes and odors to water supplies; shortening filter runs or otherwise hampering industrial and municipal water treament; impairing areas of picturesque beauty; reducing or restricting resort trade; lowering waterfront property values; interfering with the manufacture of certain products; causing diurnal fluctuations in dissolved oxygen and pH, which are detrimental to fish and on occasion become toxic to some warm-blooded animals. Algae appear as floating scums; as suspended matter giving rise to murky, turbid water or water have a "pea soup" appearance; as attached filaments; or as bottom-dwelling types that may be confused with the higher aquatic plants that grow as rooted, submerged, floating, or emergent plants.

The Regional Water Quality Control Board has recommended that "the concentration of dissolved nutrients shall be maintained at levels below those which may cause undesirable agal densities, slime, or bacteriological growth, or other undesirable biological growths." The RWQCB has further recommended a total nitrogen limit of 1.0 mg/l to control aquatic plant growths. In addition, the Federal Water Pollution Control Administration (20), has found that limiting total phosphorus content to 0.1 mg/l in flowing water will help control excessive growths of undesirable algal and aquatic plants. Therefore, for the purpose of this study, the recommended maximum total nitrogen and phosphorus levels are 1.0 and 0.1 mg/l respectively. These are maximum levels; algal and aquatic growths can occur in lesser concentrations but the density is generally tolerable and the resulting growths may contribute to a balanced ecology in the river.

PRESENT CONDITIONS

Concurrent with the great interest shown in preserving the Lower American River, several agencies have been conducting studies of the present water quality of the river. Since one of its most important sources of water is the American River, the city of Sacramento has conducted routine chemical and biochemical analyses on the river. A review of these observations has disclosed that the dissolved oxygen level collected from five sampling points downstream from Nimbus Dam has been consistently at or above saturation during an 18-month period, January 1966 to June 1967. Some slightly undersaturated samples were collected. The mean BOD_5 of river water samples collected during the same period was about 1.0 mg/l.

In the present stage of basin development, the total annual runoff of the American River from Folsom Dam is released to the lower river, but minimum flows included in the current agreement concluded between the California Department of Fish and Game and the U. S. Bureau of Reclamation in 1957 have been approached on several occasions since 1960.

The Regional Water Quality Control Board is satisfied with present conditions in the river. No requirement for flow augmentation exists with the present waste loading conditions in the river and releases from Nimbus.

Field and laboratory studies conducted by the Federal Water Pollution Control Administration in the Lower American River during the summer of 1967 assessed the present environmental quality and provided a basis for interpretation of water quality projections described later in this report. The objectives of these studies were to:

1. Assess the general character of the Lower American River through a summer season under varied flow conditions by taking physical measurements (water temperature, transparency) and photographs of the area.

2. Obtain a record of existing macro- and microscopic plant life in the Lower American River and near Nimbus Dam.

3. Collect water samples at three station in the Lower American River for nutrient and chlorophyll analyses and algal growth potential studies.

The chemical and biological tests included the nitrogen series (NO_3, NH_3, and organic N), total phosphorus, dissolved ortho-phosphate phosphorus, chlorophyll fluorescence, phyto-plankton identification and enumeration, and algal growth potential (AGP).

The sampling stations selected (see Figure 2) were located as follows:

Station 1 - Downstream from Nimbus Dam

Station 2 - At Guy West Bridge

Station 3 - Near the mouth of the American River

The Lower American River is a clean stream, compared to the westward draining rivers of the San Joaquin Valley. The general riverside character is pleasant, and the waters support many forms of recreation. The 1967 studies found water temperatures ranging from 13°C in June at flows of approximately 8,000 cfs to 19°C in August at a flow of 4,000 cfs. Transparency as measured by Secchi disc was generally greater than six feet and in most places the river bottom was clearly visible. Photographs taken in October reveal the character of the bottom, which is composed of clean gravels in the upper areas and a slightly more varied substratum, including sand and silt deposits, in the lower reaches.

BIOLOGICAL CHARACTER

Aquatic plants of various kinds were found in the river but not in nuisance proportions. In May 1967, growths of filamentous green algae were reported in Lake Natoma behind Nimbus Dam and fragments were observed in the river below the dam. Immediately downstream from the dam, luxuriant growths of filamentous green alga, Ulothrix, and gelantinous globules of the stalked diatom, Cymbella, were found on boulders near the water-line.

Similar attached growths of Ulothrix were observed by FWPCA biologists during May 1967 along the north shore of Lake Tahoe in the Sierra Nevada and immediately downstream from Friant Dam on the San Joaquin, California. In each case the growths occurred in clear waters which are known to be generally low in nutrient content. Since Ulothrix is considered a clean water organism, the bloom that occurred in Lake Natomas during May 1967 does not necessarily portend severe biological problems in the river at current nutrient levels.

At Arden Rapids, no growths were apparent during the summer observations. Further downstream near Watt Avenue Bridge, periphyton growths were apparent and detached segments of the filamentous golden brown alga, Hydrurus, were numerous. These segments were observed as undulating strands approximately one inch long. Benthic diatoms were observed at the Guy West Bridge and near the mouth of the American River in May. These were Cymbella, Diatoma, Fragillaria, and Gomphonema. Short streamers and felt-like coatings were formed on the stalks of submerged terrestial plants. The river flow was high during this period as a result of a late spring runoff during 1967.

Surveys in June, July, and August showed no prolific growths of attached or planktonic algae in the river, although filamentous green algae of the genus Spirogyra were abundant along the shore and in shallow water behind Nimbus Dam. Phyto-plankton levels were very low throughout the summer, but concentrations increased downstream.

During October, a matrix of light brown, gelantinous growths comprised of diatom stalks (Cymbella, Synedria) were found on rocks at the shoreline one mile downstream from Nimbus Dam. Similar growths were not observed elsewhere.

Floating particulate matter was observed in the river; this condition, to the naked eye, was similar to the conditions caused by Hydrurus in May. Under laboratory observation, the material was found to be actually detritus that was extensively covered with loose aggregates of diatoms (Cymbella, Fragillaria and Melosira). Water primrose plants were observed near Arden Rapids but not in any abundance.

In August and September 1968, blooms of blue green algae were recorded. These blooms created taste and odor problems in water supplied from the city water treatment plant located on the Lower American River. The blooms were attributed to the combination of warm temperatures, low river flows (about 1000 cfs), high nutrient inflow from cannery wastes at the Folsom State Prison sewage treatment plant, and nutrients from the upstream watershed.

Nutrient analyses for the three sampling stations indicated that the total nitrogen and phosphorus levels were low, generally less than 0.5 and 0.05 mg/l respectively. A general increase in total nitrogen and phosphorus from Station 1 to Station 3 was found. This was attributed to the nutrient-rich waste sources from sewage and other waste streams entering the river between Nimbus Dam and the mouth of the river. Chlorophyll concentration in samples collected during the study period were consistently below 5 ug/l. Little variation occurred between the three stations for any given sampling period, probably because the time of travel from Nimbus to the river mouth was insufficient to permit extensive phyto-plankton development. This finding was consistent with the level and character of the cell count which showed extremely few organisms. The enumerated few were probably sloughed from benthic growths.

For comparison, chlorophyll levels at the American River mouth (Station 3) were far lower than those found at the mouths of the Stanislaus and Tuolumne Rivers, where chlorophyll levels exceeding 100 ug/l have been recorded.

IMPACT OF PROJECT ON WATER QUALITY

Dissolved Oxygen

Sustaining an adequate dissolved oxygen concentration is essential to the maintenance and propagation of the fishery in the stream. To hold these oxygen levels, adequate flows much be available for the assimilation of treated waste effluent. The projected BOD loadings at the various levels of development shown in Table 5 were imposed on the river to determine the required flow. It is estimated that a minimum flow of 200 cfs will be needed by 2025 to sustain the required dissolved oxygen levels. Results of these computations are shown in Table 6. The flow requirements shown do not take into account the influence on dissolved oxygen levels of excessive algal and aquatic growths that result from nutrient enrichment of the water.

TABLE 6 - FLOW REGULATION FOR DISSOLVED OXYGEN CONTROL
LOWER AMERICAN RIVER

	1975	2000	2025
Flow regulation, cfs	50	100	200

The flow required to maintain minimum dissolved oxygen level in the various states of development up to 2025 are less than the proposed operation schedule during the base year, and mean releases, or the present agreed minimum fishery and water supply releases below Nimbus Dam.

