Draft

Environmental Impact Report & Statement

San Francisco Wastewater Master Plan February 1974

City and County of San Francisco
U.S. Environmental Protection Agency

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DRAFT

ENVIRONMENTAL IMPACT REPORT AND STATEMENT
(D-EPA-24003-CA)

SAN FRANCISCO WASTEWATER MASTER PLAN
FEBRUARY 1974

Prepared by:

U. S. Environmental Protection Agency
Pacific Southwest, Region IX
100 California Street
San Francisco CA 94111

City and County of San Francisco
Department of City Planning
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ABSTRACT

ENVIRONMENTAL IMPACT REPORT AND STATEMENT

Draft (x)

Final ( )

Prepared jointly by:

City and County of San Francisco
Department of City Planning
100 Larkin Street
San Francisco, California 94102

U. S. Environmental Protection Agency
Pacific Southwest, Region IX
100 California Street
San Francisco, California 94111

1. Type of Action:

Administrative

2. Description of Project:

The San Francisco Master Plan for Wastewater Management is a concept which includes a combination of pumps, pipes, storage reservoirs, treatment plants, and disposal locations which it is believed most effectively reduces the detrimental effects of waste discharges from the City and County of San Francisco. The Master Plan will be constructed in four stages during the next 20 years.

Implementation of the first stage of the Master Plan is necessary to comply with provisions of the Federal Water Pollution Control Act Amendments of 1972 and existing Cease and Desist Orders of the California Regional Water Quality Control Board, San Francisco Bay Region, which require secondary treatment of all dry weather flows by July 1, 1977.

Upon completion of the Master Plan, wastes will receive secondary treatment at the Southeast and Richmond-Sunset plants. Effluent from these plants will be transmitted through a tunnel and pipeline system to the southwest corner of the City and discharged approximately four miles offshore. During storm conditions, flows exceeding the capacity of the secondary treatment plants will be transported to the 1,000 mgd capacity Southwest Treatment Plant where it will receive Level I (low dose ferric chloride) treatment and be discharged about two miles offshore.

Implementation Plan I, North Point Transport Project, is scheduled for construction in 1974. The North Point Transport Project will convey untreated wastewater from the existing North Point Water Pollution Control Plant to the Southeast Water Pollution Control Plant which will allow conversion of the North Point plant to a wet weather treatment facility.

3. Summary of Environmental Impacts:

   A. Construction impacts will occur in almost every area of the City--land use changes, traffic disruption, noise, dust, flora and fauna disruption, aesthetics, utility disruption, and temporary turbidity increases in the Bay and Ocean waters.

   B. Interim discharge of combined North Point and Southeast secondary treated effluent into South San Francisco Bay.

   C. Elimination of the North Point primary discharge to San Francisco Bay.

   D. Control of wet weather flows along the northeast shoreline at completion of Stage I resulting in only five wet weather overflows per year.

   E. Control of wet weather flows City-wide at completion of the Master Plan resulting in only eight wet weather overflows per year.

   F. Master Plan provides secondary treatment of all dry weather flow and discharge to the Pacific Ocean through a five-mile outfall.

G. Capacity of the treatment facilities will not allow for population growth beyond that compatible with the applicable air implementation plan prepared pursuant to the Clean Air Act Amendments of 1970. Secondary impacts in this area are expected to be minor.

4. Alternatives:

   A. No Project

   B. Many Individual Treatment Plants

   C. Expansion of Three Existing Plants

   D. One Regional Plant Without Wet Weather Storage

   E. Sewer Separation

   F. Reclamation

5. Dates Available to CEQ and the Public:

   Draft: March 13, 1974

   Final:

6. Distribution List Attached

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PREFACE

The Draft Environmental Impact Report and Statement (EIR&S) was prepared jointly by the City and County of San Francisco and the U. S. Environmental Protection Agency (EPA) on the City's Master Plan for Wastewater Management.

The Draft EIR&S is in two volumes. The first evaluates the overall environmental effects of the Master Plan for Wastewater Management while the second evaluates the specific environmental effects of Implementation Plan I, North Point Transport Project, scheduled for construction in 1974. This transport project is part of the Master Plan's Stage I facilities.

The Draft EIR&S has been prepared to fulfill the mandate of both State and Federal legislation which requires that consideration of environmental aspects be built into the decision making process. This legislation includes the California Environmental Quality Act (CEQA) of 1970 and the National Environmental Policy Act (NEPA) of 1969.

EPA is considering assisting the City and County of San Francisco in constructing the North Point Transport Project. A final decision on this action will not be made, however, until after public review of the Draft EIR&S as required by CEQA and NEPA.

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February 1974

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City and County of San Francisco
U. S. Environmental Protection Agency

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SUMMARY

THE PROBLEM

The people, businesses, and industries in the City and County of San Francisco generate more than 100 million gallons of wastewater each day--an average of about 140 gallons per day for each resident in the City. The City has improved its facilities to convey and treat this wastewater before it is discharged into San Francisco Bay and the Pacific Ocean. However, increasing environmental knowledge and standards, combined with recent State and Federal regulations and enforcement actions, require a vastly accelerated improvement program.

In meeting these needs, San Francisco must cope with a special situation. The municipal and industrial wastewaters together with stormwater runoff are transported in a combined wastewater collection system, most of which was constructed in the early 1900's. This type of system, which is common in older communities throughout the United States, creates special problems in the conveyance and treatment of wastewaters. For instance, the City's average dry weather wastewater flow of 100 million gallons per day (mgd) increases to as much as 14 billion gallons per day during storm periods.

Municipal and industrial wastewaters must be treated to lessen health hazards and damage to aquatic environments. Stormwaters, although they may contain large concentrations of grease, oil, lead, bacteria, and other pollutants, are not normally treated prior to discharge. However, the discharge of untreated combined wastewaters is a definite health hazard and is aesthetically unacceptable. Therefore, the combined wastewaters of San Francisco must be treated prior to discharge to the aquatic environment.

Presently, during dry periods all wastewater is collected and treated at three separate treatment facilities--Richmond-Sunset, North Point, and Southeast. However, during most rainy periods the 340 mgd combined hydraulic capacity of these three plants is exceeded, resulting in untreated wastewater being discharged from the collection system at 41 overflow structures located around the periphery of the City as shown on Figure 1.

SUMMARY

THE PROBLEM

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The three plants provide advanced primary treatment. In each case, the effluent quality and treatment efficiency is superior to conventional primary treatment[1] but not adequate to meet the present State requirements or the provisions of the 1972 Amendments to the Federal Water Pollution Control Act (PL 92-500). Compliance with those regulations can only be achieved by major capital expenditures for new secondary treatment facilities.

During rainstorms, despite the high flow rates, the treatment plants do remove approximately 60 percent of pollutants. However, large quantities of bacteria, grease, and untreated human waste are discharged along the shoreline, particularly in the beach areas, as a result of some of the average 82 overflows per year. Although these overflows occur only about 2.4 percent of the time in an average year, water quality and beach conditions are affected for days after each overflow. Generally, these overflows leave waste material on the beaches throughout the winter months.

ALTERNATIVE SOLUTIONS

There are a variety of ways in which the City can correct its wastewater problems. Some of the more obvious solutions are:

- The construction of separate stormwater and sanitary sewer systems. Separation of sewers would cost over $3 billion and result in major disruption throughout the City for many years. If separation were achieved, some treatment or special disposal practices might still be necessary for the stormwaters due to the highly urban characteristics of the City which result in pollutants in the stormwaters.

- The construction of improved treatment facilities at the existing plant locations plus separate treatment facilities for wastewaters bypassed at the existing 41 overflow points or at some consolidation of those sites. This alternative would also cost an estimated $3 billion and its effectiveness and reliability are questionable.

- The construction of an integrated system of transport, storage, treatment, control, and disposal facilities designed to provide a given degree of control (i.e., eight overflows per year). This alternative would cost an estimated $672 million.

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[1]In general terms, primary treatment will provide 50 percent removal of pollutants, secondary treatment will provide 90 percent removal of pollutants, and tertiary treatment will provide 99 percent removal of pollutants.

THE MASTER PLAN

The Master Plan is a concept which includes a combination of pumps, pipes, storage reservoirs, treatment plants, and disposal locations which it is believed most effectively reduces the detrimental effects of waste discharges from the City of San Francisco. It includes the location and sizing of storage basins, plus the construction of dry weather and wet weather treatment facilities, transportation systems, and disposal facilities in a series of stages to achieve any desired or required level of control. The Master Plan, as shown on Figure 2, was developed by an environmental planning approach including thorough studies of key sanitary and stormwater considerations with special emphasis upon the stormwater sector as the critical aspect to the design of the combined system.

Assuming the construction of 45 retention basins, a wastewater transport system, a major wet weather treatment facility in the Southwest area of the City, an ocean outfall, and short-term high level dry weather treatment facilities at the existing Richmond-Sunset and Southeast treatment plants, the capital costs of the Master Plan concept would be approximately \$672 million (\$339 million for dry weather control and \$333 million for wet weather control). The \$333 million cost for wet weather facilities is equal to \$18,000 per acre of City area which can be compared with the cost of similar programs in other cities: \$12,500 in Chicago, \$65,000 in Boston, and \$31,000 in Washington, D.C.

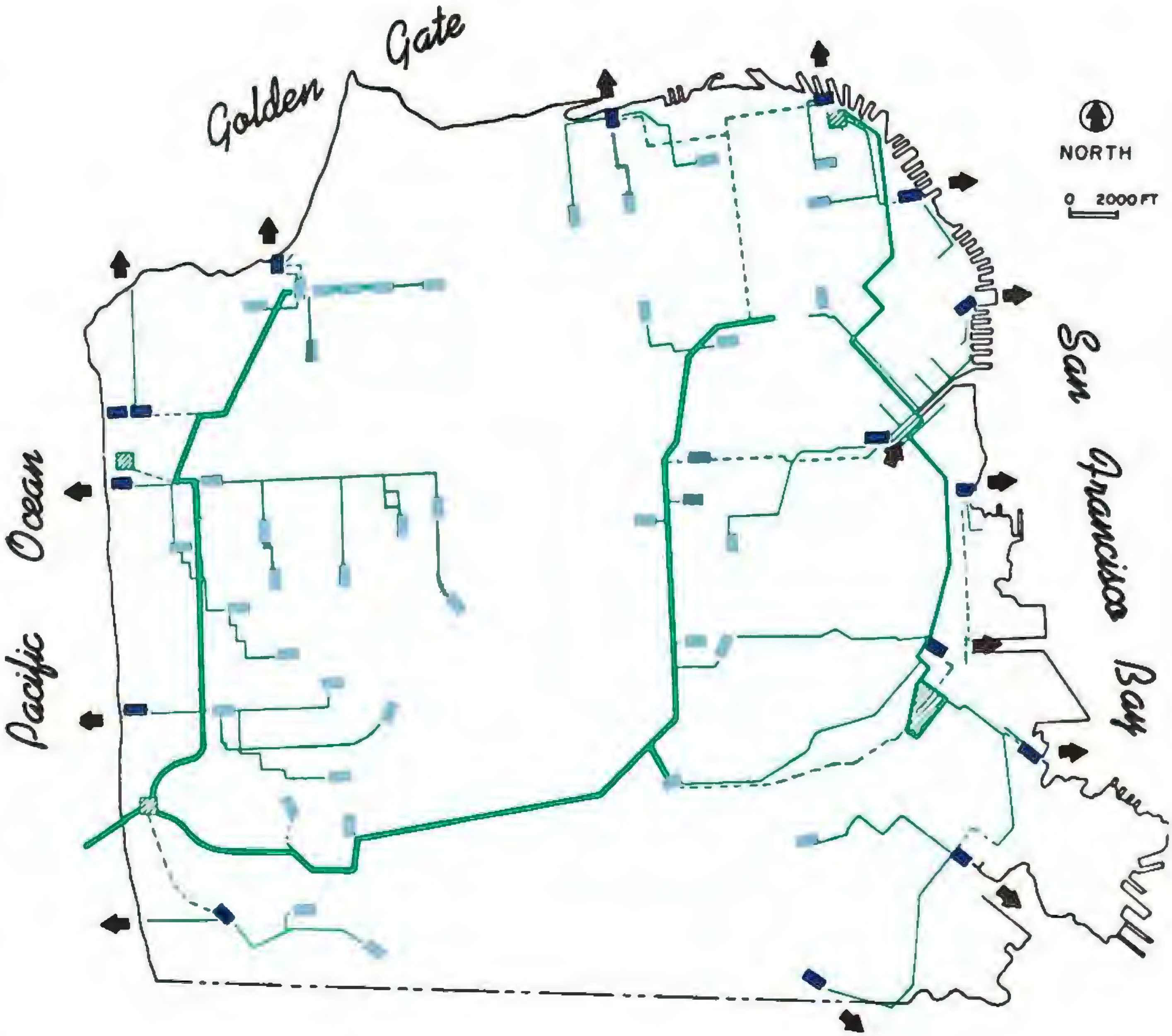
On an annual basis, the estimated \$672 million capital cost equates to the following, assuming a 30-year payoff at 6 percent interest:

Assumption	Annual per capita Cost
No grant funds are available	\$70
87½ percent grant funds are available for total project	\$10
87½ percent grant funds are available for dry weather portion only	\$30

Although the capital expenditure is rather large, it is doubtful if the committment of \$10 per person per year would have any effect on other capital improvement programs. However, if no grant funds were available, the City probably would be forced to delay implementation of the Master Plan. In this

Figure 2

MASTER PLAN



The complete Master Plan for wastewater management is shown above. Retention basins (upstream — light blue, shoreline — dark blue) provide storage, control flooding, and allow regulation of flow to the transportation system (green). During the major portion of the year, wastes will receive secondary treatment at the Southeast and Richmond-Sunset plants. These treated effluents will be transmitted through the tunnel and pipeline systems to Lake Merced where they will be discharged approximately 4 miles offshore. The North Point Plant will be abandoned. During storm conditions, flows exceeding the capacity of the secondary treatment plants will be transported to a 1000 million-gallon-per-day capacity treatment plant at Lake Merced. The effluent will be discharged 2 miles offshore. The system will provide secondary treatment of all waste during a major part of the year and the bypassing of untreated waste will be virtually eliminated.

event, it is unlikely that the State would force the City to complete the program with 100 percent local financing. While the State could require the City to proceed, it is not likely to as long as the potential for grant funds remains.

The estimated cost was based on the reduction of overflows to only 8 per year compared to the existing 82 overflows per year. This would accomplish 90 percent control of wet weather overflows. However, it should be pointed out that by the addition of storage capacity essentially complete control (99 percent) could be accomplished. The additional costs of greater control are presented below:

		Additional capital costs	
Number of overflows	Level of Control	million	Annual per capita (30 years @ 6%)
8 per year	90%	$0	$0
4 per year	95%	$63	$6.50
1 per year	99%	$189	$19.50
1 per 5 years	99+%	$332	$34.50

The exact level of control that is to be selected will be determined during special detailed studies for the three major watersheds.

Implementation of the first stage of the Master Plan, as shown on Figure 3, is necessary to comply with provisions of the Federal Water Pollution Control Act, which requires secondary treatment of all dry weather flows by July 1, 1977.