Total Dissolved Solids and Hardness

Under the proposed regulated flows, future water available to the Sacramento City water system will contain higher total dissolved solids (TDS) and hardness. This reduction of water quality will be caused by the progressively greater proportion of sewage effluent present in the river water as the result of decreased releases from Nimbus Dam.

The mean TDS and hardness of water available to Sacramento City are shown in Table 7 at the various states of development. In the early stages of project development after 1975, the changes in hardness will be insignificant, but by 2025 average hardness will have increased by 37 percent. Similarly, the TDS changes will be insignificant in the early years, but by 2025 the average TDS will have increased by 38 percent. However, increased in TDS and hardness should not affect the usefulness of the water for municipal and industrial purposes. The water will meet the mineral quality recommended by the U.S. Public Health Service Drinking Water Standards (6).

TABLE 7 - PROJECTED TOTAL DISSOLVED SOLIDS AND HARDNESS IN LOWER AMERICAN RIVER

	1975	2000	2025
Hardness, mg/l [a]	25.6	29.4	34.2
Increase, %	2.4	17.4	36.7
TDS, mg/l [b]	42.4	51.6	65.1
Increase, %	5.9	29.0	37.8

a/ Present flow weighted hardness, 25 mg/l as calcium carbonate

b/ Present flow weighted TDS, 40 mg/l

Nutrients

The total nutrient load discharged into the river by 1965 population and by projected populations at various levels of development is shown in Table 8. Nitrogen and phosphorus loads are based upon the per capita contribution rate reported by Weinberger (21), which reflect a 50 percent removal of nitrogen and a 30 percent removal of phosphorus in secondary sewage treatment plants. Although recent reports indicate higher phosphorus removal rates are possible (22,23), the conventionally accepted removal rates have been used in this study to compute nutrient loading.

TABLE 8 - NUTRIENT LOAD LOWER AMERICAN RIVER

NUTRIENT	1965	1975	2000	2025
Nitrogen (lb/yr)				
Sewage	969,000	1,665,000	3,330,000	4,625,000
Runoff	142,000	125,000	117,000	82,000
Total	1,111,000	1,790,000	3,447,000	4,707,000
Phosphorus (lb/yr)				
Sewage	256,000	441,000	882,000	1,225,000
Runoff	32,000	32,500	32,800	35,800
Total	288,000	473,500	914,800	1,260,800

The nutrient loads shown in Table 8 include contributions from local drainage. Since detailed data are not available on the character of runoff from the agricultural and urban areas of the Lower American River basin, estimates were based on data given by Weibel (24). In addition to surface runoff, mainly attributable to local precipitation the urban area includes large areas of lawn, brush, parks, and other beautification growths. Sustaining this vegetation through the hot, dry summer of the Central Valley requires large quantities of water. Drainage from these household and municipal irrigation practices forms a measurable nutrient load to the river. Field observations and sampling of several drains during the summer of 1967 have provided some information on the character of the drainage water. It was estimated that a large part of the nutrient analyzed was derived from lawn fertilizer. An estimation of their contributing load was included in the local runoff shown on Table 8.

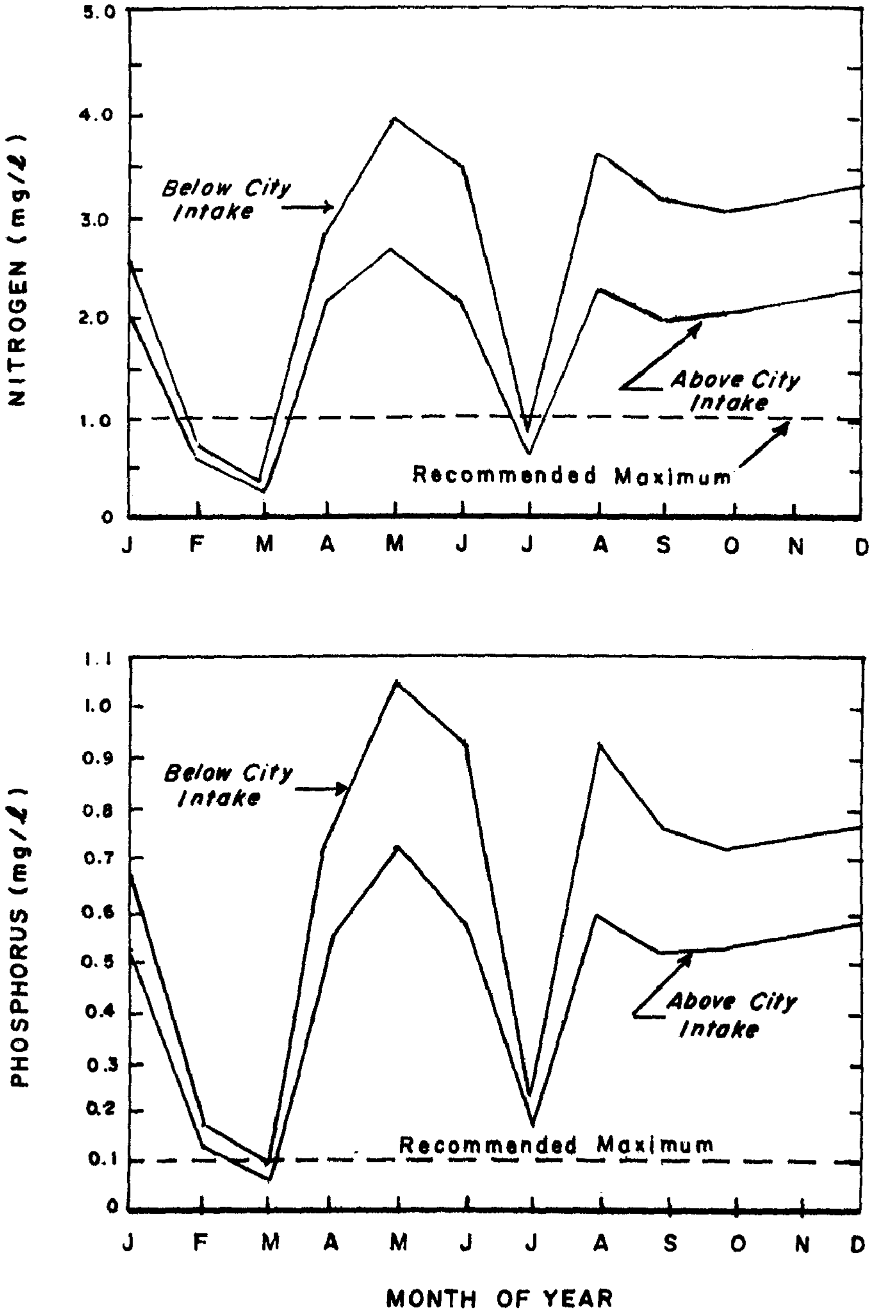
To evaluate the impact of the nutrient load on the river, the project releases from the base year were used to control the projected nutrient loads in the Lower American River. Thus, the nutrient concentrations will be the maximum levels expected at least once in ten years. In Figure 7, nitrogen and phosphorus levels in the river are shown under 2025 project conditions. As indicated, the nitrogen level below the city intake will exceed the maximum recommended value (1.0 mg/l) for 75 percent of the year and will reach a peak of 4.0 mg/l in late spring. Similarly, the phosphorus level by 2025 will also exceed the maximum recommended level almost the whole year (except March) and will reach a peak of about 1.0 mg/l below the Arden Sewage Treatment Plant. The major contribution to the nutrient load at the 2025 level of development will be derived from sewage effluent that will form as much as 15 percent of the river flow upstream from the City of Sacramento water intake system and reach a peak of 24 percent of the river flow downstream during the base year flow. Thus, under the base-flow releases, the maximum recommended nutrient objectives for nitrogen will be exceeded during a large part of the year and the objectives for phosphorus will be exceeded for almost the entire year.

Impact of Fertilization

To provide a basis for evaluating the impact of future nutrient load in the river, algal growth potential (AGP) studies were conducted in the river and laboratory during the summer of 1967. They were undertaken to provide data on the biological potential of American River water under future conditions of low flow and sewage enrichment.

The AGP value is the peak chlorphyll concentration achieved in 14 days. The AGP test involved incubation of river waters replicated in 500 ml flasks at 20°C in an incubator equipped with fluorescent lamps with an on-off cycle of 12 hours each 24 hours. Chlorophyll was measured every

NUTRIENT CONCENTRATION
BASE FLOW RELEASES
2025 LEVEL OF DEVELOPMENT



LOWER AMERICAN RIVER STUDY

NITROGEN AND PHOSPHORUS CONCENTRATIONS

DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION SAN FRANCISCO, CALIF.

Figure 7

2 or 3 days. Three series of tests were performed, each involving samples from each of the three stations sampled.

Progressively higher AGP values were obtained in raw river water incubated from the downstream stations. They ranged from a mean of about 5 ug/l chlorophyll at Station 1 to 30 ug/l chlorophyll at Station 3.

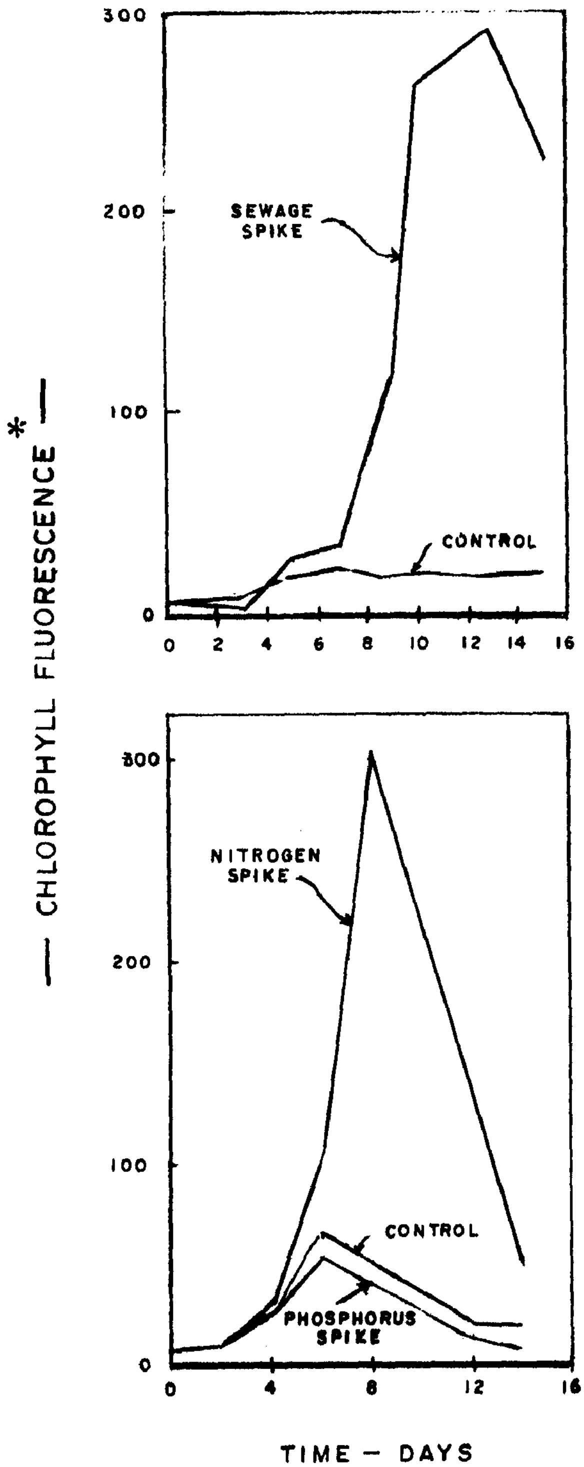
Addition of inorganic nitrogen and treated sewage to American River water yielded higher AGP values than did raw river water incubated with treated sewage and phosphorus supplement. Examples of these bio-assays are shown in Figure 8. Addition of 17 percent sewage to the mixtures yielded AGP values from 8 to 30 times greater than those in the raw water controls.

The AGP values provide an index of eutrophication (state of enrichment). Higher AGP values by definition indicate an ability to produce denser crops of algae or aquatic plants. Where physical conditions of streams are similar (i.e., depth, temperature, substrate), it is reasonable to make general analogies of the biological character of streams based on AGP values.

Considering the above field and laboratory tests, the character of the Lower American River is expected to be altered as a direct consequence of over-fertilization if stream flow is reduced and present waste disposal practices are continued. Aquatic plants such as water hyacinth and water primrose will become abundant in the river, particularly in the shallow near-shore regions. Attached green algae such as Cladophora and bluegreen algae such as Oscillatoria will develop in the river bottom below sewage discharge points. The density of these plant growths will be proportional to the nutrient loads reaching the stream during the growing season.

Nuisance conditions related to over-abundant plant growths have been recorded in several San Joaquin Valley streams in California. Water primrose and water hyacinth growths have repeatedly clogged the Stanislaus and Tuolumne rivers and blocked shore access. Mats of blue-green algae (Oscillatoria) have caused wide fluctuations in dissolved oxygen (more than 8 mg/l in 10 hours) and excessive pH values in the Tuolumne River. Dissolved-oxygen depressions (below 3 mg/l) and unsightly growths of stalked ciliates occurred in the lower reaches of the Tuolumne River below a municipal sewage outfall during a 1966 low-flow period.

Nuisance growths of attached green and blue-green algae and dissolved oxygen deficiency related to these growths have occurred in the shallow, sewage-enriched Truckee River below the city of Reno (25).



Algal Growth Potential
American River
at Guy West Bridge
Series C
sample collected
6 Oct. 1967

Algal Growth Potential
American River
at Mouth
Series B
sample collected
22 Aug, 1967

* Scale relative to fluorometer readings

LOWER AMERICAN RIVER STUDY

A G P STUDIES

DEPARTMENT OF THE INTERIOR
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PACIFIC SOUTHWEST REGION   SAN FRANCISCO, CALIF.