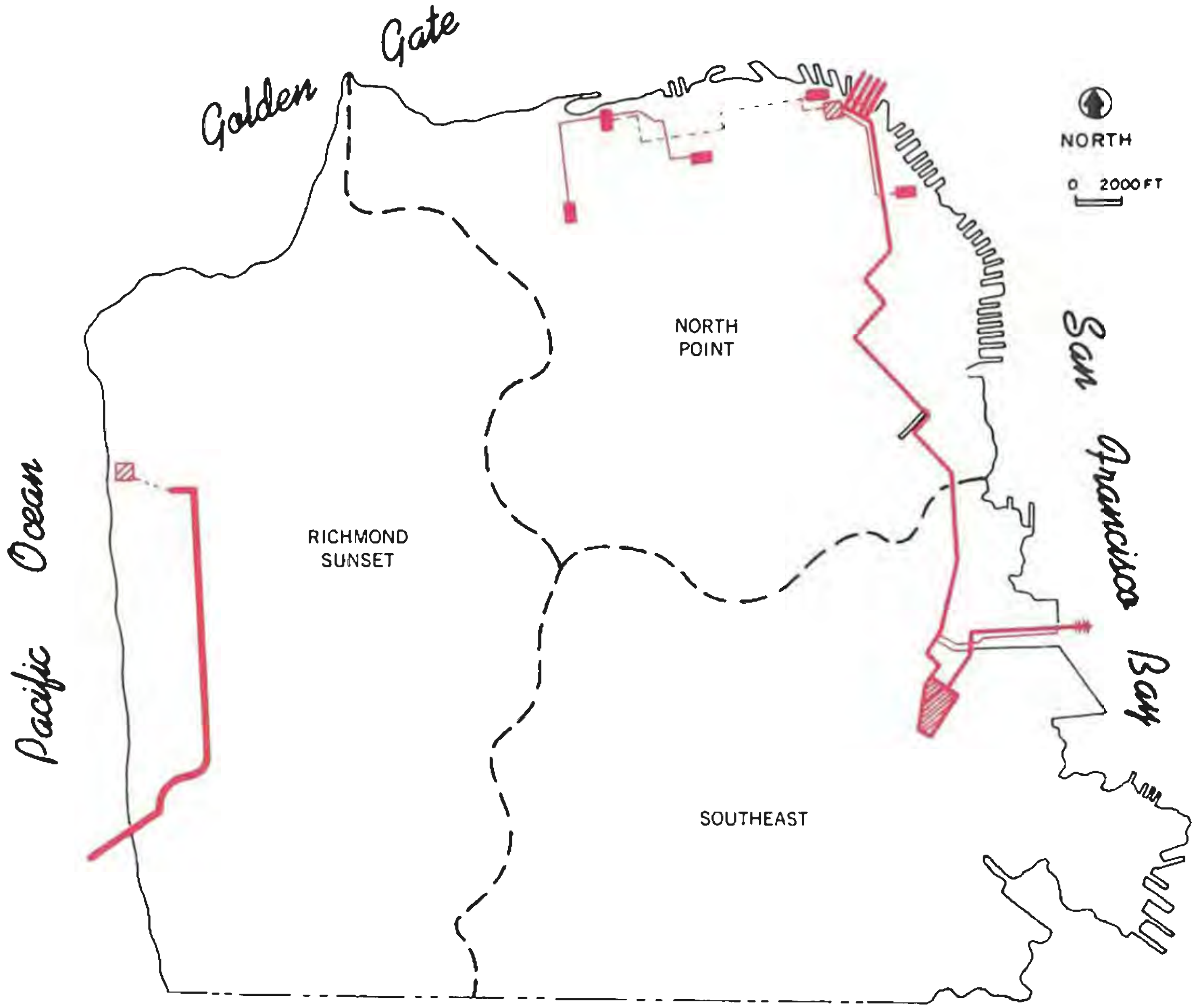
However, it is not possible for the City to comply with the July 1, 1977 date. The City does intend to proceed with due diligence and provide secondary treatment of all dry weather flows by January 1, 1980.

The Master Plan can be adjusted in a number of ways. For example, the number of upstream basins could be reduced by increasing the number of shoreline basins; the cross-town tunnel could be enlarged to provide additional storage as well as conveyance; or the wet weather treatment facility could be located on the Bay side of the City and treated wastewaters discharged to the Bay or Ocean.

It is not possible, or even desirable, to fully define the Master Plan at this time; too many changes in land use, wastewater treatment technology, and construction costs will take place in the next few years. Therefore, each phase or stage of the project should be designed to provide optimum water quality improvement as well as allowing for future changes such as a greater potential for wastewater reclamation.

Figure 3

FIRST PHASE OF MASTER PLAN



The improvement program designed to achieve early compliance with State and Federal treatment standards and to reduce overflows in the critical north shore and ocean beach areas is shown in red. Raw waste from the North Point service area will be pumped to the Southeast Treatment Plant. The Southeast Plant will provide secondary treatment for the dry weather flows from the North Point and Southeast areas. The effluent will be discharged to the Bay through an improved outfall. Wet weather waste control facilities will be constructed to control overflows in the north shore area. The North Point Plant will be converted to a wet weather facility to treat wastewaters from the area during storm periods. The Richmond-Sunset wastwater treatment plant will be substantially improved to produce an effluent quality acceptable for continued ocean disposal. Effluent from the Richmond-Sunset Plant will be transmitted to the Lake Merced area for ocean disposal.

The most promising potential use of reclaimed San Francisco wastewater appears to be landscape irrigation within Golden Gate Park and the three golf courses in the Lake Merced area. However, the total seasonal demand for these uses is only 5.0 mgd--less than 5 percent of the total average dry weather flow.

There is also a potential for irrigation use in the Central Valley; however, the economic and environmental costs of conveyance systems make the use of reclaimed water in these areas far more costly than existing water supplies. As the existing water supplies become more fully used, however, it may become more economically feasible to reclaim wastewaters for large scale irrigation projects.

The potential for reclamation can best be realized first in the construction of small, advanced waste treatment plants to provide local reclamation for park use; and second, as part of an areawide program that can be developed in the next 10 to 20 years. Therefore, the Master Plan should remain flexible to allow for these eventualities.

Environmental Evaluation

The overview environmental impact report-statement is designed to evaluate all of the reasonable alternatives and subalternatives considering not only ecological and public health factors but also functional and economic factors. The overview report was prepared to comply with the Federal guidelines for preparation of environmental impact statements and with the State and City guidelines for preparation of environmental impact reports.

A comparison of the alternative concepts considered in the development of the Master Plan on the basis of functional, economic, and environmental factors is presented in Table 1. Each of the alternative concepts is assigned an overall environmental ranking.

Criteria for evaluating functional rating factors are as follows:

Regulatory Compliance.

1. Ability to comply with State and Federal water quality requirements.

2. Conformity with regional planning.

TABLE 1

FUNCTIONAL, ECONOMIC, AND ENVIRONMENTAL RATING[1]
OF ALTERNATIVE CONCEPTS

	No Project	Many Individ. Treatment Plants	Expand Three Existing Plants	One Regional Plant Without Storage	Storage/ Treatment Master Plan	Sewer Separation
Functional						
Regulatory Compliance	Unaccept.	Marginal	Unaccept.	Good	Good	Marginal
Implement.	Unaccept.	Unaccept.	Unaccept.	Unaccept.	Accept.	Unaccept.
Reliability	Unaccept.	Unaccept.	Marginal	Marginal	Good	Marginal
Flexibility	Unaccept.	Unaccept.	Marginal	Marginal	Good	Unaccept.
Reclamation Potential	Marginal	Marginal	Accept.	Accept.	Good	Marginal
Economic						
Total Capital Cost ($million)	0	3,000	1,000[3]	2,000[3]	672	3,000
Per Capita w/grants		$540	$180	$360	$120	$540
w/o grants		$4,300	$1,430	$2,860	$960	$4,300
Environmental						
Construct. Impacts	None	Sig.	Sig.	Sig.	Sig.	Sig.
Operational Impacts	Sig.	Sig.	Sig.	Moderate	Minimal	Sig.
Secondary Impacts	Sig.	Moderate	Moderate	Minimal	Minimal	Moderate
Environmental Ranking[2]	6	5	3	2	1	4

[1]Rating Scale--Functional: Good, Acceptable, Marginal, Unacceptable. Environmental: Significant Adverse Effects, Moderate Adverse Effects, Minimal Adverse Effects

[2]Environmental Ranking--1 is most acceptable, 6 is least acceptable.

[3]Plant cost only exclusive of collection system modifications.

Implementation.

1. Acceptability of the concept and probability of support by the general public and local government.

2. Ease of construction and permit acquisition.

Reliability.

1. Ability of concept to consistently attain design performance standards.

2. Vulnerability to system failure or natural disaster and resulting impacts from such a failure are minimized.

Flexibility.

1. Ability to adapt to advanced technology and future discharge requirements.

2. Ability to adapt to future land use changes.

3. Research options are not constrained.

4. Concept provides maximum interim protection.

Reclamation Potential.

1. Concept provides no location restraints on future reclamation options.

2. Ability of concept to adapt to treatment requirements for reclamation.

As shown in Table 1, the Master Plan is the most environmentally acceptable, the most cost-effective, and the most functional concept of the six that were considered.

All alternatives considered would result in a substantial reduction in the total quantity of pollutants discharged into the Bay and Ocean. Long-term discharges to the Bay are likely to require greater pollutant removals than similar discharges to the Ocean. This reflects the greater dilution available in the Ocean, environmental characteristics, and likely interpretations of new Federal effluent requirements. In addition, detailed biological studies, that are still in progress, have shown that the least sensitive area of the marine environment adjacent to San Francisco is in the Ocean southwesterly from the City.

One of the most important aquatic species in this area is the Dungeness crab. Extensive studies of the effects of San Francisco wastewater on the Dungeness crab life cycle have been unable to demonstrate that there would be any detectable short-term harm to this species because of the proposed waste discharge.

Until significant quantities of the City's wastewaters can be reclaimed, the least risk area of discharge is that proposed in the Master Plan. Any possible future impacts would be mitigated through design to improve levels of pollutant removal with a minimum of capital investment in the Southwest Treatment Facility.

Implementation of the Master Plan will provide the following benefits to the residents of San Francisco:

- Significant improvement of the aquatic environment, particularly in nearshore waters.
- Significant (77 to 99 percent) reduction in the average annual days in which bacteriological swimming standards are exceeded.
- Improvement in the aesthetic quality of nearshore waters and beaches.
- Elimination of all continuous Bay discharges.
- Significant (90-99 percent) reduction of all wet weather overflows.

Unfortunately, the Master Plan also has the following negative impacts:

- High cost.
- Disruption caused by the long-term construction period (up to 20 years).
- Continuance of some overflows.
- Delay in solving the City's wastewater problems.

The degree of environmental alteration that will be caused by implementation of the project is greatly dependent upon the measure of care taken during the long-term construction period. Care should be exercised in excavation activities, equipment operation, and other construction activities to minimize all environmental disturbances. A summary of the potential adverse construction impacts and possible mitigation measures is presented in Table 2.

TABLE 2

SUMMARY OF THE POTENTIAL ADVERSE IMPACTS
AND ASSOCIATED MITIGATION MEASURES
DUE TO CONSTRUCTION OF THE
SAN FRANCISCO WASTEWATER MASTER PLAN

Potential Adverse Impacts	Mitigation Measures
Land use change from open space to public use.	All facilities should be designed for multipurpose uses where practical.
Temporary disruption in traffic flow.	Close liaison should be maintained with the City's traffic engineers to assure that traffic movement is as smooth as possible.
Increase in ambient noise levels due to operation of construction equipment.	Requirements of San Francisco's noise ordinance must be met.
Disturbance of soils creating possible erosion problems and additions of dust to the atmosphere.	Construction should be scheduled to avoid rainy weather; dust can be minimized by watering dry soils and covering haul vehicles.
Temporary disruption of native flora and fauna.	Care should be exercised during construction activities to minimize disruption.
Temporary loss in aesthetic appeal in localized areas.	Replacement of destroyed vegetation should be included in post-construction planning.
Temporary disruption in utility service.	Communication with all utility companies should be maintained prior to and during construction period.
Temporary increase in turbidity in Bay and Ocean waters during outfall construction.	Requirements of the regulatory agencies must be met.

Present research indicates that operation of the Master Plan will have, at most, minimal adverse environmental impacts. All wastewater facilities have the potential for producing odors. The risk will be higher at the storage and treatment facilities than it will be in the conveyance system. However, this potential impact can be mitigated through careful design of components to completely control exhaust gases through covering and treatment. Through careful design, construction, and operation of these facilities, the potential impact and risk of future odor nuisance can be reduced to an insignificant level.

The proposed facilities could be damaged or disrupted as a result of a significant earthquake and associated movement along the San Andreas Fault. However, earthquake effects need not be critically damaging to the on-land portion of the Master Plan facilities, if proper seismic planning and design are utilized. It is certain, however, that the Ocean outfall will be subjected to right-lateral earthquake displacements (sea-side moves north) where it crosses the San Andreas Fault rift zone. There will likely be breakage (probably at the rift zone) of the outfall during rupture of the San Andreas Fault resulting in a major reconstruction program at the point of breakage following such an event. If the two-mile wet weather outfall is kept short of the fault zone, an automatic back-up discharge point would be provided while the dry weather outfall is being repaired.

PART I

BACKGROUND

CHAPTER I

ENVIRONMENTAL FEATURES

MARINE ENVIRONMENT

The City and County of San Francisco is surrounded on three sides by salt water, being bounded on the west by the Pacific Ocean and on the north and east by San Francisco Bay. As a consequence much of the economic and social well-being of the citizens of San Francisco is associated with the marine environment.

The geographical extent of the marine environment adjacent to San Francisco may be defined as Central San Francisco Bay extending from the County boundary on the southeast to the Golden Gate on the northwest and that portion of the Pacific Ocean known as the Gulf of the Farallones extending from Bolinas Peninsula on the north to Point Montara on the south, and from the Golden Gate to Southeast Farallon Island.