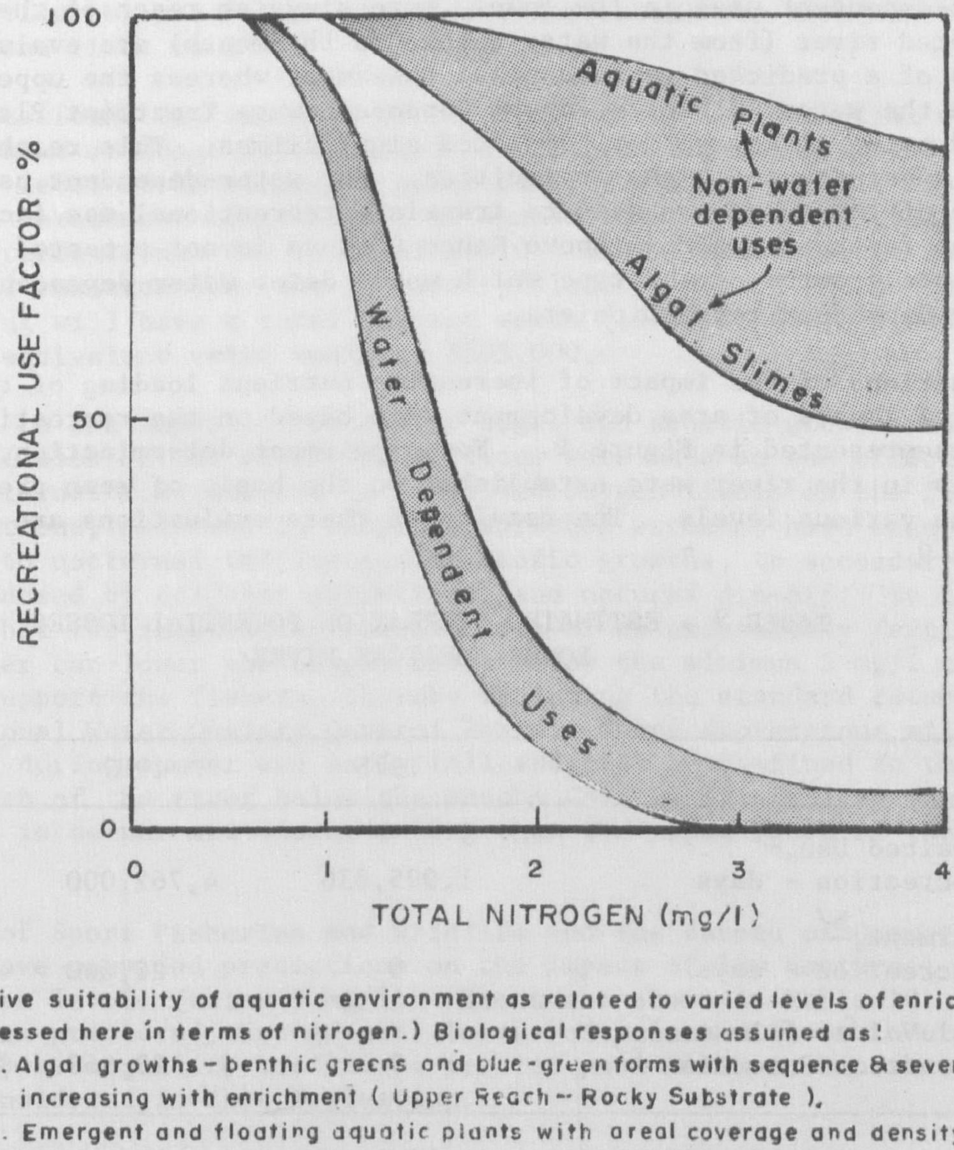
Figure 8

Nitrogen levels in the Tuolumne and Stanislaus Rivers are generally greater than 1 mg/l during the low-flow months; concentrations greater than 2 mg/l have been recorded. Studies carried out in July 1962 and August 1963 in the Truckee River below Reno disclosed nitrogen concentrations of 2-3 mg/l. Nuisance benthic algal growths were also observed. Phosphorus is apparently not a limiting nutrient in these sewage-fertilized streams.

<u>Impact of Project on Recreation and Fishery</u>

Economic evaluations must relate water-oriented recreation to water quality and to various biotic growths, in accordance with predicted flow depletion and sewage-induced enrichment. To gain background information for such evaluation, FWPCA and Bureau of Outdoor Recreation (BOR) personnel made field visits in early October to numerous points on the San Joaquin, Stanislaus, Tuolumne, and Merced Rivers in California to compare general conditions of these streams with those of the American River. Photographs of these waters in 1967 and 1966 (a lower water year) were compared. Aquatic growths, including water hyacinths, water primrose, blue-green algal mats, and various associated algal conditions, were discussed in relation to nutrients and the reactions of vacationers to these growths at different nuisance levels. Photographs of conditions in the Truckee River near Sparks, Nevada, were used as examples of blue-green algal nuisances in a river, and examples of rooted aquatics were taken from streams in the San Joaquin Valley area.

The relationship of recreation to enriched conditions was developed by relating the types of water quality problems to recreation uses. The uses selected were both water-dependent (swimming, etc.) and nonwater-dependent (picnicking, etc.). Water quality aspects of recreation were considered in light of the results of recreation surveys carried out in other studies. The relationships developed are illustrated by the graph on Figure 9. The curves on the figure represent the judgment of a group of biologists, sanitary engineers, and recreation specialists. Seasonal factors were used, whereby water quality was assumed to have no effect on winter recreation from November-April and a factor of 50 percent of the peak effect was applied during the months of May and October. The full 100 percent factor was applied during the peak recreation season June-September. The conditions in which total loss of water-dependent recreation occur were taken as equivalent to nearly total blockage of the flow-depleted stream by aquatic plants such as recorded in the Tuolumne River near Modesto, California, or dense blue-green algal crops with attached slimes and floating scums, as in the enriched Truckee River during 1962-63. It should be noted that the blue-green algal genus (<u>Oscillatoria</u>), which was dominant in the Truckee River, was found in mats in the Tuolumne and San Joaquin Rivers by FWPCA biologists in 1966 and 1967. Water primrose plants and filamentous



Notes:

1. Relative suitability of aquatic environment as related to varied levels of enrichment (expressed here in terms of nitrogen.) Biological responses assumed as:
   a. Algal growths – benthic greens and blue-green forms with sequence & severity increasing with enrichment (Upper Reach – Rocky Substrate).
   b. Emergent and floating aquatic plants with areal coverage and density increasing with enrichment. (Lower Reach – Mud & Sand Substrate).
2. Lower Reach – mouth to water intake of Sacramento City Water Treatment Plant
   Upper Reach – water intake to Rancho Cordova Sewage Treatment Plant.
3. Recreational use factors apply seasonally since nuisance conditions are expected only during the warm dry season (May – October). Factors are expected to be half the plotted value in May and October and the full value in June – September. Unimpaired recreational use is applied for remainder of year.

LOWER AMERICAN RIVER STUDY

WATER QUALITY – RECREATION USE RELATIONSHIP

DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION SAN FRANCISCO CALIF.

Figure 9

green algae were found in the American River by FWPCA biologist in 1967. The water quality-recreation use relationship is shown in Figure 9.

Projected total nitrogen levels (abscissa) based on sewage volumes and river flows are translated to recreational use factors (ordinate). The recreational factors are applied according to the use category. Non-water-dependent uses in the lower, more sluggish reach of the future flow-depleted river (from the water intake to the mouth) are evaluated on the basis of a predicted aquatic plant nuisance, whereas the upper reach (from the water intake to Rancho Cordova Sewage Treatment Plant) is evaluated using the curve for predicted algal slimes. This reach has more rock substrate and higher velocities. For water-dependent uses, the mid-range of the curve was used to translate recreational use factors. The region farthest upstream above Ranco Cordova is not expected to have nuisance growths of the type which would deter water-dependent and non-water-dependent recreationists.

Evaluations of the impact of increasing nutrient loading of the river at several levels of area development were based on the recreational use curves presented in Figure 9. For impairment determination, the nutrient levels in the river were established on the basis of mean project releases at the various levels. The results of these evaluations are shown in Table 9.

TABLE 9 - ESTIMATED RECREATION POTENTIAL LOSSES
LOWER AMERICAN RIVER

	1975	1987	2019
Unimpaired Use,[a/] Recreation - days	1,995,836	4,762,000	14,635,000
Impairment,[b/] Recreation - days	0	20,600	1,475,000
Annual Value of Lost Recreation Potential [c/]	0	$ 23,960	$ 1,622,500

a/ Bureau of Outdoor Recreation preliminary projections based on quality of river water in 1967 (16).

b/ Impairment due to water quality deterioration.

c/ Based on recreation day value of $1.15/day in 1987 and $1.10/day in 2019.

According to Table 9, no impairment of recreational opportunities is anticipated in 1975 as a result of water quality since the quality of the river will still be satisfactory. By 1987 water quality will have suffered minor deterioration resulting from lowered releases and the increase of waste discharge which will have an adverse effect upon the recreational use of the river. The preliminary projection of unimpaired use of the river by the Bureau of Outdoor Recreation was based on water quality of the river in 1967.

With a recreational-day value of $1.15, lost recreation potential with an annual value of about $23,690 will be incurred beginning in 1987. At the 2019 level of development, water quality will be further impaired by nutrient enrichment resulting in an annual loss of about $1,622,500, based on a recreational-day value of $1.10. The harmful effects to the recreational resource over the 100-year evaluation period discounted at 4-5/8 percent will have a total present worth (1975) of $10,835,000. Its annual equivalent value would be $505,000.

In addition to the impact of excessive algal and aquatic growths on recreational uses of the river, predictions were made on the effects of severe diurnal fluctuations in dissolved oxygen levels on the fishery. The fluctuations, observed in nutrient enriched streams, have been attributed to nocturnal respiration of biotic growths, to secondary pollution caused by cellular excretions, and natural die-off. It is predicted that the respiration requirements of an excessively fertilized body of water can lower the oxygen level below the minimum 5 mg/l required to support the fishery, thereby violating the standard established by the Regional Water Quality Control Board. These depressions will be most severe during summer and early fall and will be confined to the lower stretch of the river below the Rancho Cordova Sewage Treatment Plant which is deeper and slower moving than the upper reach of the river.

The Bureau of Sport Fisheries and Wildlife and the Bureau of Commercial Fisheries have provided predictions on the impact of low nocturnal dissolved oxygen levels (below 5 mg/l). These are shown in Table 10. It has also been predicted that greater losses of salmon will be incurred if the poor water quality conditions persist past October, but these were not considered in this evaluation.

TABLE 10 - IMPACT OF LOW DISSOLVED OXYGEN ON FISHERY
LOWER AMERICAN RIVER
2019

FISHERY [a/]	RANGE OF IMPAIRMENT %	REDUCTION IN ANGLER-DAYS	VALUE OF ANGLER-DAY $	DETRIMENT $
Warm Water Species	70-90	17,500	1.00	17,500
Striped Bass	100	8,000	3.50	28,000
American Shad	100	30,000	2.50	75,000
Rainbow Trout	80-100	28,000	1.50	42,000
Steelhead Trout	80-100	20,800	5.00	104,000
Chinook Salmon-Inland	90-100	69,300	4.00	277,200
Chinook Salmon-Ocean	90-100	66,600	6.00	399,600

a/ Bureau of Sport Fisheries and Wildlife, Office Communications. In addition, an annual commercial fishery of 675,000 pounds valued at $0.55 per pound will be reduced 90-100 percent.

Using the conservative (lower) impairment rate, the reductions in angler-days and commercial fish harvest are shown for the 2019 level of development. It was assumed that minor problems will be experienced in the years immediately after 1975, but significant impairments will not commence until the year 1987. They will peak at the 2019 level of development. Based on the impairment rates shown in Table 10, an annual reduction of 240,200 angler-days and about 300 tons of commercial harvest will occur. When expressed in monetary values, these detriments would have a present worth (1975) of $8,423,000, evaluated over a 100-year period and discounted at 4-5/8 percent. An annual equivalent value of about $394,000 over this period could be attributed to the water quality deterioration resulting from excessive nutrient fertilization.

IMPACT WITHOUT FOLSOM SOUTH CANAL DIVERSION

To provide a basis for evaluating the impact of the Folsom South Canal diversion, the effects of future developments in the Lower American River were appraised separately by studying projected conditions without the project in place and without scheduled diversions. To realistically appraise these future conditions, it was assumed that the conditions without the project and economic growths therefrom would induce constraints on the population growth of the study area. Under these conditions the sewage waste loads to the Lower American River would be reduced correspondingly. Based on the proportion of water which the project would furnish for municipal and industrial purposes to the study area it was estimated that the future population and sewage waste loads would be reduced by about 15 percent. The mean monthly runoffs through the same historical period of project operation (1921-1954) were used to dilute the projected sewage loads at levels of development up to 2025, and the various water quality parameters were evaluated.

1. Dissolved Oxygen Control and Impact on Total Dissolved Solids and Hardness

Under conditions without the project, as described above, the dissolved oxygen needs of the river will be met to the year 2025. Flow regulation for control of dissolved oxygen deficits incurred by organic loading of the river will not be needed. The TDS and hardness of the river water will increase as the result of increasing volumes of sewage effluent discharged into the river at the various levels of development. These increases will be most evident during the dry months of August and September. Nevertheless, the increases in TDS and hardness will not influence the usefulness of the water because the water would still be considered excellent. The water will meet the mineral quality requirements recommended by the U. S. Public Health Service Drinking Water Standards (6) and will be adequate for municipal, industrial and agricultural purposes.

2. Water Quality and Relation to Recreation and Fishery

Employing the methodology for relating nutrient loads in the river to recreation, as previously described, the impact of future nutrient loads on the river was evaluated under conditions without the project. It was found that by 1975, the recommended nitrogen level (1.0 mg/l) will be exceeded during the three dry summer months and will reach a peak of 2.1 mg/l in September in the downstream reaches of the river. At the 2000 and 2025 level of development, the nitrogen concentration will exceed the recommended level during four and five months of the year respectively and will reach a peak of 4.8 mg/l during September at the 2025 level of development. For the remainder of the year, the natural runoffs of the basin will be adequate to dilute the nitrogen load.

Under conditions without the project, the recommended phosphorus level

(0.1 mg/l) will be exceeded five months of the year during the dry season at the 1975 level of development and will reach a peak of 0.50 mg/l in the downstream reaches. By 2000 and 2025, the recommended phosphorus level will be exceeded during seven and nine months of the year respectively, and will reach a peak concentration of 1.29 mg/l during the summer of the terminal study year (2025). It should be noted that the concentrations of both nutrients (N & P) reached higher levels than under project conditions during the dry summer months but the nutrients were highly diluted during the runoff season to much lower concentrations. Thus, the effects of the dry season flow are more pronounced under conditions without the project.

When monthly nutrient levels were related to recreation uses, the lost recreation potential was evaluated by methods previously described. The results of these evaluation shows an annual loss of $40,000 at 1975, $251,000 at 1987 and reaching $1,339,000 at the 2019 level of development. The impact over the 100-year evaluation period discounted at 4-5/8 percent will have a total present worth (1975) of $11,585,000. Its annual equivalent value will be $540,000.

In addition to the impact of excessive algal and aquatic growths on recreational uses, predictions were made on the effects of severe diurnal fluctuations in dissolved oxygen levels on the fishery. Using the predictions furnished by the Bureau of Sport Fisheries and Wildlife and the Bureau of Commercial Fisheries, it was found that the reduction in angler-days use and commercial fish harvest would not differ significantly from under project conditions. As previously evaluated, these detriments show a present worth (1975) of $8,423,000 when evaluated over a 100-year period discounted at 4-5/8 percent. The reduction in fishery use is estimated to have an annual equivalent value of about $394,000 over this period that could be attributed to water quality deterioration resulting from excessive nutrient fertilization.

IMPACT OF PROPOSED DIVERSION COMPARED WITH CONDITIONS WITHOUT THE PROJECT

When the impact of the proposed diversions is compared to the impact of future waste loadings without the project, it was found that the detriments were not significantly different and were within the estimated accuracy of the methodology employed for the evaluations. The total detrimental impact under project diversions is estimated to be $12,590,000 over the 100-year evaluation period, compared to detriments of $13,340,000 without the project. Thus, the impact of the project, by itself, is not considered significantly different from the anticipated river conditions without the project.

IX. WATER QUALITY CONTROL NEEDS

MITIGATION OF NUTRIENT IMPACT BY FLOW AUGMENTATION UNDER PROJECT CONDITIONS

Flow augmentation to reduce nutrient concentrations is one method which could decrease the harmful impact of excessive fertilization of the Lower American River. Flow augmentation necessary to reduce nutrient concentration to the recommended objectives at various levels of development under project conditions is shown in Table 11.

TABLE 11 - FLOW AUGMENTATION FOR NUTRIENT CONTROL
LOWER AMERICAN RIVER
Under Project Conditions

NUTRIENT CONTROL a/	1975	2000	2025
Protection, nine out of ten years b/			
Nitrogen control, AF/yr	0	175,000	435,000
Phosphorus control, AF/yr	0	1,138,000	2,233,000
Protection under mean project flow c/			
Nitrogen control, AF/yr	0	83,000	413,000
Phosphorus control, AF/yr	0	1,119,000	2,143,000

a/ Stream flow needs in addition to project releases.

b/ Maximum augmentation flows required to provide protection, nine out of ten years.

c/ Mean augmentation flow over 33 years of historical record.

The flows indicated in Table 11 show both the maximum requirements to provide protection in nine out of ten years and also mean requirements during the project releases over the 33 years of operation study. Augmentation releases, in addition to scheduled project releases, are needed only during the spring and summer months from May to October when the effects of excessive fertilization are most pronounced. During the winter and early spring months, excessive fertilization will have less impact on water quality and use and augmentation flow will not be needed.

In the early years after project completion in 1975, the anticipated nitrogen load will be controlled adequately by project releases, during more than 90 percent of the year. To control nitrogen levels to subeutrophic concentrations by the year 2000 will require an annual peak augmentation release of 175,000 acre-feet for protection in nine out of 10 years and a mean annual release of 83,000 acre-feet. To control the increased nitrogen load in 2025, these releases will have to be increased to 435,000 and 413,000 acre-feet respectively.

In the early years after completion of the project, the phosphorus level in the river will also be controlled adequately under base and mean flow conditions. Phosphorus levels will be exceeded during the winter months, but because nuisance aquatic growth will be unlikely, the impact on the river will be insignificant. By the year 2000, flow augmentation will be needed to maintain the recommended level to suppress nuisance growths. A maximum additional release of about 1.1 million acre-feet will be needed to provide protection during nine out of 10 years and also for the 33 years of historical record. These augmentation flows will have to be increased to a peak of 2.2 million acre-feet and a mean of 2.1 million acre-feet by the year 2025.