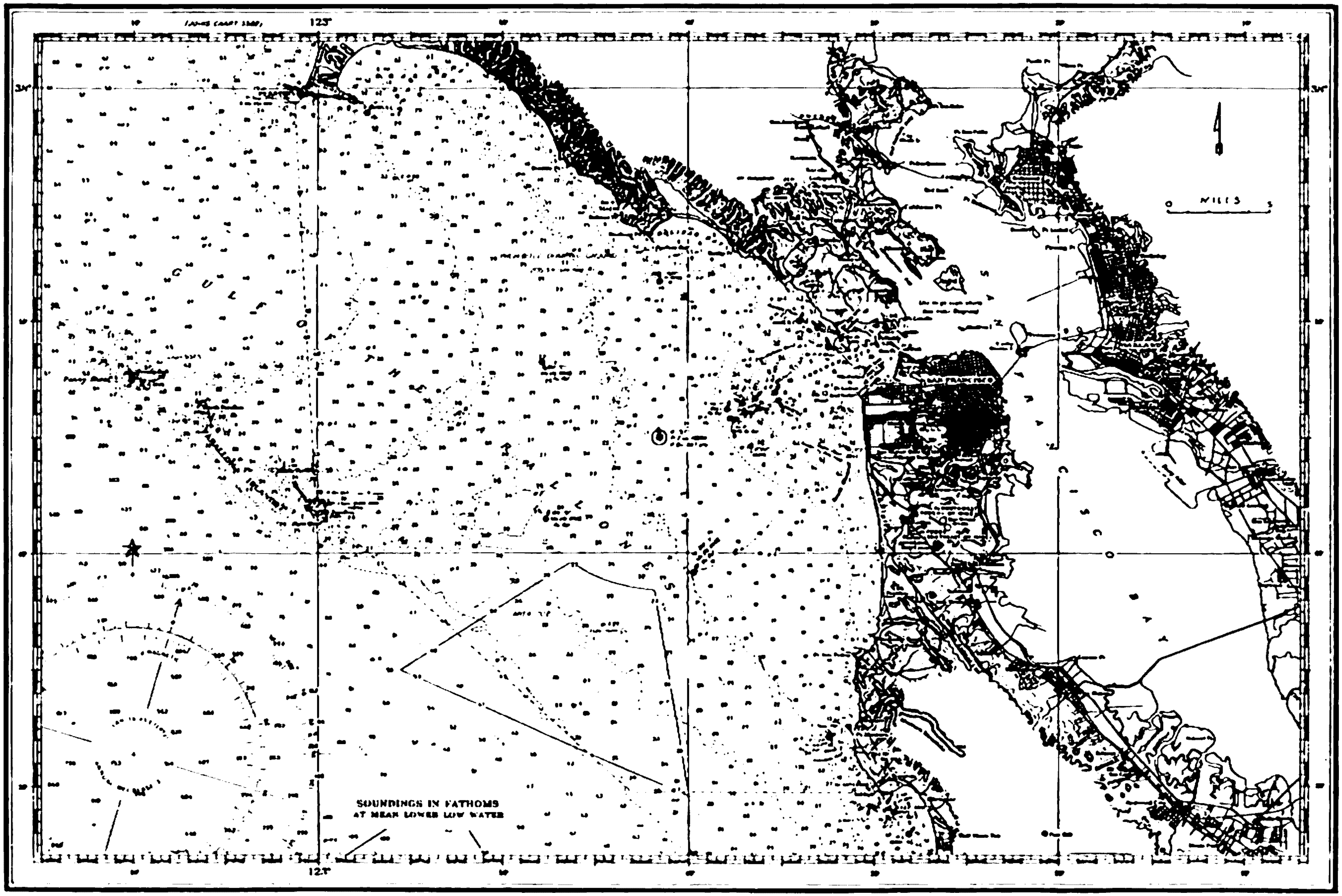
A map of the City, Bay, Ocean, and vicinity, with latitude and longitude coordinates, is presented as Figure I-1.

The most influential factor controlling distribution of marine life along the ocean shore is temperature; on the San Francisco coast the range of temperature is relatively narrow. Near the Farallones, the monthly averages range from 52.4^{o}F during April to 56.3^{o}F in September. Northern California has some of the coldest sea temperatures, for its latitude, on the earth. In the Bay temperatures are often higher. The cold water along the ocean cost is associated with the process known as upwelling, the movement toward the surface of cold subsurface water. The upwelling carries nutrients from the nutritious upper layer of the sediments where worms, echinoderms, bacteria, and other organisms live.

San Francisco Bay is an estuary, i.e. a partially enclosed body of marine water where fresh water from land runoff mixes with high salinity water from the ocean. This mixing of water masses and the concomitant fluctuations in salinity are the main factors in determining the distribution and abundance of flora and fauna in the estuary. The adaption to these salinity stresses by a variety of specialized organisms in the estuary produces an ecosystem quite unlike the adjacent fresh or marine environments.

FIGURE I-I
SAN FRANCISCO BAY, GULF OF THE FARALLONS
AND VICINITY

LATITUDE



C. & G. S. 5402

LONGITUDE

There are four main groups of organisms to be found in estuarine and marine environments: the intertidal organisms, which are alternately covered and exposed to the air as the tides advance and recede; the benthos or bottom-dwellers; the fish and mammals; and the plankton, consisting of small floating or swimming animals and plants.

Much of the ocean and Central Bay intertidal areas consist of sandy beaches which support a relatively low diversity of animals. Chief inhabitants of these areas are sand crabs, amphipods, clams, the red worm Pectinophelia, and shore birds. Along the eastern and northeastern intertidal areas of the City, landfill and pier construction have limited the availability of marine habitats and the major biota are barnacles, limpets, mussels, and shipworms (Teredo) on pilings.

In the central area of San Francisco Bay the highest diversity of benthic organisms occurs near the Golden Gate, where Bay and oceanic species are mixed; diversity declines as distance from the Golden Gate increases, due to the gradual loss of oceanic forms. Local fish are discussed later in this chapter.

About 0.2 percent of the energy in the sunlight that falls on the ocean is used by plants to make carbohydrates. Microscopic algae, called diatoms, are the "grass" of the ocean, serving as food for young fish, larval forms of invertebrates, and bacteria in the plankton, the benthos and the intertidal areas. Diatoms and other phytoplankton (plant plankton) play a similar role in San Francisco Bay, where diatoms occasionally exceed one million cells per liter of Bay water.

The phytoplankton are the "primary producers." Their chemical energy is passed largely to zooplankton (animal plankton) and bacteria, which in turn supply protein to the filter feeders and small carnivores. Phytoplankton are also major sources of dissolved oxygen. Oxygen is produced by photosynthesis so it is only produced during daylight and dissolved oxygen tends to drop at night. The most common zooplankters in the Bay waters are copepods (minute crustacea) of the genus Paralabidocera.

Sea water generally has a higher concentration of dissolved salt than the fresh water it mixes with in an estuary, while fresh water typically is higher in nutrients. The mixing of high salinity, nutrient-poor waters with low salinity, high-nutrient waters in an estuary frequently results in the formation of highly productive ecosystems. Estuarine productivity has historically attracted human settlement. The development of major urban centers around estuaries has in turn generated sewage, industrial wastes, dredging, and filling activities, which have disturbed the natural ecosystems. The preservation and restoration of the estuarine environment requires improved control of pollutant discharge. The Wastewater Master Plan provides for improved treatment of San Francisco sewage effluent discharged to the Bay, followed by elimination of such discharges in favor of discharge to the less sensitive ocean environment.

Marine Resources and Area Use

The uses of the marine environment surrounding San Francisco include water-oriented recreational and commercial activities.

The extent of the recreational use of the waters of the Pacific Ocean and San Francisco Bay adjacent to San Francisco was defined in a report to the Regional Water Quality Control Board, prepared by the Board's staff and dated October 30, 1968, which states in part,

> "Almost all of the City and County's 30 miles of waterfront are used for recreation and aesthetic enjoyment. There are 5.5 miles of continuous beach along the ocean and other beaches at Lincoln Park, the Presidio, and Marina and Aquatic Parks. There are five marinas in the City. They are located at Marina Park, in the China Basin channel, and adjacent to Mission Rock. There are also two boat launching ramps near Mission Rock. Sport fishermen use almost all of the shoreline from which they are not physically excluded. They are excluded from only a few piers and two shipyards. Even then the servicemen and employees fish at Hunters Point. They also fish from boats at several locations along the City's Bay Shore."

Throughout every season of the year the waters of the Pacific Ocean and the Bay adjacent to San Francisco serve either as a habitat or as a migration route for striped bass, king and silver salmon, steelhead, and other sport fish. The shallow areas of San Francisco Bay and its estuaries are a natural habitat for shellfish, and the Bay at one time supported a thriving commercial oyster industry. Over the years, however, sewage discharges have contaminated the growing areas to the point where shellfish within San Francisco Bay are no longer recognized as safe for human consumption.

The California Department of Fish and Game indicates that the Gulf of the Farallones is probably the most important nursery area along the California coast for both finfish and shellfish and that San Francisco Bay is also important in this respect. The Department's observations indicate that juvenile Dungeness crabs, from larvae to 140 millimeters (up to 1½ years), are predominant in the Bay and nearshore shallow areas of the Gulf.

For over 50 years the Gulf of the Farallones has also been a source of market Dungeness crab for which the restaurants of San Francisco are famous. From an all-time record of nearly 9 million pounds in the 1956-57 season, the crab catch has declined in recent years and during the 1972-73 season the catch was only 300,000 pounds. Although the majority of the fishing effort is presently concentrated between 10 and 90 fathoms, the most productive fishing grounds in the past were restricted to nearshore waters (less than 10 fathoms) and San Francisco Bay.

The waters surrounding San Francisco also support an extensive commercial and sport finfishery. The commercial fishery for salmon is of primary importance in the Gulf of the Farallones. This is the only fishery in the San Francisco area that compares in size of catch and market value to the Dungeness crab fishery. The major salmon fishery is located nearshore in the Gulf and within the main migratory routes. Trawl effort is also substantial for rockfish, sole, and other flatfish; however, this fishery is generally located offshore (more than 3 miles) from the City.

The largest sport fishery in central coastal California is located in the waters surrounding San Francisco. Salmon, rockfish, striped bass, and ling cod are the main components of the sport fishery. Party boat catches account for the major portion of the salmon and striped bass fishery; however, a large shore fishery is also present within the area.

Marine laboratories are at Bolinas and several locations within San Francisco Bay. Three biological reserves are located within the coastal area at Duxbury Reef, Farallon Islands, and Moss Beach and just recently the State Water Resources Control Board designated Seal Rocks and the Farallon Islands as areas of special biological significance.

The waters of San Francisco Bay are also used extensively for industrial purposes. For many industries, particularly along the eastern shoreline, the Bay serves as the principal source of industrial cooling water.

Navigational use of the waters surrounding San Francisco include all types and sizes of ships and boats with ocean-going military, passenger, and freight vessels using port facilities in the Bay. A dredged channel is maintained through the Bar in the Gulf of the Farallones to permit passage of these large vessels.

Other uses for the waters adjacent to San Francisco include waterfowl and mammal habitat and aesthetic appeal.

Water Current Patterns

Central California Coast. Prevailing ocean currents off the coast near San Francisco are characterized by two major currents. In the winter months during the rainy season, the prevailing nearshore current is the northerly Davidson Current which is followed in the spring, summer, and fall by the southerly California Current.

The influence of these currents is diminished in the nearshore zone east of the Farallones where tidal exchange with the Bay overrides the effect of the offshore currents. Bay waters which move west and south from the Farallones during ebb tides are entrained in these prevailing ocean currents and soon become intermixed with the ocean water.

Gulf of the Farallones. Oceanographic characteristics of the Gulf are largely dependent upon the tidal ebb and flood flow through the Golden Gate which varies in magnitude with the season.

Wet Weather Mass Water Movement - During winter periods of maximum Delta outflow, the less dense Bay water produces a tidal outflow which occurs primarily as a surface layer. It extends up to 15 miles west and 10 miles south of the Golden Gate before becoming entrained in the ocean currents. At times of high Delta outflow the surface flow may ebb continuously and surface flood tides are almost nonexistent. Most of the flooding tidal prism consists of dense bottom ocean water entering the Bay from the north through Bonita Channel and from the south around Lands End.

Wet Weather Currents - Current velocity and direction during the winter season vary dramatically with depth following the stratification developed in the tidal waters. A surface layer of 10 to 15 feet moves westward and southward with current speeds of 2 to 4 knots (2.3 to 4.6 miles per hour). Immediately below this layer there exists a more balanced pattern of ebb and flood currents of lesser speeds. Low speed flood currents predominate near the bottom.

Dry Weather Mass Water Movement - In the absence of stratification during the summer and fall, the same general movement southward and westward by the ebbing surface layer still exists. During this period of minimum Delta outflow, tidal outflow is decreased and the net surface movement is much smaller. The ebbing tide now extends westward to the shipping channel and southward to a point west of Lake Merced.

As before, the flooding tidal prism consists primarily of flow along the shore north and south of the Gate. Under minimum outflow conditions there is an eastward movement of surface water toward the Gate but of a lesser displacement than exists in the bottom water.

Dry Weather Currents - Surface currents are in phase with, but of a greater magnitude than, bottom currents during the ebb; and bottom currents are greater during flood tides. This results in a net surface displacement away from the Gate with bayward movement predominant near the ocean bottom. Current speeds are greatest near the Golden Gate but seldom exceed one knot outside the bar.

Central Bay. The volume of the tidal prism is so large that it overrides the influence of even the Delta inflow. As a result, although the pattern of mass water movement is modified somewhat, the basic flow patterns remain unchanged throughout the year.

Mass Water Movement - From the Bay Bridge through Alcatraz Channel, there is a pronounced net seaward displacement of the surface layer and a southerly bayward flow of bottom waters. Surface displacement is much greater than that found on the bottom indicating the shallowness of the faster moving top layer. During wet weather conditions, a surface displacement of 10 to 25 nautical miles per tidal cycle is evidenced. This would result in a mean Bay retention time for a surface field released near Alcatraz of less than 12 hours. This net seaward displacement still exists under dry weather conditions but subsides to several nautical miles per tidal cycle during the period of low Delta inflows.

Currents - In the Alcatraz Channel, current direction for both ebb and flood tide is approximately parallel to the shoreline. Maximum velocity for surface currents commonly exceeds 3 knots with occasional 4-knot velocities. Greater velocities occur on the ebb tide but they are of shorter duration than the flood tide currents. Maximum bottom velocities are generally less than 2 knots.

Tidal Exchange - The ratio of new Ocean water entering the Bay with each flood tide to the total tidal prism, the tidal exchange ratio, varies with the amplitude of the flood tide. Based on an average tidal amplitude of 4.1 feet, a dry weather tidal exchange ratio at the Gate of approximately 24 percent exists. For each 25-hour tidal cycle, this means an introduction of 20 to 30 billion cubic feet of new Ocean water through the Golden Gate into the Bay with approximately 15 to 25 billion cubic feet passing through the Alcatraz Channel south of Alcatraz and the remainder flowing into the North Bay.

During wet weather conditions, fresh water inflow from the Delta and other tributaries into the Bay and out through the Gate increases the magnitude of new water flowing through the Bay. It is estimated that the total tidal exchange during large fresh water inflow exceeds 80 percent.

Surface Drift - Release of cardboard floats by Brown & Caldwell during the oceanographic studies in the Alcatraz Channel in June and October of 1970 indicate the general surface drift for this region. It was found that release of floatables near Alcatraz results in their accumulation on the Ocean beaches north and south of the Golden Gate with no significant accumulation on the Bay shoreline. Floatables released outside the Gate during different tidal conditions will not enter the Bay.

These findings were verified by the oil spill that occurred near Alcatraz in January 1971. Oil contamination was concentrated mainly on Ocean beaches outside the Bay with shoreline contamination inside the Bay limited to a small area seaward of the release point.

Surface drift studies by U. S. Geological Survey in March 1970 through April 1971 further substantiated this general observation of surface water movement. Central Bay surface drift was seaward for the entire study period. It was also found that no surface drifter released seaward of the Golden Gate was recovered within the Bay system.

South Bay.

Mass Water Movement.- South of the Bay Bridge to Hunters Point there is a net seaward flow on the surface and a net southerly flow on the bottom. The net surface seaward displacement south of the Bay Bridge is substantially less than that of the Central Bay but amounts to several nautical miles per tidal cycle in the waters adjacent to Hunters Point.

South of Hunters Point the tides create a counter-clockwise circulation in the South Bay which can be attributed to the deep navigation channel on west side and broad shallow areas on the east side.