To furnish a basis for comparison of alternative plans, costs were evaluated for the mitigation of water quality detriments by augmentation flows for the control of nitrogen concentration. The AGP studies indicate that nitrogen will be the limiting nutrient controlling algal growth in the Lower American River. Therefore, control of nitrogen levels would be the most effective means to suppress eutrophic conditions in the river. However, it should be recognized that phosphorus levels would remain above the recommended 0.1 mg/l concentration when only the nitrogen content is reduced to the 1.0 mg/l level.

The maintenance of higher flows in the Lower American River by increased releases from Nimbus Dam and supply of Folsom South Canal water needs by pumping, will result in lower TDS and hardness levels in the Sacramento River as it reaches the Hood pumping installation. The water returned to the Folsom South Canal will have slightly higher TDS and hardness, reflecting Sacramento River water quality. Thus, the quality of water in the Sacramento River below Hood will have been improved while the water available from the Folsom South Canal will be somewhat higher in TDS and hardness. In terms of the economy of the whole region, the impact of these small water quality changes will be insignificant. In any case, the quality of water in both the canal and the Sacramento River will still be excellent for all purposes.

For the purpose of this study, the costs for the return to the Folsom South Canal of the additional releases through the Hood-Clay Pump Station were considered. Preliminary cost estimates for a single-purpose pump station and transmission system were evaluated for this need beginning in the year 2000. The present worth (1975) of the capital cost will be about $5,000,000 and the maintenance operation costs and replacement for the pumping plant and conveyance system will be about $2,500,000. The operational cost includes electrical power needs. When this total present worth is discounted over a 100-year period at 4-5/8 percent, an annual cost of about $350,000 will be incurred to meet the additional releases into the Lower American River to lower nitrogen concentrations to acceptable levels.

It is recognized that the cost for additional releases could be reduced if the proposed project releases into the Lower American River were to be increased for fishery maintenance. As the Bureau of Sport Fisheries and Wildlife and the Bureau of Reclamation are considering additional releases for fishery maintenance, the reduction in costs for nutrient control will require further evaluation when revised releases are firmed.

ALTERNATIVES UNDER PROJECT CONDITIONS

Although control of nutrient concentrations with project water is feasible, it is not the only solution to the nutrient problems of the Lower American River. Moreover, with the projected population growth, even the release of all flow to the American River rather than diversion to the Folsom South Canal would not be adequate to control the phosphorus level. Alternative solutions to the problem have been investigated and the two solutions that have been considered are advanced sewage treatment methods and diversions of wastes from the Lower American River.

1. Advanced Sewage Treatment Methods

Traditionally, the removal of nitrogen and phosphorus has not been a primary objective in modern secondary treatment plants. The main goal has been the reduction of oxidizable organic matter. In recent years, however, greater attention has been focused on the need to control the eutrophication of receiving waters by removing nutrients. Recent investigations (22,23) have shown that the removal of phosphate could be increased in the secondary treatment process by changing conventional operating practices to result in 90 to 95 percent phosphate removal. Advanced treatment methods (26,27,28,29) have shown that 90 percent phosphate and 80 percent nitrogen can be removed. Pilot plants and small sewage treatment plants have used advanced waste treatment techniques successfully (26,27,28,29). Adaptation of these techniques to large plants awaits only the appropriate time, place, and justification.

Based on nutrient removal levels expected from advanced treatment methods, the need for flow augmentation at the various states of development was determined. It was found that augmentation flows will not be needed at any stage up to the year 2025 to maintain recommended nutrient levels. By 2025, reservoir release into the lower river in accordance with present operation plans will total 1,230,000 acre-feet during the base year flow period. This will be adequate for dilution of phosphorus and nitrogen loading during nine out of 10 years. Thus, with provision made for advanced treatment, the nutrient level in the river will be lowered at least 90 percent of the time to acceptable level without augmentation.

To provide a basis for comparing alternative solutions to the nutrient loading problems in the river, costs were estimated for providing advanced treatment of wastes before discharge to the river. To offset the cost of advanced treatment, the treated effluent has been considered suitable for reuse in the American River Parkway and other irrigation areas. The city of Sacramento presently purchases water from the Bureau of Reclamation at nine dollars ($9) per acre-foot. Water-treatment costs are approximately $24 per acre-foot (30). Thus, the cost of finished water to the city is about $33 per acre-foot or about $100 per million-gallons, in storage before distribution. Present estimates of advanced treatment costs range from $150-$200 per million-gallon (26,28,29). These costs are in addition to primary and secondary treatment.

Using the lower figure ($150 per million-gallon), thereby allowing a discount for the value of reclaimed water, an annual cost of about $2,108,000 by 2000 is estimated for the provision of advanced treatment. This amount will increase to about $3,663,000 by 2025 to provide for the increased sewage flows. The 1975 value of advanced treatment cost will be approximately $20,680,000 or about $967,000 per annum, when discounted over a 100-year evaluation period at 4-5/8 percent.

2. Diversion of Wastes from the Lower American River

Without employing advanced treatment methods for removing nutrients from sewage, quality objectives in the Lower American River could be maintained by diverting waste from the basin.

The Aerojet-General Corporation (13) has suggested an out-of-basin transport plan that calls for a central collection and export system to serve the entire Sacramento metropolitan area. Terminal discharge point will be in the Delta or the Pacific Ocean. However, this study does not examine such plans.

The present study considers a plan to export waste from the Lower American River to the Sacramento River. This plan requires the continued operation of the Sacramento County's Cordova, Arden, and Northeast Treatment Plants to the limit of their present capacity. The future increased flows from the northeast areas will be transported across the American River southward to the county's Central Plant for treatment and disposal into the Sacramento River near Freeport.

Expansion of the Cordova Plant should be limited and increased flows from the area would be diverted to the Central Plant. Existing sewers of the Central Plant are located as far as the boundary of the present collection system of the Cordova Plant and across the river from the Northeast Plant (see Figure 6). These sewers were installed under the county's master plan (12). Since excess capacity is presently available in these sewers, because they were designed for future flows, connections thereto will be feasible in the immediate future up to the year 2000. Utilimately, a larger sewer system to serve the diverted flows from across the river and a local service area south of the river will be required to handle a large volume of sewage (see Figure 6).

Expansion of the Arden Plant should also be limited by diverting future sewage flow into the proposed North Central and Northwest Plants or across the river to the city of Sacramento sewer system. The proposed plants will be located in the lower elevations of the natural drainage basin of various creeks flowing parallel to the American River. The natural drainage of the sewage system from the basin between the Northeast area and the Sacramento River to the west will be toward these new plants, if the advantage of the natural gradients of the terrain were to be followed. A superior plan would be to divert all future flows to the proposed Northwest Plant for treatment and discharge to the Sacramento River and to delete the North Central Plant from the county master plan. Extension of the local sewer collection system north of the American River should be planned on the basis of the need to divert flows to these proposed plants to minimize nutrient discharge to the river.

For effective waste management, centralizing waste disposal sites has many advantages. Not only will capital, maintenance, operation, and replacement costs be reduced, but also the centralized facilities will be better suited to advanced treatment processes than will many scattered units.

To make the maximum use of available water resources, effluent from the existing Arden, Cordova, Northeast and Aerojet-General Plants should be reclaimed for recreational and irrigation uses within the American River Parkway, including the Caliofrnia Exposition. The proposed County Parkway Plan includes recreation lakes and an extensive greenbelt covering more than 3,500 acres of land. Reclaimed sewage has been used successfully for recreation lakes and park irrigation elsewhere in California. Such reclamation will conform with the intent of recent state legislation which actively supports the reuse of reclaimed sewage as a means of fully developing the water resources of the state. Sewage effluent could be stored at several proposed recreation lakes located within the American River Parkway, and water could be withdrawn from these lakes for greenbelt irrigation as needed. The total capacity of the existing treatment plants is about 24 mgd

(26,500 acre-feet per year). If this quantity of water, diminished by percolation losses from recreation lakes, exceeds the needs of the American River Parkway, or any other section of the area, surplus water could be released to the Lower American River during the peak runoff season (December through March) when greater dilution capacity would be available and undesirable aquatic growths would not be prevalent.