Currents - Direction of currents is similar to the pattern of mass water movement described above. During both ebb and flood tides current direction is generally parallel to the shoreline.

Surface Drift - Data available from current U. S. Geological Survey surface drift studies in March 1970 through April 1971 and earlier studies by the San Francisco Department of Public Works in September-October 1958 indicate the general surface drift for the northern part of South Bay. Release of surface drifters just south of Yerba Buena Island resulted in their displacement seaward out through the Golden Gate.

Nearshore Zone. Superimposed upon the general mass water movement for the Bay and the Gulf is the more complex region of water movement found in a zone extending approximately 500 to 1,000 feet off the shoreline of the peninsula. In this zone the current direction and speed varies from the general pattern described above. Friction from the shoreline and shoreline geometry produce eddies which vary in magnitude and direction with each tidal exchange and stage. The effect of this nearshore condition is to limit the exchange of water between prevailing offshore masses and that in the nearshore zone. This increases nearshore discharge retention times in the Bay considerably over that for a discharge further offshore.

Receiving Water Conditions

A summary of the general receiving water conditions is presented in Table I-1. The effects of existing and proposed discharges upon receiving waters are evaluated in this section.

Data on the receiving water conditions of the Bay have been gathered over a long period of time and consists of research results from studies by State agencies, private consultants, and independent researchers. The data are generally more complete and descriptive of actual conditions than are found in other areas where discharge occurs or is proposed.

Investigation and documentation of conditions existing in the Gulf of the Farallones is much less thorough and the majority of these data were obtained in a one-year study. As a result, there are limited data on physical characteristics of the Gulf and the conclusions derived from this study may not accurately represent the extremely variable conditions which exist in this very complex system.

Dissolved Oxygen. Depression of dissolved oxygen from waste discharge at each location is not a critical factor. Initial dilution capability for each outfall in combination with the fact that oxygen levels in the waters of the Gulf and Central Bay are near saturation should minimize problems associated with depression of oxygen levels. Mathematical model studies performed by Brown & Caldwell in 1969 indicated that the maximum depletion of oxygen in the Bay resulting from all San Francisco discharges would occur south of the Bay Bridge in the vicinity of the Southeast plant. The maximum depletion would be approximately 0.07 mg/l which is not significant.

Nutrients. Algae, micro-organisms containing chlorophyll, possess the capability of converting inorganic substances such as carbon dioxide, ammonia, nitrates, and phosphates into organic material with energy provided in sunlight

TABLE I-1

RECEIVING WATER CONDITIONS

	Gulf of Farallones Inside Bar	Gulf of Farallones Outside Bar	Central Bay Alcatraz	Lower Bay Near Hunters Pt.
DO CONCENTRATION, MG/L				
Dry Weather				
Surface	6.5-8.5	8-10		
Bottom	6.5-8.0	4-6		
Wet Weather				
Surface	8-9	8-9		
Bottom	8-9	8-9		
Minimum			6.5	7.0
Mean			7.3	7.4
Maximum			8.2	8.5
SECCHI DISK TRANSPARENCY, FT				
Dry Weather	5-17	6.5-25		
Wet Weather	1.5-8	4-15		
Jan-June Mean			3.5	2.5
July-Dec Mean			6.5	6.0
SUSPENDED SOLIDS, MG/L				
Minimum			5+	8+
Mean			15	29
Maximum			38	56
TEMPERATURE, ^{o}C				
Minimum			10.1	10.7
Mean			13.5	14.8
Maximum			19.0	21.0
NITRATE NITROGEN, MG/L, NO_3				
Minimum			0.05	0.06
Mean			0.15	0.12
Maximum			0.48	0.21
AMMONIA NITROGEN, MG/L, NH_3				
Minimum			0.16	0.08
Mean			0.24	0.34
Maximum			0.36	0.55
ORTHO PHOSPHATE, MG/L, PO_4				
Minimum			0.2	0.3
Mean			0.3	0.5
Maximum			0.4	0.8

through the photosynthetic process. Low concentrations of any of these nutrients, however, limit the population of algae even though all the other necessary factors are in abundance.

Total nitrogen and phosphorous concentrations in San Francisco Bay waters are substantially higher than the growth limiting concentrations for either. However, signs of enrichment are generally observed only along the shores and in tidal reaches of some of the tributaries. A possible explanation for lack of excessive algal production is light availability and/or the presence of toxic components from wastewater.

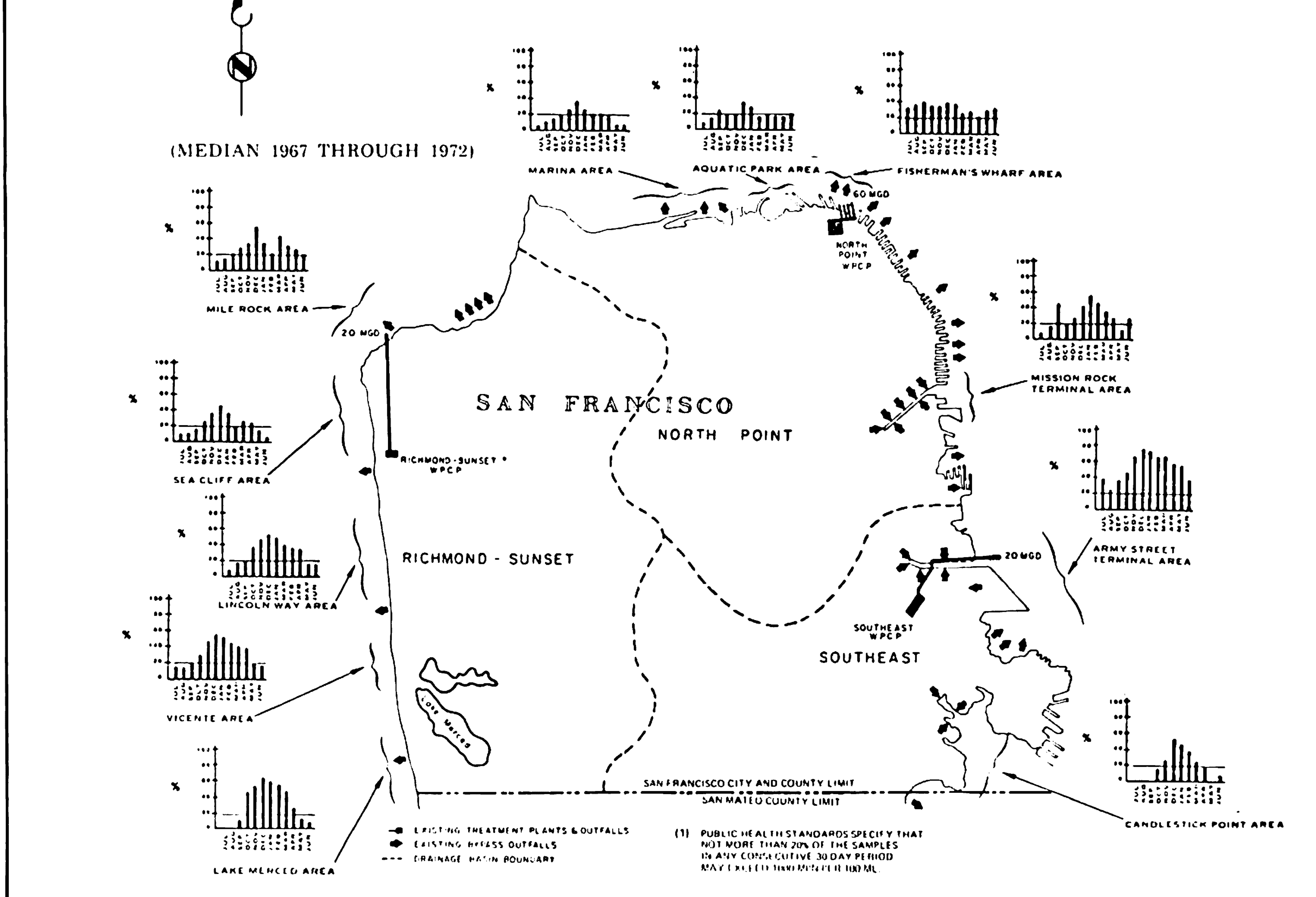
Nitrate nitrogen and ammonia nitrogen are listed separately in Table I-1 because various algae and bacteria can use one or the other of these forms of nitrogen (or both).

Projected controls of Delta waters could significantly reduce turbid fresh water inflows to the Bay and result in increased available light. In addition, control of toxic materials in wastewater discharges should improve. This expected control will create conditions more favorable to algal production and could result in increases in algal growth. The net southward movement of a submerged field at the Southeast plant could also result in a slight increase in South Bay nutrient concentrations, however, it is not possible to predict any effects from this increase.

<u>Coliform Concentration</u>. Beaches on the San Francisco peninsula shoreline are normally posted by the San Francisco Department of Public Health from October to April each year due to the contamination from wet weather overflow. Maximum coliform levels are attained during the rainy season and can be attributed to wet weather overflow of combined sewage. Figure I-2 summarizes the coliform data from samples collected from 1967 through 1972 and shows that Public Health criteria for salt water bathing are normally exceeded throughout the shoreline waters surrounding the City during the entire winter season. In the vicinity of the dry weather outfalls, bathing standards are usually exceeded throughout the year with the exception of the Richmond-Sunset area where standards are normally met in July and August.

Analysis of data from routine City sampling at Outer Marina Beach from mid-1966 to December 1968 identified a significant variation between coliform levels for dry and wet weather conditions. The coliform levels increased

FIGURE 1-2
PERCENT OF SAMPLES EXCEEDING 1000 MPN PER 100 ml(1)



by a factor of six from dry to wet weather conditions at a beach sampling station and by a factor of seven at sampling stations 250 to 1,500 feet offshore. Tidal current stage was found to cause fluctuations in coliform levels with higher concentrations observed at ebb and low slack stages than at flood and high slack stages.

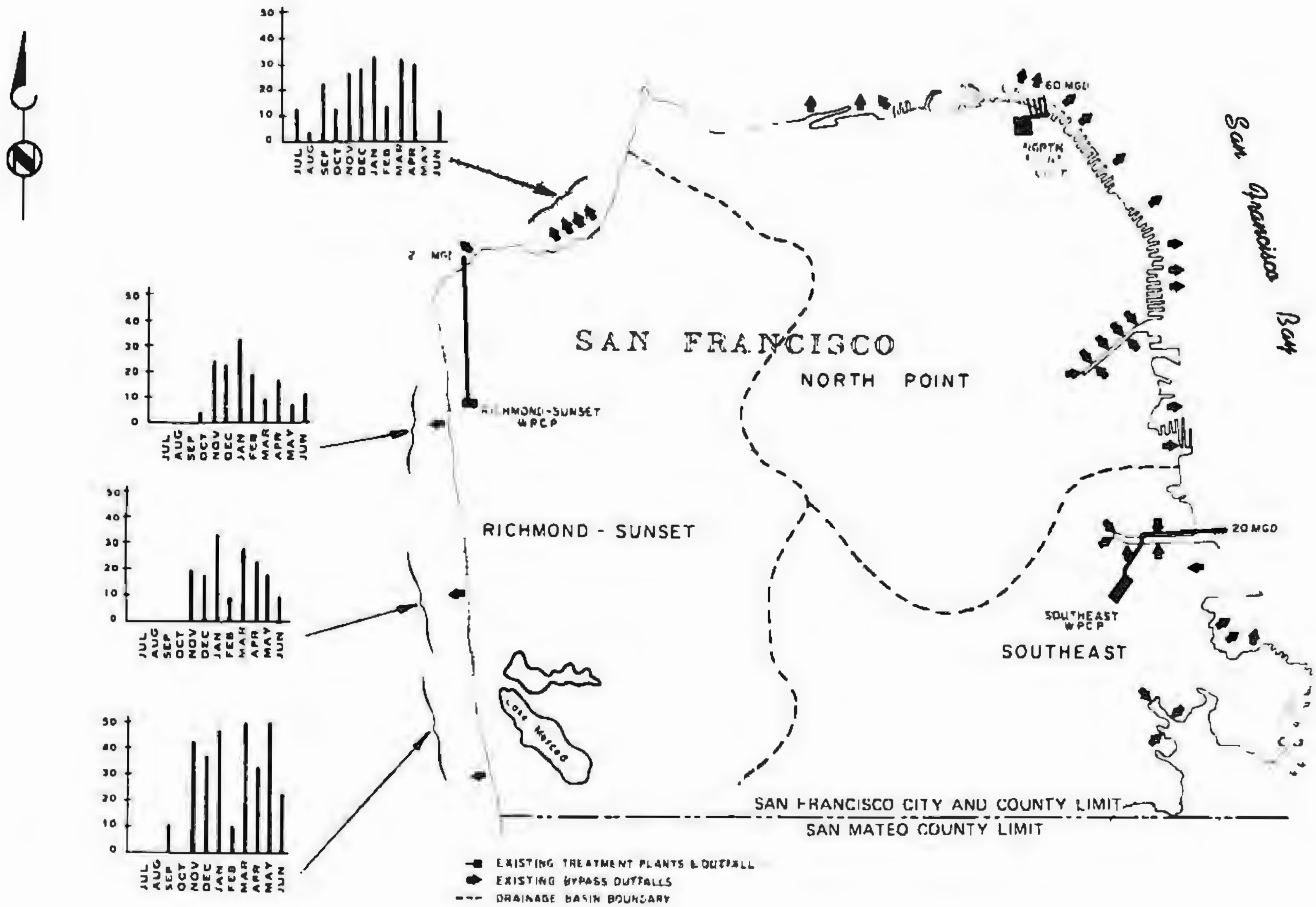
Fluctation of coliform most probable number (MPN) levels at Outer Marina Beach after cessation of wet weather discharges was also evaluated for two stations. It was found that median coliform levels at both stations decreased from a high value attained during wet weather to the background dry weather level within five dry weather days.

This analysis provides a basis for estimating the number of days of contamination per year attributable to combined overflows. It is estimated that the actual number of days that shoreline waters exceed bathing water standards due to wet weather overflows averages approximately 171 days per year.

Floatables. Variation in the frequency and distribution of floatable materials, both on the water surface and on the beaches, can also be related to wet weather bypassing of wastewater. Distribution is also related to surface drift which for the Central Bay leads to an accumulation on the Ocean beaches outside the Golden Gate. Figure I-3 summarizes data on observations of floatable material on ocean beaches from June 1967 through June 1968 by the State Department of Public Health. The data indicate a significant increase in observable floatable material on Ocean beaches during the rainy season from November through April in all areas. Floatable material was observed throughout the year near the Richmond-Sunset outfall.

The average floatable particulate concentration observed in the 1969-70 wet weather surveys was 10.5 mg/m^2 as compared to 1.5 mg/m^2 observed during dry weather. A similar increase in dry weather levels over those for wet weather was also observed in the surface waters of Outer Marina Beach. Wet weather levels were consistently an order of magnitude greater for these sampling stations. There was also a difference between concentrations west of Marina Beach and those in the easterly sector. This corresponds to the lack of both combined and sanitary sewers west of Bakers Beach within the Bay.

FIGURE I-3
PERCENT POSITIVE OBSERVATIONS OF FLOATABLE MATERIAL ON OCEAN BEACHES (1967-1968)



Conservative Pollutants (Non-degrading). An evaluation of the dispersion capability of San Francisco Bay is available from a modeling study recently completed by the Department of Water Resources. In this study, a computer modeling technique was used to estimate the concentration of conservative pollutants under varying conditions of Delta outflow, tidal exchange, and pollutant discharge. The dispersion capability is defined in terms of equilibrium pollutant concentrations under steady-state conditions and non-stratified flow conditions.

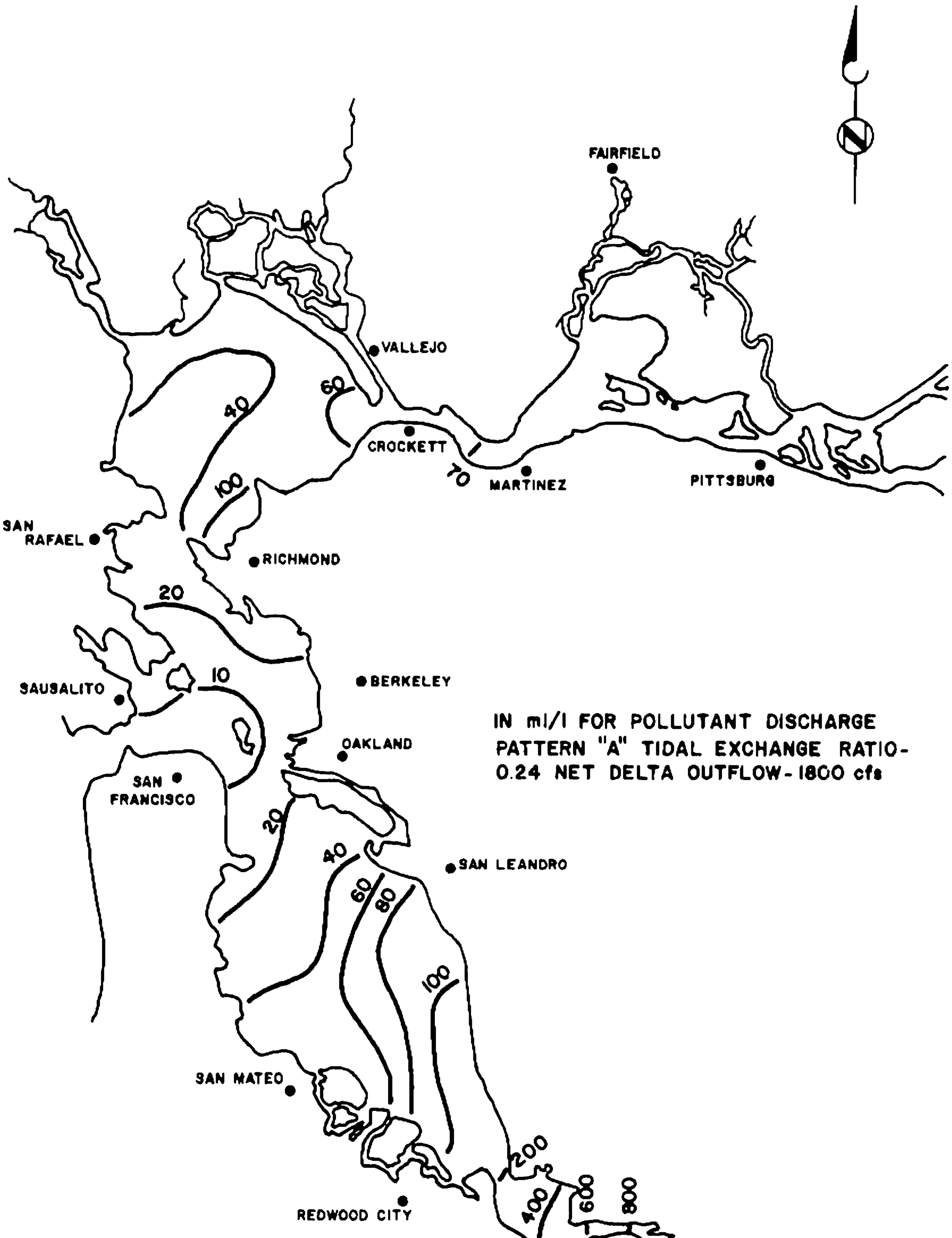
For dry weather conditions, a tidal exchange ratio of 0.24 which is the average value for the Bay, a net Delta outflow of 1,800 cfs, and a discharge pattern approximating present conditions, the distribution of conservative pollutants presented in Figure I-4 was obtained.

In the Department of Water Resources study, a comparison of pollutant concentrations is made for a tidal exchange ratio of 0.20, 0.24, and 0.30, Delta outflows of 1,800 and 5,000 cfs, and two patterns of discharge of pollutants. Discharge patterns A represents present-day conditions and pattern B represents implementation of a future water quality control plan proposed by the San Francisco Bay Regional Water Quality Control Board. Modeling results indicate that only the pattern of discharge of pollutants has a significant impact on concentration distributions, particularly in the South Bay.

The study was performed primarily to estimate dispersion capability of the Bay and a method was developed for approximating an increase in pollutant concentration at selected points in the Bay due to pollutant loadings at other points. This method allows determination of concentration profiles for toxicity but can be applied to discharges of any pollutant that does not change its characteristics with time.

Turbidity. The data in Table I-1 indicate a definite variation in level of turbidity under wet and dry weather conditions for the surface waters of the Bay and Gulf of the Farallones. Higher values evidenced in the winter are attributable to the turbid fresh water outflows from the Delta. Being much less dense than the saline water of the Bay, the Delta outflow forms a thin surface layer of 10 to 15 feet while passing through the Bay. Under most wet weather conditions, a surface field formed by stormwater discharge by the City of San Francisco would not be

FIGURE I-4
POLLUTANT CONCENTRATIONS



IN ml/l FOR POLLUTANT DISCHARGE PATTERN "A" TIDAL EXCHANGE RATIO-0.24 NET DELTA OUTFLOW-1800 cfs discernible. Further upstream controls on fresh water inflow to the Bay could reduce background turbidity levels in the future. It is also possible for wet weather overflows to occur early in the rainy season before development of stratified conditions and high receiving water turbidity. At this time, storm overflow discharged as a surface field would be more turbid than the receiving water and would be easily visible within the Bay or near-shore zone of the Gulf of the Farallones.

Oceanographic Design Criteria

Based on the above physical and chemical characteristics of the Gulf of the Farallones and the Bay, the following criteria which are considered important for the minimization of adverse impacts on receiving waters were developed.

For dry weather discharges, the fall season represents the design condition because:

- Water clarity is greatest.
- Surface net advection is lowest.
- Density stratification is least pronounced because of low fresh water inflow.
- The tendency of an effluent field to rise to the surface is greatest.
- Atmospheric and water temperatures are at the annual high, and recreational use of the shore areas is likely to be the greatest.

For wet weather discharges the winter season represents the design condition for the obvious reasons. During the winter period of high fresh water runoff:

- Water clarity is lowest.
- Surface net advection is highest.
- Density stratification is most pronounced.

Oceanographic design criteria which apply only to the Gulf of the Farallones may be summarized as follows:

- To achieve a continuously submerged effluent field, an outfall diffuser must be located outside the bar in 80 feet or more of water.

- A surface field released at any point inside the bar in a water depth greater than about 60 feet will be advected seaward.

- The bar area itself is too shallow to permit either surface installation of a major pipeline or good initial dilution for a major effluent discharge.

- Effluent discharged through a properly designed diffuser located west of the mouth of the Golden Gate will have no measurable effect on the Bay.

- Floatable material released west of the mouth of the Golden Gate will not enter the Bay.

- Any dry weather discharge to the Gulf of the Farallones should be located at least one mile offshore to:

  Avoid the nearshore currents which have a net bayward displacement;

  place a surfacing field beyond the limit of easy visibility from shore; and

  increase the minimum shoreward travel time.

A wet weather discharge might suitably be made less than one mile offshore near the mouth of the Golden Gate in an area where the effluent field would be entrained in the westward moving surface water mass. However, an outfall and diffuser in the high current and unstable bottom area near the mouth of the Golden Gate would cost more per unit of length than in areas of lower currents.

Oceanographic design criteria which apply only to the Central Bay may be summarized as follows:

- Net advection of the surface layer in the Central Bay is seaward at all times of the year. Seaward advection is weakest in the summer and fall and strongest during periods of high runoff.

- Surface advection in the Bay south of the Bay Bridge is much weaker than in the Central Bay, but still has a net seaward vector at most times and stations.

- Surface drift of floatables released in the mid-Central Bay is seaward at all seasons. No significant deposition will occur along the Bay shoreline, and the distribution along the Ocean shoreline will be approximately the same as for an Ocean release.

- Density stratification is sufficient to keep an effluent field submerged most of the time at initial dilutions of 100 to 1 or greater. At times in summer and fall, however, there is no density gradient, and the effluent field will surface.

- Dissolved oxygen resources of the Central Bay are in excess of the lower limiting values established by the Regional Water Quality Control Board and recommended by the Bay-Delta Program.

- Tidal exchange at the Golden Gate brings 20 to 30 x 10^9 cubic feet of new ocean water into the Central Bay each 25-hour tidal cycle during the dry weather months, and up to twice that amount in wet weather.

- Tidal exchange at Alcatraz Channel brings 15 to 25 x 10^9 cubic feet of new water past that site each 25-hour tidal cycle in dry weather months.

Ecological Data

Diversity, distribution, and numbers of marine biota found in San Francisco Bay, Gulf of the Farallones, and adjacent ocean, and the effect of waste discharges on these biota, was obtained from studies by consultants and other researchers.

In 1969-70, under contract with the City of San Francisco, Brown & Caldwell performed an ecological investigation of the Bay and the Gulf of the Farallones to assess the impact of primary effluent. This study concluded that:

- No significant toxic response to seven species of fish could be demonstrated after 96 hours exposure in dilutions of San Francisco sewage effluent greater than 1:100.

- Eggs and larvae of Dungeness crabs showed a toxic effect at a dilution of 1:50 and a stimulatory response at greater dilutions.

Three sampling programs were conducted by Engineering-Science, Inc., in 1969-70 at the Outer Marina Beach to identify the water quality and biological characteristics of surface water, the benthos, and the beach intertidal zone. The following conclusion regarding biota in the area was derived from the study:

"Both the concentrations of microplankton in the receiving waters and benthic animals in the sediments were low and represented by a number of varieties. The combination of low and diverse populations is considered generally to be representative of a balanced ecology."

In 1971, Brown & Caldwell performed supplemental ecological investigations to determine the distribution of Dungeness crab zoea and adults in the Gulf of the Farallones and the toxicity of wastewater effluents to various life stages of local crab species. This supplemental study concluded that:

- The study area (on the Golden Gate Bar offshore from Ocean Beach) could again become an important crab fishery area upon return of the Dungeness crab to past population levels in the Gulf of the Farallones and that the area must therefore provide appropriate protection for all stages of the Dungeness crab.

- Laboratory tests conducted on adults, juveniles, larvae, and eggs of four species of crabs, with primary emphasis on Dungeness crab, showed no statistically significant effect due to wastewater dilutions ranging from 1:400 to 1:20.

- The results of the 1971 laboratory studies generally confirm the results of the 1970 laboratory studies.

- The 1971 laboratory work reinforces the basic finding of the 1969-70 study, which is that primary effluent discharged from the City of San Francisco at appropriate points through properly designed submarine diffusers will not adversely affect the marine environment of the Central Bay or the Gulf of the Farallones.

Ecological Design Criteria

Based on the 1969-70 studies and results reported by other researchers of the marine biology of the Gulf of the Farallones and the Bay, design criteria were developed to be used as a guide for selection of the levels of waste treatment and discharge location necessary to provide maximum protection to the marine resources. It was assumed that future toxicity loadings would be equivalent to chlorinated primary effluent. In addition, a factor of safety of 10 was incorporated.

Design criteria include:

- Where possible, effluent dilutions along the shoreline or in shallow water should not be less than 1000 to 1 for more than 24 hours at a time.

- Gravid Dungeness crabs appear to be vulnerable to the effects of exposure to sewage effluent through reduced egg-mass viability. The benthos in areas where gravid crabs are present should not receive sustained exposure to effluent in dilutions less than 500 to 1.

- Plankton and fish populations should not be exposed to effluent dilutions less than 100 to 1 for more than 24 hours or less than 200 to 1 for long-term exposure.

- Deposition of sewage solids on the ocean floor should be avoided. Settled material of sewage origin has been demonstrated to have a negative effect on benthic populations.

- From the standpoint of protecting the marine ecosystem in the Gulf of the Farallones, a surface effluent field is preferable to a submerged field for two reasons:

  - A surface field will be transported away from intertidal areas.

  - A surface field provides the greatest factor of safety for protection of the benthos.

  This is particularly true during the winter season when gravid crabs are migrating shoreward.

- Since rocky intertidal areas have a greater diversity and productivity than sandy beaches, a preferred location for an outfall in the Gulf of the Farallones would lie south of a line extended westward along the centerline of the Golden Gate.

- Submarine pipelines and diffusers in the Gulf of the Farallones should be constructed in a manner which will not impede the periodic shoreward migration of breeding Dungeness crabs and certain other benthos.

In 1971, Brown & Caldwell study concluded that the ecological design criteria developed at the end of the 1970 work were still valid.

Data Evaluation

The data summarized above describing the receiving water conditions and marine biology of the San Francisco Bay and the Gulf of the Farallones were used in the development of the

Master Plan to select the type and placement of the outfalls and the necessary treatment level. The assimilative capacity of each proposed or existing outfall location was estimated and the treatment level determined to ensure compliance with requirements of the Regional Water Quality Control Board for both wet and dry weather conditions.

In developing the Master Plan certain assumptions must be made of the level of water quality protection that will be required in the future for the Bay and the ocean. It is correctly stated in the Master Plan that a higher level of effluent quality will be required for discharge to the Bay than to the ocean; however, the level has not yet been defined for the Bay and questions still remain on ocean discharge requirements.

There are sufficient data to develop general conclusions regarding the impact of discharge at various locations. Criteria have been developed to determine the relative benefits of alternative discharge sites. Based on these design criteria, it has been possible to analyze the impact of alternate waste treatment and disposal schemes in sufficient detail to conclude that the ocean disposal alternative is superior with regard to environmental protection.

A more detailed description of currents, mass water movement, and surface drift associated with the proposed discharge location would facilitate a better understanding of that particular area. These data could be used to further identify the ability to maintain a submerged or surface effluent field. Additional oceanographic data would also permit a closer approximation of movement of the effluent field. Extent of possible beach contamination, exposure of the benthos to critical concentrations, and movement of floatable materials could also be more clearly defined. Identification of dilution and dispersion would permit determination of the concentrations of potential pollutants in receiving waters to allow correlation with toxicity studies.

The City of San Francisco recognizes the need for certain supplemental data regarding receiving water characteristics and the impacts of waste discharge on marine resources. In this regard, studies are underway to evaluate the impacts associated with marine waste disposal especially its toxicity to marine resources.

CITY ENVIRONMENT

Climate

San Francisco is an air conditioned city with cool pleasant summers and mild winters. This climate results from its unique location on both the Pacific Ocean and the southern shore of the Golden Gate, which is the only sea level entrance through the coastal mountains into the interior of California.