Under this proposal, the only effluent reaching surface waters of the Lower American River would be derived from the Aerojet-General Corporation area. Even here, efforts should be made to use effluent from Aerojet operations for irrigation or to divert it to percolation ponds, which have been successful until recently in limiting waste discharge to surface water. These percolation ponds were lately removed under a storm drainage improvement project. Ultimately, future expansion of the sewerage system in the Areojet area should consider the diversion of waste to the county's Central Plant near Freeport.

If the reclamation plan for reuse of sewage in the American River Parkway is not enacted, minimum flows will be required to control nutrient discharges from existing plants. Minimum flows for nitrogen and phosphorus control in the reaches upstream and downstream from the city intake system, shown in Table 12, will be required from May to October when algal and aquatic growths are most likely to be harmful. To dilute the nitrogen load from the existing secondary sewage treatment plants, flows of 1,000 cfs will be needed upstream from the city water intake system, and 700 cfs will be needed downstream. For limitation of phosphorus concentrations, flows of 2,500 cfs and 2,000 cfs will be needed upstream and downstream respectively. If 50 percent of the nitrogen load reaches the river, a flow of 500 cfs upstream and 300 cfs downstream will be needed. Phosphorus control needs for 50 percent return to the river will be 1,500 cfs and 1,200 cfs respectively. However, with a lower return of phosphorus (25 percent), the dilution flow will be decreased to 750 cfs and 500 cfs respectively.

Lower nutrient return rates were not evaluated since even with total reuse of plant effluents, a portion of the fertilizing load will reach the river by surface and sub-surface migration. The 50 percent and 25 percent returns of nitrogen and phosphorus respectively, are the best estimates presently available for nutrient recycling to the river after land application on the American River Parkway.

Since the control of nitrogen levels will be the most effective means to suppress eutrophic conditions in the river, augmentation releases for this purpose will be nominal, as shown on Table 12. With the discharge of all the effluent from existing sewage treatment plants into the river (100% return), flows of 1,000 cfs upstream of the water intake and 700 cfs downstream will be required. To maintain these flows, additional releases above mean project releases of 1,800 AF/year

TABLE 12 - FLOW REQUIREMENT FOR CONTROL OF NUTRIENTS IN EXISTING SEWAGE TREATMENT PLANT EFFLUENTS LOWER AMERICAN RIVER

NUTRIENT	NUTRIENT[a/] RETURN TO RIVER (%)	FLOW[b/] REQUIREMENT UP/DOWN-STREAM (cfs)	AUGMENTATION RELEASE [c/] (AF/YR)		
			1975	2000	2000
Nitrogen control	100	1000/700	0	1,800	35,000
	50	500/300	0	0	0
Phosphorus control	100	2500/2000	0	258,000	336,000
	50	1500/1200	0	60,000	155,000
	25	750/500	0	0	0

a/ Nutrient return to river is based on proportion of sewage effluent reclaimed for American River Parkway and proportion of this nutrient load returned with subsurface and surface flows.

b/ Upstream - above city of Sacramento water intake system. Downstream - below city of Sacramento water intake system.

c/ Augmentation flows, in addition to project releases required during recreation season, May-October under mean conditions.

will be required by the year 2000 and these releases will increase to 35,000 AF/year by 2025. These releases are nominal and could be supplied coincidentally by the increased flows for fishery purposes which are presently being considered by the Bureau of Sport Fisheries and Wildlife and the Bureau of Reclamation.

In summary, the annual augmentation flows needed at various stages of development and at different levels of nutrient return to the river are shown on Table 12 for nitrogen and phosphorus control. If the entire effluent flow from the existing treatment plants were to be discharged to the river, a mean annual augmentation flow of 1,800 acre-feet in the year 2000 would be needed for nitrogen control. This annual flow requirement would increase to 35,000 acre-feet by the year 2025. For phosphorus control, a mean annual augmentation of 258,000 acre-feet and 336,000 acre-feet, respectively, would be needed over the same periods. Lower flows would be required commensurate with the degree of effluent reuse for the American River Parkway irrigation. Since nitrogen should limit the process of eutrophication, the cost of augmentation flow necessary to control nitrogen concentration was evaluated. As these releases are relatively small, only electrical power cost for pumping of releases to the Folsom South Canal through the Hood-Clay Pump Station was considered. It was found that these costs will have a present worth (1975) of $125,000 or an annual cost of $5,900 when discounted over a 100-year period. If all the effluent from the existing plants were used for irrigation, augmentation flows above scheduled releases would not be needed and additional costs would not be incurred.

Alternately, under the sewage diversion plan, the effluent from the existing sewage treatment plant could be provided advanced treatment for nutrient removal and effluent discharged to the river. Augmentation flow will not be required, but advanced treatment costs having a maximum present (1975) worth of $8,230,000 or an equivalent annual cost of $385,000 will be required. This figure will decrease if all or part of the effluent from existing plants is used for irrigation of the American River Parkway. The equivalent annual cost for providing advanced treatment to the effluents of existing plants is greater than provision for dilution of the nutrient load.

To complete the comparisons of alternatives, the remaining costs of the sewer diversion scheme were analyzed. Cost estimates were made for the force mains across the American River from the Arden and Northeast Plants and these were added to the force main cost of diverting sewage from the Cordova Plant to the Central Plant. Included in this plan was the cost of 16 miles of gravity sewers from the boundary of the Cordova District to the Central Plant. This new sewer collection system (see Figure 6) will be merged with the sewer requirements of the master plan of the area so that the total costs for connecting gravity sewers can be shared. The cost for the enlargement of the Central Plant and the proposed North Central Plant to handle future diverted flows will be less than that for expansion of the four smaller existing plants. In short, the merits of a large centralized sewage treatment system will make the best use of waste management practices as recommended by the Aerojet-General Corporation (13).

Based upon preliminary data, the total cost for this diversion was estimated to be about $14,000,000. As a single purpose alternative was considered, advantage was not assigned for centralized treatment or combined interceptor sewer costs to serve jointly the area south of the American River, thus, the cost of diversion has been estimated conservatively. The present worth (1975) of the diversion cost is about $5,688,000, since major capital costs could be deferred until the year 1990 by taking advantage of surplus capacities in existing master sewers on the south side of the river leading to the Central Plant (see Figure 7). Further, more efficient removal of phosphorus in existing secondary sewage treatment plants (22,23) will also provide an additional margin of safety to permit deferral of construction of the master sewer until the year 1990.

The annual cost of the diversion when the capital investment is discounted over the 100-year project evaluation period at 4-5/8 percent, will be about $266,000. This annual amortization cost will be increased by maintenance, replacement, and operation costs for the sewers and pumping plants, including power consumption. These costs have been estimated to reach a maximum of $55,000 per annum by the year 2000. When discounted, the present (1975) worth of the annual maintenance operation and replacement costs will be about $30,000, thus increasing the total annual cost for the diversion plan to about $296,000. This amount can be reduced because reclaimed sewage effluent for parkway irrigation was not included as a benefit.

3. Summary of Alternative Plans

A summary of alternative plans is shown in Table 13. Advanced treatment for nutrient stripping will result in the highest cost ($967,000/annum), followed by the plan for stream augmentation for nutrient control ($350,000/annum). The regulation of flow for nutrient control will provide only an interim solution, since by the year 2000 even the total runoff from the basin will not supply sufficient water for phosphorus control. The least costly plan will be provision for the diversion of waste from the basin into the Sacramento River. Under this diversion plan additional costs for additional flow for nutrient control or advanced treatment of effluent from the existing plants will be incurred, depending on the degree of reuse of effluent on the American River Parkway. The total annual cost for diversion of future waste and provision for the advanced treatment of all effluent from existing plants will range from $296,000 to $687,000 per year. The lower cost reflects maximum reuse of sewage effluent for park irrigation. If the diversion plan is merged with control of nutrient loads from existing plants by flow augmentation, annual cost will range from $296,000 to $302,000; the lower cost is associated with maximum reuse of effluent for park irrigation.

In summary, it is concluded that the least costly plan should include the diversion of all future waste water from the Lower American River and the maximum reuse of effluent from existing plants for irrigation in the American River Parkway.