Sea fogs, and the low stratus cloudiness associated with them, are a striking characteristic of San Francisco's climate. In the summertime the temperature of the ocean is unusually low near the coast and the atmospheric pressure relatively high, while the interior is characterized by the opposite in both elements. This strongly tends to intensify the landward movement of air and to make the prevailing westerly winds brisk and persistent, especially during the period from May to August. The fog off the coast is carried inland by strong westerly winds during the afternoon or night and is evaporated during the following forenoon. Despite the fog, the sun shines on an average of two-thirds of the daylight hours in downtown San Francisco.

As a result of the steady sweep of air from the Pacific, with an annual mean speed of 9 miles per hour, there are few extremes of heat or cold. During 90 years of records, temperatures have risen to 90° or higher on an average of once a year and dropped below freezing less than once a year. The recorded highest was 101° and the recorded lowest was 27°. The average daily temperature through the year ranges from 45° in January to 69° in September. As a rule, abnormally warm or cool periods last only a few days.

Climatic differences exist within the City of San Francisco, depending on the hills and the geographical relationship to the Ocean and Bay. The most obvious difference is the greater frequency and duration of fog along the Pacific coastal side of the City.

The normal total annual rainfall within San Francisco is about 20 inches. As shown in Table I-2 84% of the total annual rainfall generally occurs during the period November to March and 42% generally occurs during December and January.

TABLE I-2
ANNUAL AND MONTHLY RAINFALL VARIATION
FEDERAL BUILDING GAGE

	Amount Inches	% of Annual
January	4.57	22.5
February	3.36	16.5
March	2.80	13.8
April	1.43	7.0
May	0.59	2.9
June	0.14	0.7
July	0.02	0.1
August	0.02	0.1
September	0.24	1.2
October	0.89	4.4
November	2.24	11.0
December	4.03	19.8
Total	20.33	100.0

Measurable amounts of precipitation fall on less than 70 days per year and rainfall more intense than 0.02 inches per hour, which produces a runoff exceeding the capacity of the water pollution control plants, occurs about 3% of the time during a year. Table I-3 presents the average hourly intensities representing 62 years of record at the Federal Building Gage and Figure I-5 presents rainfall intensity-duration-frequency curves based on the same data.

TABLE I-3
FREQUENCY DISTRIBUTION OF
HOURLY RAINFALL INTENSITIES

Intensity Inches/Hour	Percent of Time Equaled or Exceeded
0.01	94
0.02	83
0.05	72
0.10	47
0.20	20
0.55	1

With its extreme variation in topography and high exposure to ocean storms, considerable variation exists in rainfall intensities across the City at any time during a storm. Recognizing this concept, the City has engaged in continuous monitoring of the rainfall at 19 or more rain gages throughout the City, beginning with the 1969-70 rainy season. For that season, the data indicated a 15 percent lower overall average volume of rainfall over the whole City than indicated by the Federal Building gage. Data collected on one large storm during the 1970-71 season and during the large storm in October 1972, indicate that large storms move across the City, frequently from northwest to southeast, with the area of most intensive rainfall covering only a small part of the City at any one instant and changing from minute to minute as the storm progresses. Both the maximum intensity of rain and the total rainfall vary widely throughout the City.

Topography and Land Use

San Francisco is located on a collection of hills, comprising part of the coastal range, and is surrounded on three sides by salt water. The streets slope steeply toward the water on the west and north and toward a flat coastal strip along the east side of the business district. A relief map of San Francisco is shown on Figure I-6.

FIGURE I-5
RAINFALL INTENSITY - DURATION - FREQUENCY CURVES

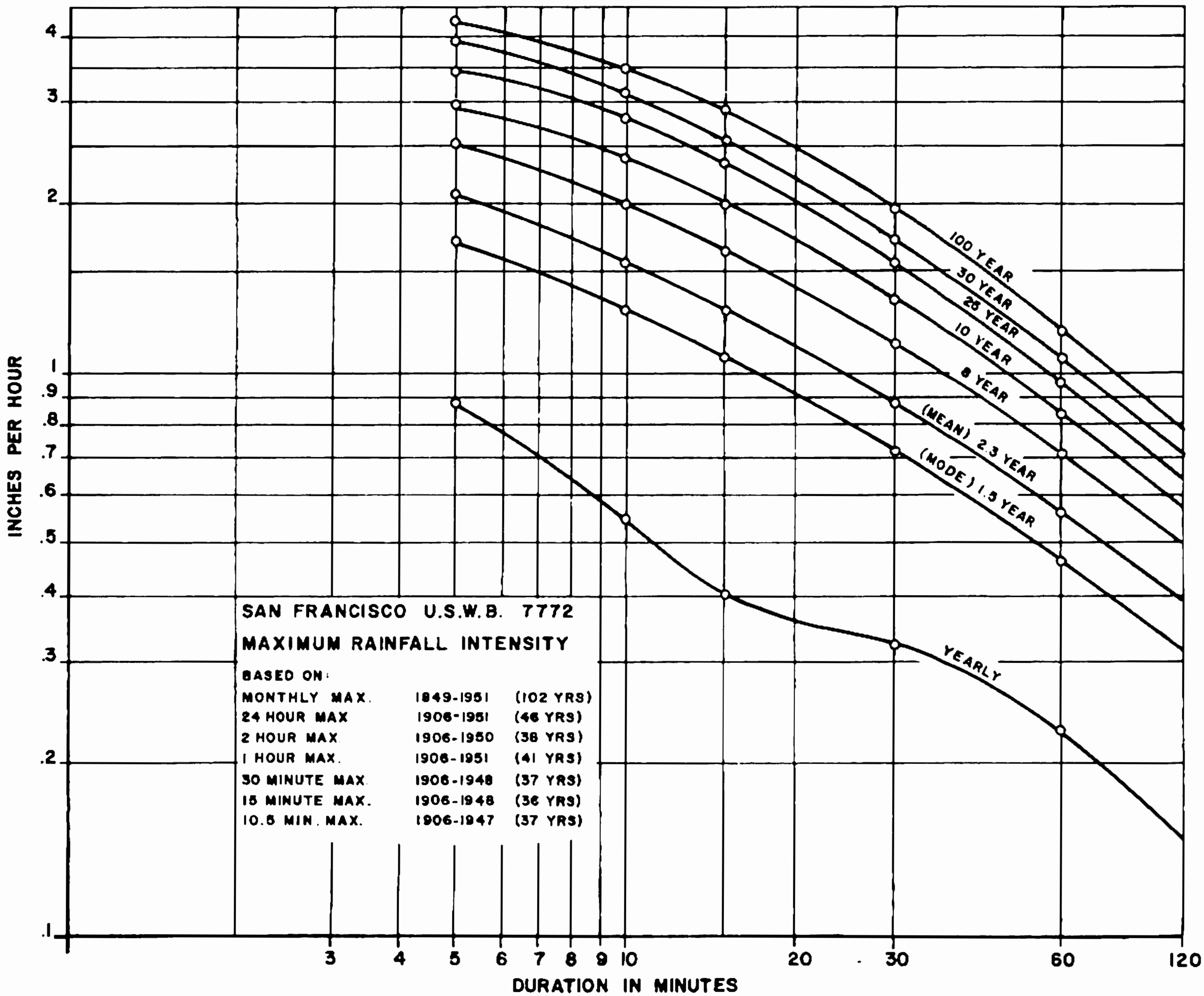
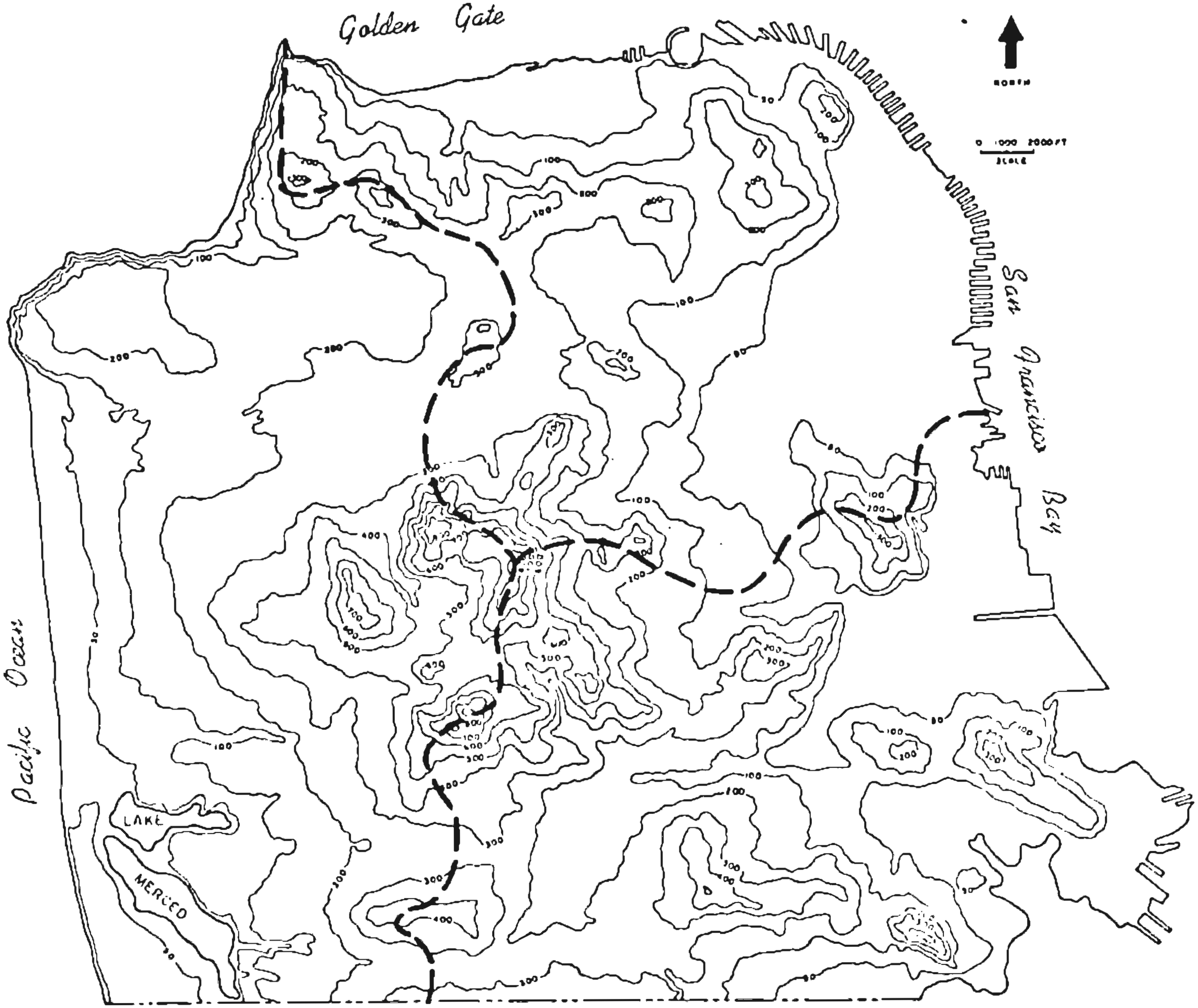


FIGURE I-6
TOPOGRAPHIC MAP OF SAN FRANCISCO



Drainage Basin Boundary

The natural drainage is to the Bay for North Point and Southeast districts, and to the Ocean for the Richmond-Sunset district. The City reaches a maximum elevation of 922 feet above sea level at the confluence of the three major districts.

Although commonly known as the city built on seven hills, there actually are dozens of peaks and heights, but no general agreement exists on their actual count. At least 42 of the hills have names.

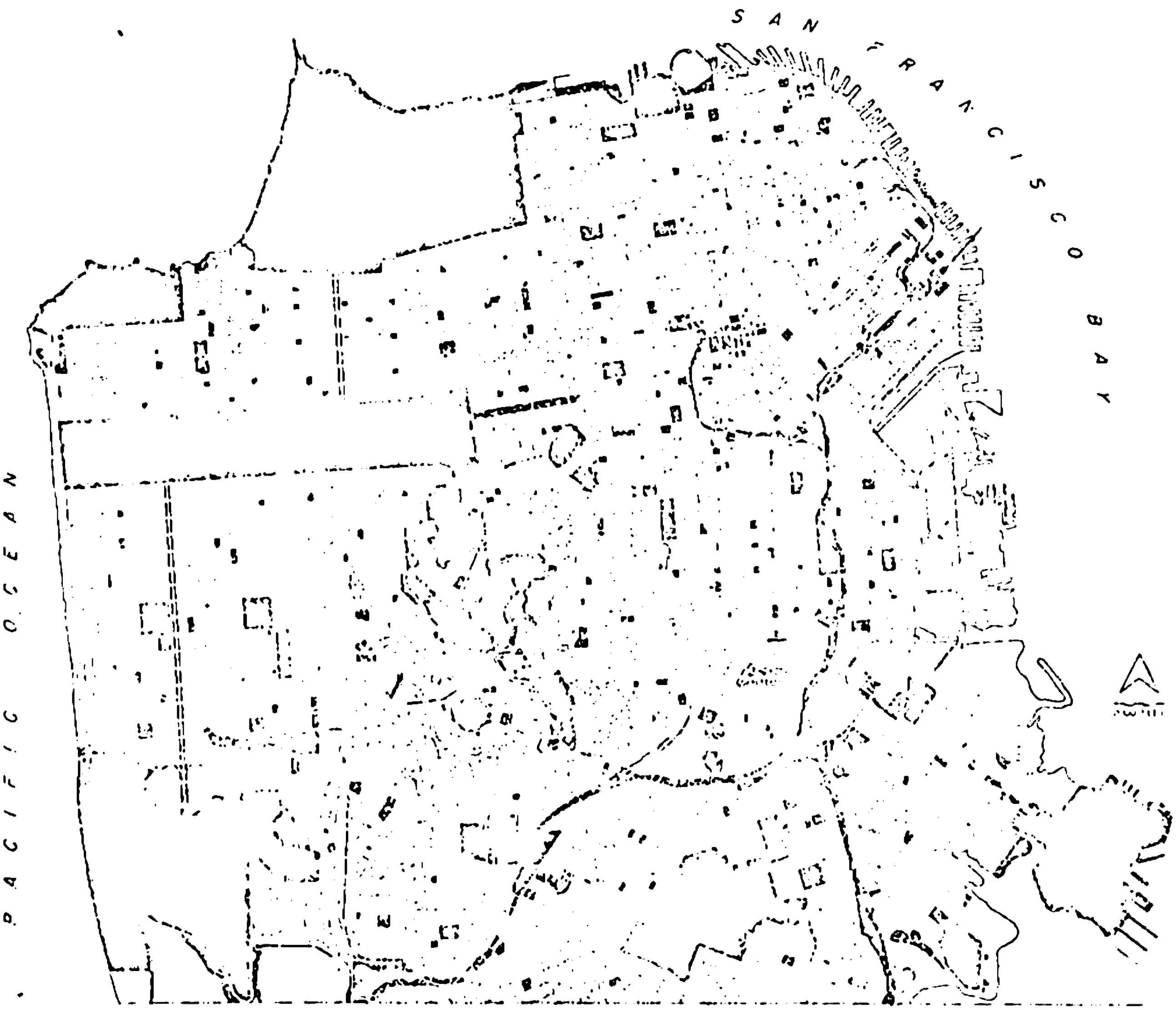
San Francisco's major summits are in effect islands in a sea of sand. The sand was blown by the sea wind, which forced it around rocky obstacles and up the seaward side of the higher hills. The highest sand dune is located at an elevation of over 600 feet, on the north-south ridge known as Golden Gate Heights. This dune covers bedrock of Franciscan chert. The smooth slopes and rolling contours of the Richmond and Sunset districts were created by the moving sand. The low areas of Polk Gulch and the valley now occupied by Market Street were also created by sand. The concrete sea wall now stopping the flow of sand replaces the original timber and wire wall built in 1870 by John McLaren and William Hall, the first Golden Gate Park Superintendent.

The northwestern shoreline of the city is distinguished by steep headlands rising to 300 feet. The cliffs were created by the battering ocean which gouged out the soil, sand, and rocks. In marked contrast, portions of the northeastern shoreline are man-made, the original bay mud having been reclaimed with about 3,700 acres of fill.

Except for parks, military reservations, and mountain slopes the City is practically 100 percent developed. The west side is predominantly residential, mostly single-family houses. The North Point district includes the downtown commercial area with its large daytime work force from all over the Bay area, a large industrial area, and a large residential area, predominantly multi-family units. The area tributary to the Southeast plant, while mostly single family residential, includes a large industrial area of industries producing liquid wastes which greatly influence the characteristics of the sewage received at that plant. The land uses of the various areas of the City have been established and are shown in Figures I-7 through I-11. Little change has occurred since these maps were prepared and only minor changes are to be expected in the near future.

The shoreline has also been fully developed. The east side of the City from Hunters Point to Fisherman's Wharf consists of docks and shipping terminals. The North side of the City includes a swimming beach at Aquatic Park and recreational facilities at the Marina. Bakers Beach and Phelan Beach lie outside the Golden Gate, and Ocean Beach extends along the entire length of the western shore from the Cliff House to Fort Funston.

FIGURE I-7
PUBLIC LAND USE



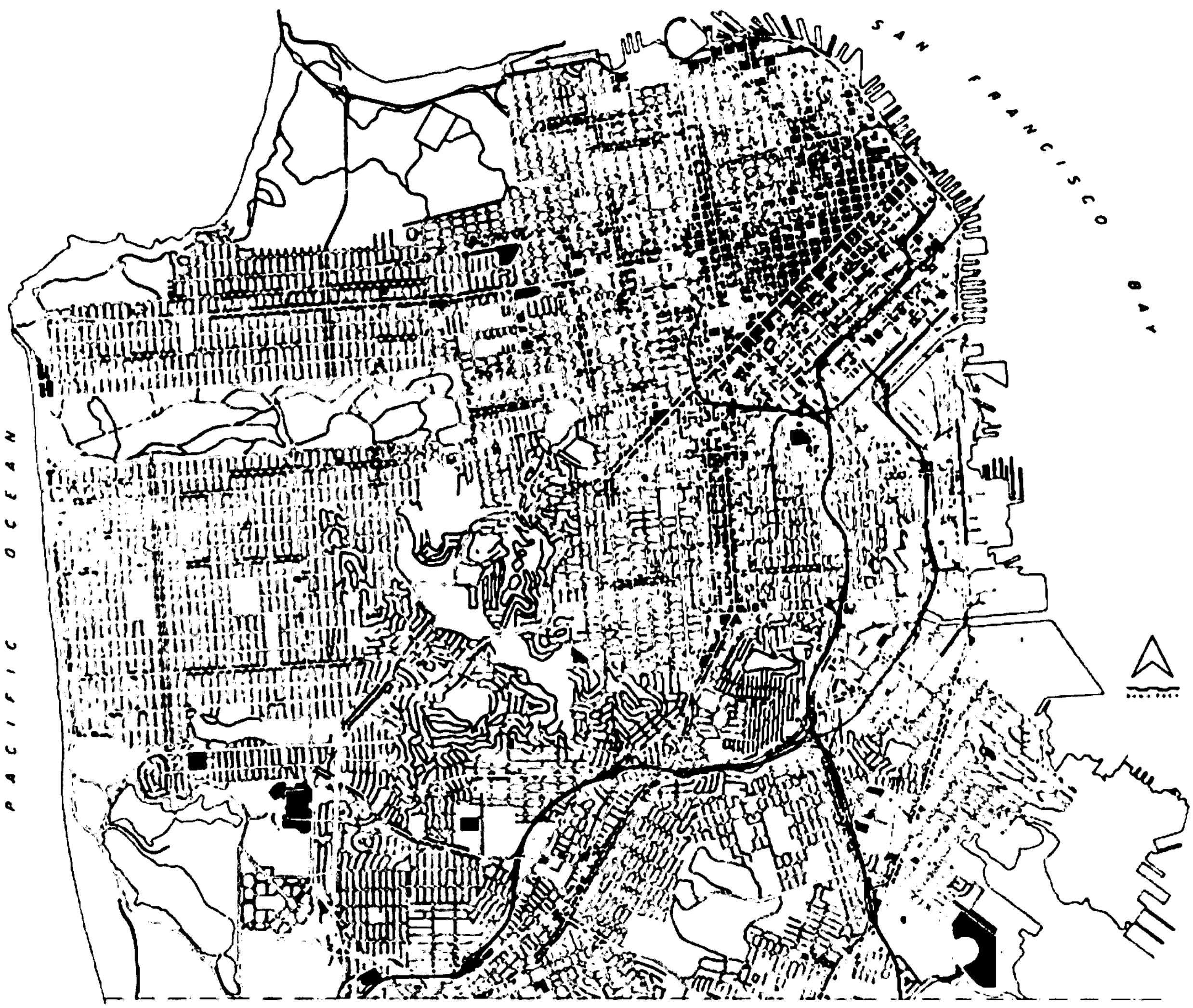
PUBLIC LAND USE

(EXCLUDING PUBLIC HOUSING)