TABLE 13 - ALTERNATIVE PLANS FOR MITIGATION OF WATER QUALITY PROBLEMS WITH PROJECT CONDITIONS LOWER AMERICAN RIVER

ALTERNATIVE PLANS	PRESENT a/ WORTH (1975)	EQUIVALENT a/ ANNUAL COST
	Million Dollars	
Advanced Treatment	$ 20.680	$ 0.967
Augmentation of Flow	7.500	0.350
Diversion of Waste - range of costs	6.325 - 14.680	0.296 - 0.687
Capital Cost Conveyance System	5.688	0.266
Maintenance, Operation & Replacement	0.637	0.030
Control of Nutrient Loads from Existing Sewage Plant Effluents by Flow Augmentation b/	0 to 0.125	0 to 0.006
Advanced Treatment of Existing Effluent b/	0 to 8.230	0 to 0.385

a/ Evaluation discounted at 4-5/8 percent over 100 years.

b/ Alternatives for effluent of existing plants. Range of costs depends on degree of reuse of effluent for American River Parkway irrigation.

ALTERNATIVES UNDER CONDITIONS WITHOUT PROJECT

To provide a basis upon which to determine the amelioration costs attributable to the project itself, alternative costs were determined for the correction of the excessive nutrient concentrations under river conditions without the project and proposed diversions to the Folsom South

Canal. The control of nutrient concentrations is a possiblity that could be realized only by provision of reservoir storage for augmentation flows and therefore is not realistic of conditions without the project reservoirs and diversions. Therefore, only alternative means other than flow regulation were evaluated and these are discussed as follows:

1. Advanced Waste-Treatment Methods

As previously discussed, advanced treatment methods are available to reduce the nutrient content of effluent before discharge into the river, thereby maintaining acceptable nutrient levels in the receiving waters. Augmentation flows would not be required under these conditions. However, the requirement for advanced treatment will exist by the year 1975 which is earlier than under project conditions. The lower dry-season flows under conditions without the project, create this earlier need. Using treatment cost figures previously noted, an annual cost beginning in 1975, and rising to $1,792,000 by the year 2000 will be incurred. This annual cost will rise further to about $3,114,000 by 2025 to provide treatment for the expanding urban area. The present worth (1975) for provision of advanced treatment of sewage effluent will be about $29,380,000, or about $1,374,000 per annum when evaluated over a 100-year period, discounted at 4-5/8 percent.

2. Diversion of Wastes from the Lower American River

In lieu of advanced treatment of waste waters, all future increases in sewage flow, above the capacity of existing sewage plants could be diverted and provided secondary treatment in the large Central Plant located near Freeport and discharged into the Sacramento River where the flow would be greater. This plan would be identical with that proposed under project conditions, as previously discussed except that maintenance, operation, and replacement costs for the sewage diversion plan would decrease in accordance with the reduced population growths and lower sewage flows expected under conditions without the project. This population constraint has been calculated to be about 15 percent on the projected growth. However, capital costs for sewers and pumping installations would not be reduced since the 15 percent reduction in sewage flows would not significantly affect the sizing of the sewerage systems which are normally designed for peak flows and available sewer sizes. Therefore, for the purpose of this study, these costs are assumed to be the same as for project conditions.

Without the project, diversion needs would develop by the year 1975. However, the installation of the major collection system south of the American River could be deferred to the year 1990 by using the excess capacity in the existing main collection system leading to the Central Area Sewage Treatment Plant. Thus, the present value (1975) of the capital cost (5.7 million) for the diversion system, as previously estimated, combined with the reduced maintenance, operation, and replacement costs ($630,000), would total about $6,318,000 when evaluated over a 100-year period. Discounted at 4-5/8 percent, the annual cost would be about $296,000.

The costs for flow regulation or advanced treatment of the effluent from existing sewage treatment plants would not vary from expected costs under project conditions since these existing plant capacities would be exceeded even with the projected population constraints expected without the project. The range of costs reflecting the degree of effluent reuse for irrigation on the American River Parkway is shown on Table 14 along with a summary of other alternative costs under conditions without the project.

TABLE 14 - ALTERNATIVE PLANS FOR MITIGATION OF WATER QUALITY PROBLEMS WITHOUT PROJECT CONDITIONS - LOWER AMERICAN RIVER

ALTERNATIVE PLANS	PRESENT a/ WORTH (1975)	EQUIVALENT a/ ANNUAL COST
	Million Dollars	
Advanced Treatment	$ 29.380	$ 1.374
Diversion of Waste - range of costs	6.318 to 14.673	0.296 to 0.687
Capital Cost Conveyance System	5.688	0.266
Maintenance, Operation and Replacement	0.630	0.030
Dilution of Existing Sewage b/ Plant Effluent	0 to 0.125	0 to 0.006
Advanced Treatment of b/ Existing Effluent	0 to 8.230	0 to 0.385

a/ Evaluation discounted at 4-5/8 percent over 100 years.

b/ Alternatives for disposal of effluent from existing plant. Range of costs depends on degree of effluent reuse on the American River Parkway irrigation.

3. Comparative Costs With and Without the Project

To evaluate comparative costs for the amelioration of future nutrient loads under river conditions with and without the project, the corrective costs shown in Table 13 are compared to corrective costs shown on Table 14. If the least costly plans under each condition were to be compared, it is evident that the costs are about the same for the correction of the excessive fertilization of the river. The least costly plan for both conditions is the provision for the diversion of wastes into the Central Plant for treatment and maximum reuse of effluent from sewage treatment plants for irrigation in the American River Parkway (see Table 13 and 14). Since the costs are about equivalent for conditions with or without the project it can be stated that the impact of the project on water quality of the Lower American River is not significant.

X. OTHER EFFECTS OF PROJECT ON WATER QUALITY

EFFECTS ON SACRAMENTO - SAN JOAQUIN DELTA

Evaluation of the impact of the project upon water quality must take into consideration not only the effects within the local study area but also its more widespread external effects. In the study area, degradation of the mineral quality is anticipated from impoundment and from the consumptive use of project water. Deterioration results from natural evaporation of stored and applied irrigation water and also from solution of salts during transmission of applied irrigation water through the ground-water system. Increases in TDS and specific minerals can therefore be expected in both surface and ground-water drainage from the study basins. The degradation is not expected to create any problems since water quality will be suitable for planned uses despite the degradation and, furthermore, reuse of return flows will be minimal, if the recommended diversion plan is carried out.

The more widespread effects of the project on the beneficial uses of water in the Central Valley and the Sacramento - San Joaquin Delta should be considered. Preservation of water quality in the Sacramento River Basin and in the Sacramento - San Joaquin Delta is dependent upon adequate treatment of municipal and industrial wastes before discharge and upon the maintenance of adequate streamflow to provide conveyance of residual conservative and nonconservative waste to ultimate disposal in the Pacific Ocean. Dilution or conveyance water is particularly important in the disposal of drainage from irrigated agricultural land, since adequate treatment systems are not usually feasible. Maintenance of acceptable water quality must be considered in the development of water supplies for irrigated agriculture since the resulting diminution of flow and production of concentrated return flows could have significant adverse effects in the basin.

The long-term carryover yield of the Central Valley Project (CVP) will be increased by about 300,000 acre-feet annually as a result of the Auburn-Folsom South project. At present this amount constitutes a part of the annual Sacramento-San Joaquin Delta outflow. The value of this outflow to Delta water could be significant, and its loss through consumptive use could contribute to the degradation of water quality in the delta.

Water quality standards have been established in compliance with the Federal Water Quality Act of 1965 (PB 89-234). It is most probable that the maintenance of these standards will depend primarily on maintaining an adequate outflow from the Delta to convey conserative wastes from the Sacramento - San Joaquin River Basins and for repelling the incursion of sea water. The maintenance of this delta outflow during critical summer months depends on the integrated operation of all units of the Central Valley Project and the State Water Project. Because the Auburn-Folsom South Unit is only one of many units of the CVP and because the operation of the CVP is complex, it is not possible to relate the required Delta outflow in a direct manner to the 300,000 acre-feet annual yield to be developed in Auburn-Folsom South Unit. Therefore, the operation of the entire CVP, including all existing and future units, should avoid lowering the delta outflow in quality as well as quantity below that which will be necessary to maintain water quality at least equal to the standards which have been established by the State of California and the Federal government.

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