SOURCE 1961-64 LAND USE SURVEY

PREPARED BY THE SAN FRANCISCO DEPARTMENT OF CITY PLANNING . 1964

FIGURE 1-8

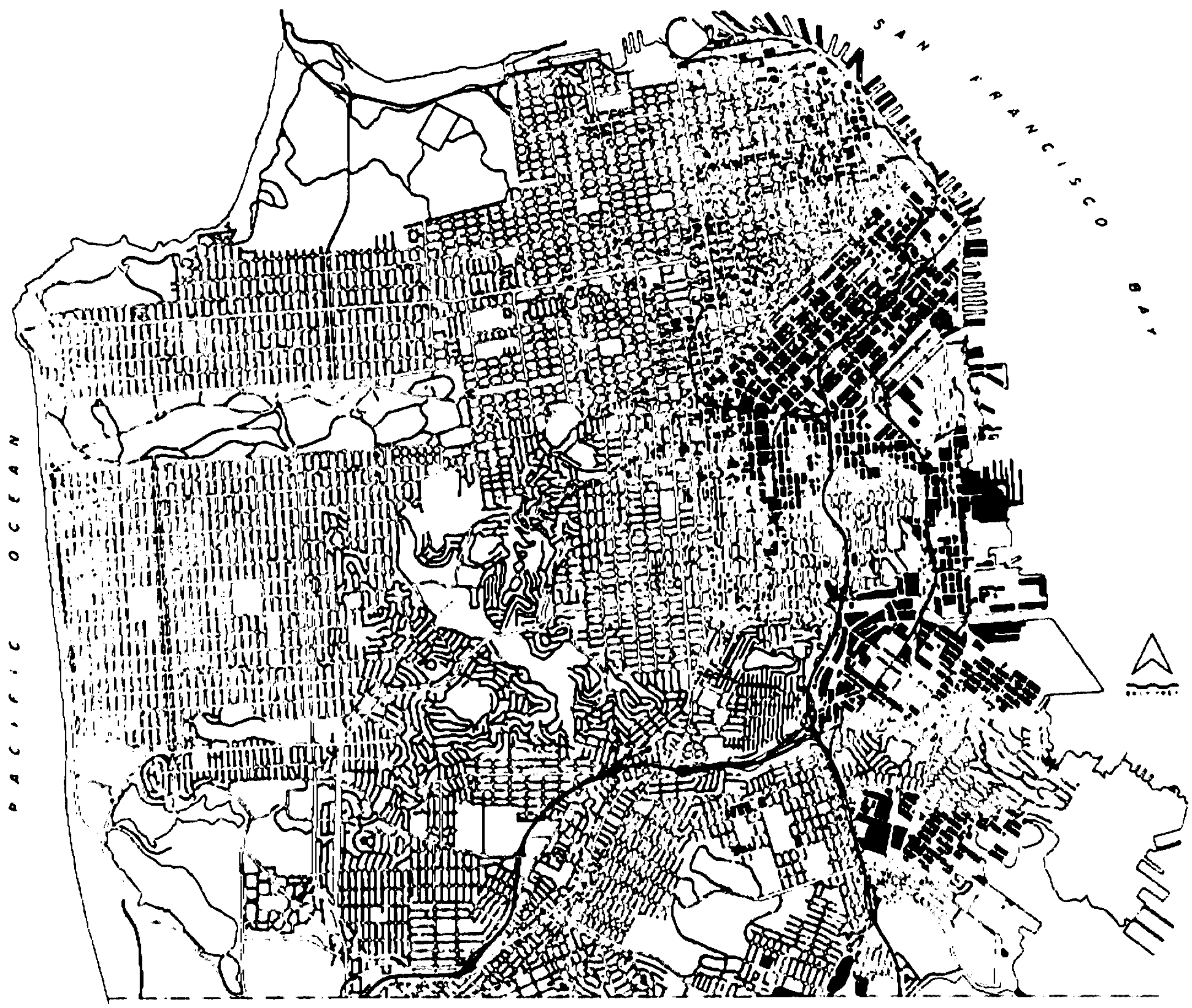


LAND USED FOR COMMERCE

SOURCE 1970 LAND USE SURVEY

PREPARED BY THE SAN FRANCISCO DEPARTMENT OF CITY PLANNING

FIGURE 1-9

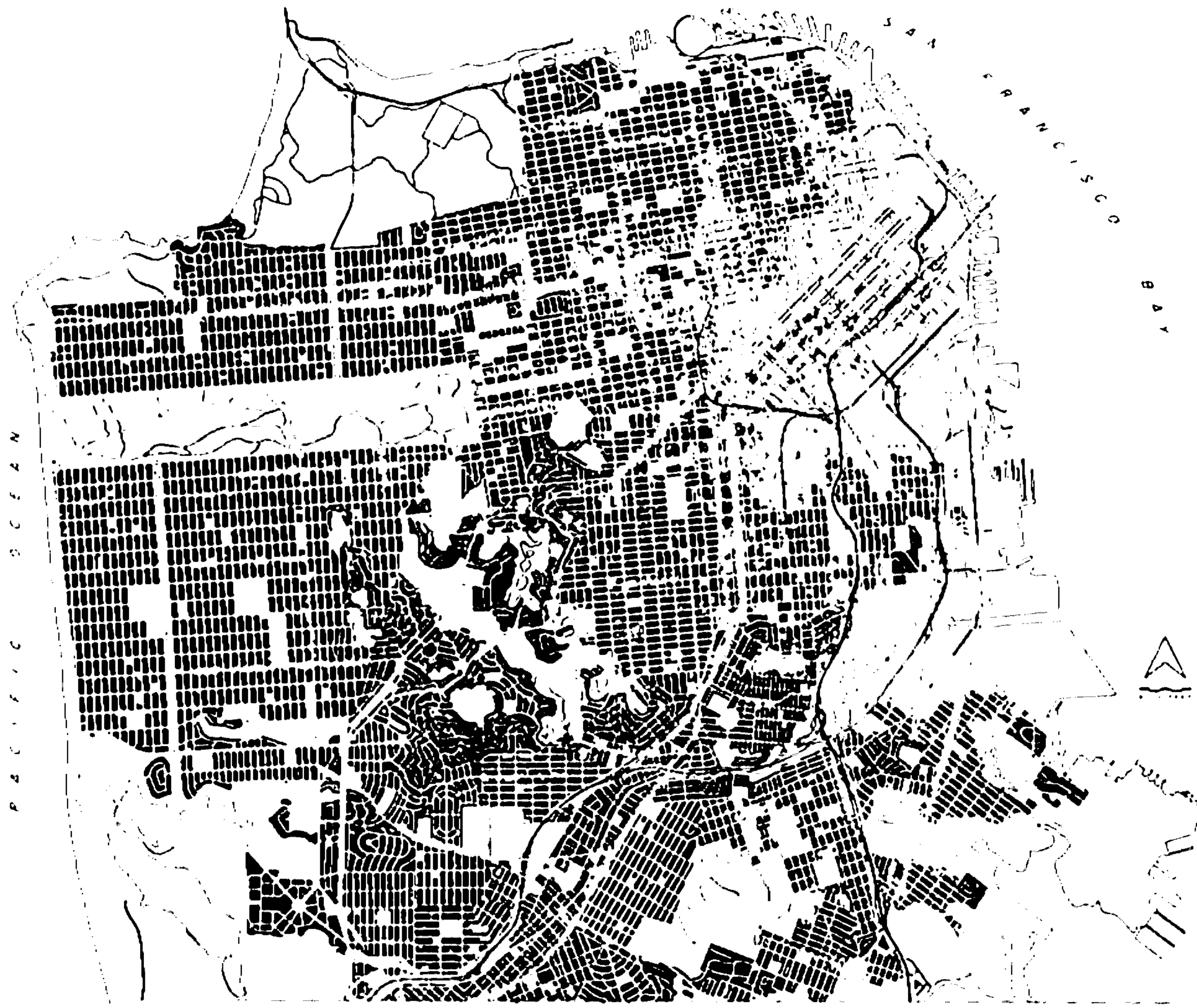


LAND USED FOR INDUSTRY

SOURCE 1970 LAND USE SURVEY

PREPARED BY THE SAN FRANCISCO DEPARTMENT OF CITY PLANNING

FIGURE 1-10

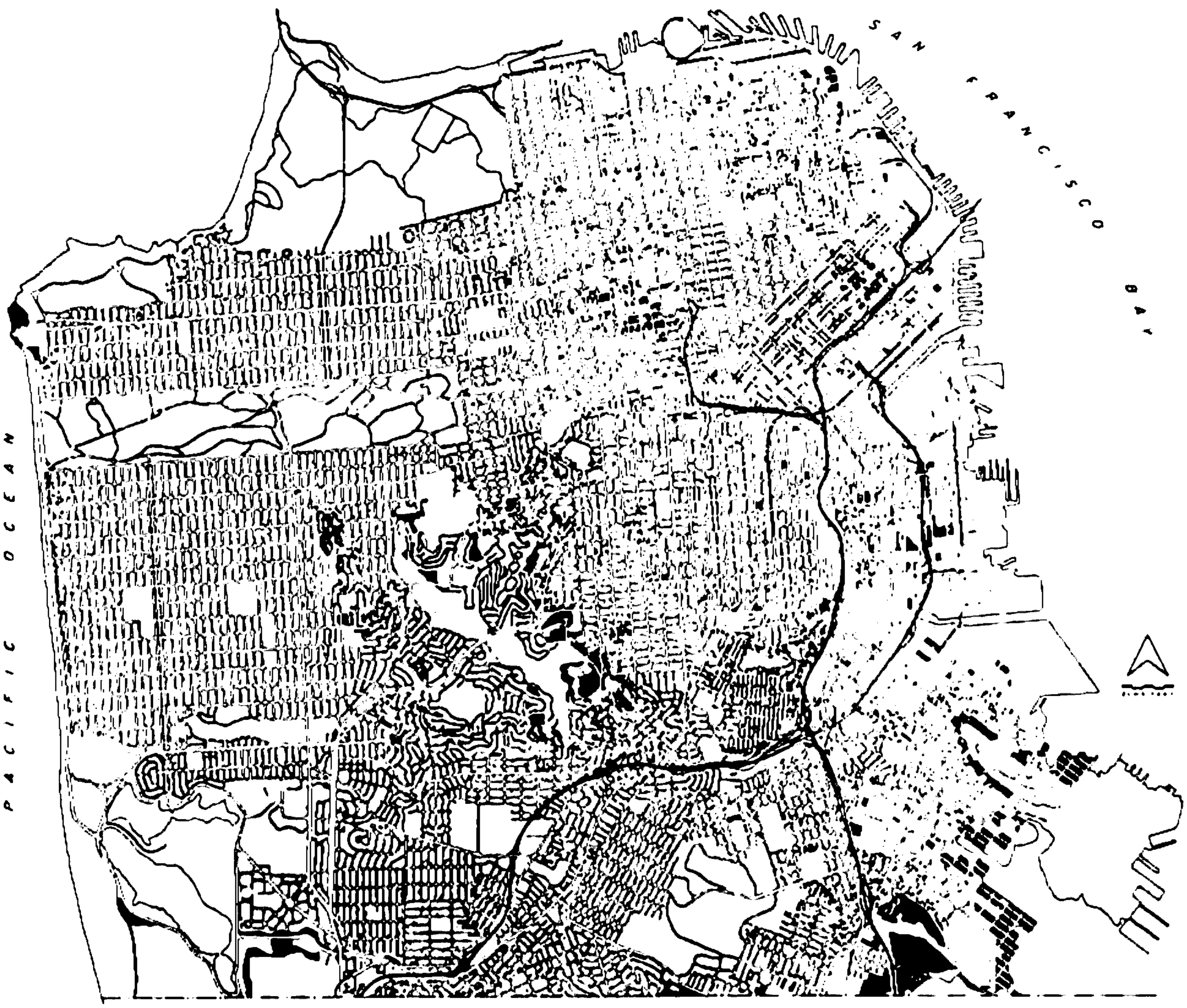


LAND USED FOR RESIDENCE

SOURCE 1970 LAND USE SURVEY

PREPARED BY THE SAN FRANCISCO DEPARTMENT OF CITY PLANNING

FIGURE 1-11



VACANT LAND

(EXCLUDING TIDELANDS AND BEACHES)

SOURCE 1970 LAND USE SURVEY

PREPARED BY THE SAN FRANCISCO DEPARTMENT OF CITY PLANNING

The San Francisco City Planning Commission has adopted a comprehensive long-term, general plan for the improvement and future development of the City and County of San Francisco. This plan is maintained as a guide to the coordinated and harmonious development of the city. It serves as a basis for administrative measures by which elements of the plan can be carried out and for such legislative measures as the Board of Supervisors may adopt. The general plan projects future land uses for the City to be 40% residential, 22% industrial and commercial, and 38% public lands and governmental reserves.

The 1970 census established the population of San Francisco as 714,300. The Department of City Planning expects the population to increase to approximately 755,000 by 1990 and 78,000 by 2020. The State Department of Finance in cooperation with the State Department of Water Resources has made alternative county level population projections for planning purposes. A comparison of the City's projections and the State's projections is shown in Table I-4.

TABLE I-4
COMPARISON OF POPULATION PROJECTIONS

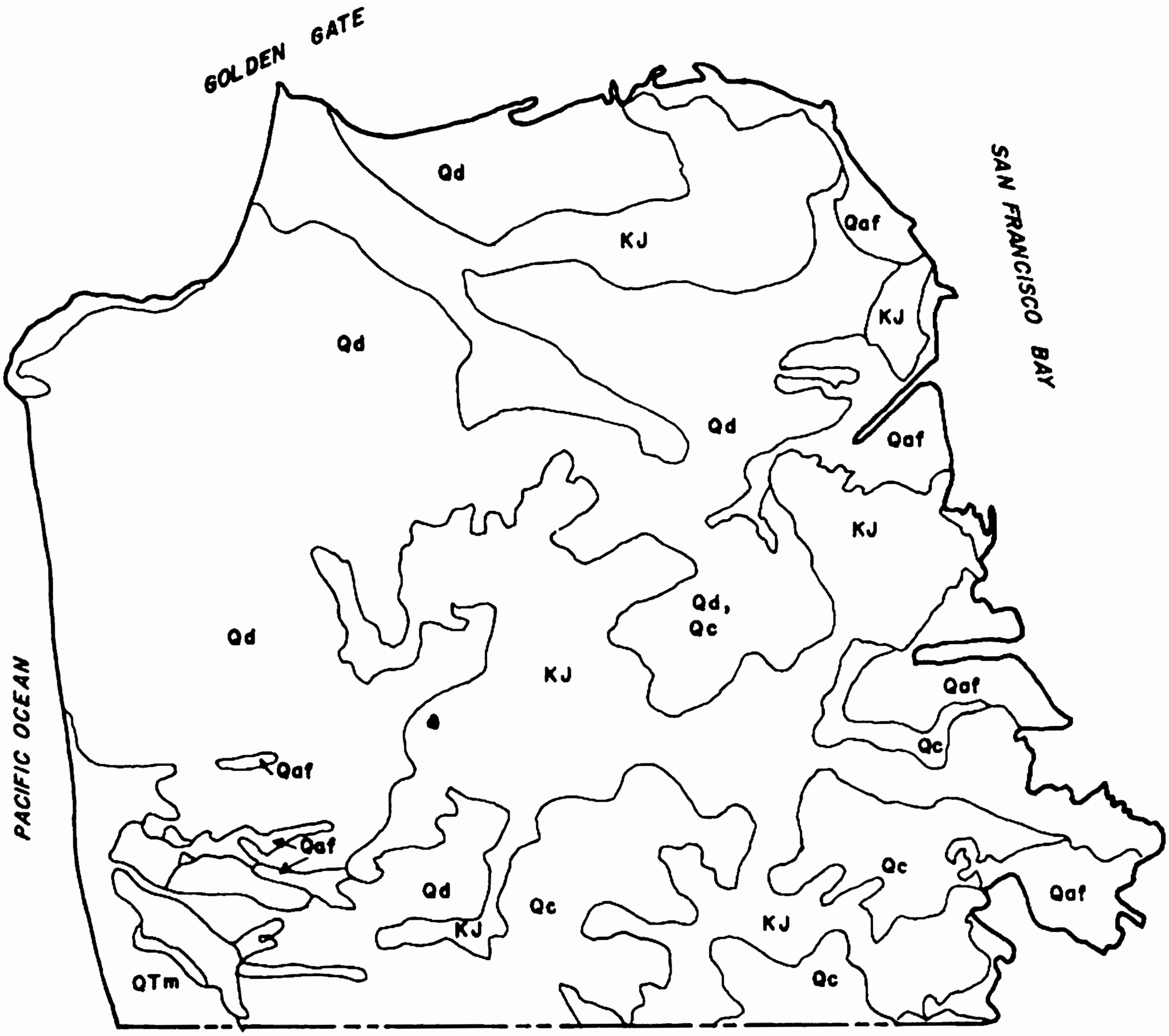
	City	D.O.F. (D-150)[1]	D.O.F (E-O)[2]
1970	714,300	714,300	714,300
1980	735,000	721,600	712,300
1990	755,000	730,000	706,400
2000	764,000	726,300	688,700
2010	772,000	728,100	672,700
2020	780,000	722,600	650,200

[1]Department of Finance, Series D fertility and 150,000 net in-migration to California for each year beginning July 1, 1980. Annual migrations from 1971-72 to 1979-80 interpolated between 1970-71 level and assumed value for 1980-81.

[2]Department of Finance, Series E fertility and zero net in-migration to California beginning July 1, 1971.

The Department of Finance projections are important as they are the basis upon which the State Water Resources Control Board has elected to allocate Clean Water Grant Funds. For San Francisco, which is in a critical air basin, the E-O projections are used.

FIGURE 1-12
GEOLOGIC MAP OF SAN FRANCISCO



KJ	Franciscan Formation- Sandstone, Shale, Chert, Greenstone, Sepentine, and Metamorphic Rocks.
QTm	Merced Formation- Friable To Dense Sand, Silt, and Clay; Minor Amounts of Gravel, Lignite, and Volcanic Ash.
Qd	Dune Sand- Well Sorted Fine-Grained Gray Sand, Loose in Most Places.
Qaf	Artifical Fill- Clay, Silt, Sand, Rock Fragments, Organic Matter, and Man-Made Debris.
Qc	Clayey Sand

FIGURE 1-13
CALIFORNIA AIR BASIN

however, there is no distinct topographic boundary between the Bay Area and Central Valley climatic zone.

The basin contains approximately 5,540 square miles of land area and 490 square miles of water surface consisting primarily of San Francisco, San Pablo, and Suisun Bays. In 1970 the total population of the basin was 4.5 million, approximately 23% of the State total. Population increase between 1960 and 1970 was 27 percent while the motor vehicle registration during the same period increased 60% to a total of 2.7 million.

Meteorology - The San Francisco Bay Area and associated valleys constitute a well-defined coastal climate zone which is broken into subparts as a result of wind climatology. Low hills, the influence of the large water areas, and a large influx of maritime air produce several well-defined wind patterns in the area.

During much of the year, the winds from the Ocean divide to flow northward into the Sonoma and Napa Valleys, eastward through the Carquinez Strait, and southward into the Santa Clara Valley. There is also an air flow from the South Bay Area, through canyons in the mountains, into Livermore Valley. This division of air flows makes the opposite ends of the Bay Area meteorological subparts of the basin. The large flow of marine air through Carquinez Strait also has a marked influence on the climate in portions of Solano and Contra Costa Counties.

As in other coastal areas, the subsidence inversion is dominant over this area most of the year. It varies, seasonally and daily, between 1,000 and 3,000 feet in elevation. Due to solar heating, the inversion may be destroyed over the extreme ends of the Sonoma and Santa Clara Valleys. Wide variations in vertical mixing occur over the extreme ends of these valleys.

Except during late September and October, and during hot spells in April, May, or June, wind movements provide consistent ventilation in much of the Bay Area.

Sources of Air Pollution - The estimated average emission of contaminants into the San Francisco Bay Area Air Basin during 1970 is presented in Table I-5. This inventory was compiled by the Air Resources Board based on information gathered jointly by the Board and the Bay Area Air Pollution Control District. Typical of highly populated urban areas, mobile sources predominate and provide the highest percentages of highly reactive organic gases, oxides of nitrogen, and carbon monoxide. Stationary sources are responsible for most of the emissions of particulate matter and sulfur dioxide. The mobile sources (i.e., motor vehicles, aircraft, ships, and railroads) contribute 81% of the total emissions into the Bay Area Basin. Motor vehicles are by far the largest single source of all pollutants, except sulfur dioxide and particulate matter.

A comparison of the estimated emissions from each of the counties in the basin is given in Table I-6. As can be seen by the data in Table I-6, the majority of the emissions originate from the more highly populated counties to the east and south of the Bay, with Santa Clara having the highest emissions. San Francisco contributes about 12% of the total emissions into the Bay Basin.

Summary of Air Quality. The Bay area has one of the more serious air quality problems in the nation. As shown in Tables I-6 and I-7, these problems are principally those of oxidants and carbon monoxide and are caused predominantly by vehicle emissions. San Francisco, however, has relatively pure air since prevailing winds carry the City's emissions to other parts of the Bay area.

Because of the seriousness of the problem, EPA has determined that the achievement of air quality standards for the protection of human health cannot be achieved in 1977 by the controls of stationary sources and conventional mobile controls alone. Consequently, EPA has promulgated a transportation control plan which requires the reduction of total vehicle miles traveled in the Bay area. These controls will affect San Francisco since it is a major source of automobile emissions. EPA has withdrawn portions of this plan, and alternatives are currently being investigated.

TABLE I-5

SAN FRANCISCO BAY AREA AIR BASIN
AVERAGE EMISSIONS OF CONTAMINANTS
INTO THE ATMOSPHERE, 1970
(TONS PER DAY)

Emission Source	Organic Gases Reactivity High	Organic Gases Reactivity Low	Organic Gases Total	Particulate Matter	Oxides of Nitrogen	Sulfur Dioxide	Carbon Monoxide
STATIONARY SOURCES							
PETROLEUM							
Production							
Refining	6.0	54.3	60.3	5.9	19.8	72.8	16.9
Marketing	51.7	63.3	115				
SUBTOTAL	57.7	117	175	5.9	19.8	72.8	16.9
ORGANIC SOLVENT USERS							
Surface Coating	41.8	167	209	5.3	0.2		
Dry Cleaning	4.0	19.8	24.7	.5			
Degreasing	8.6	34.2	42.8				
Other	15.4	61.5	76.9	0.7			
SUBTOTAL	70.7	283	354	6.5	0.2		
CHEMICAL		32.0	32.0	25.3	0.8	83.9	0.1
METALLURGICAL		2.9	2.9	28.7	1.2		3.5
MINERAL		0.2	0.2	3.7		1.0	2.3
INCINERATION							
Open Burning (dumps)	1.3	10.4	11.7	1.1			30.6
Open Burning (backyard)	3.3	26.6	29.9	3.1	0.1	0.2	73.7
Incinerators	1.6	6.4	8.0	1.1	0.5	0.3	5.9
Other							
SUBTOTAL	6.2	43.4	49.6	5.3	0.6	0.5	110
COMBUSTION OF FUELS							
Steam Power Plants		1.0	1.0	5.1	56.6	22.7	0.1
Other Industrial		2.3	2.3	9.5	69.9	57.7	0.7
Domestic and Commercial		0.3	0.3	5.1	26.2	0.2	0.1
SUBTOTAL		3.6	3.6	19.7	153	80.6	0.9
LUMBER INDUSTRY							
Logging Debris							
Teepee Burning							
Steam Generation							
Open Burning (Mill Waste)							
SUBTOTAL		0.3	0.3	0.9			3.1
AGRICULTURE							
Debris Burning	9.1	74.0	83.1	6.8		0.2	204
Orchard Heaters							
Agricultural Product Processing Plants		3.6	3.6	7.6			6.9
SUBTOTAL	9.1	77.6	86.7	14.4		0.2	211
TOTAL STATIONARY SOURCES	144	560	704	110	176	239	348
MOBILE SOURCE							
MOTOR VEHICLES							
Gasoline Powered							
Exhaust	540	180	720	28.1	429	15.6	4910
Blowby	25.8	8.6	34.4				
Evaporation	137	69.1	206				
Diesel Powered		23.1	23.1	7.3	103	7.3	99.3
SUBTOTAL	703	281	984	35.4	532	22.9	5010
AIRCRAFT							
Jet Driven	12.5	12.5	25.0	16.3	7.3	3.6	43.0
Piston Driven	2.3	2.2	4.5	0.4	1.4		21.8
SUBTOTAL	14.8	14.7	29.5	16.7	8.7	3.6	64.8
SHIPS & RAILROADS		5.7	5.7	11.7	10.7	10.6	19.0
TOTAL MOBILE SOURCES	718	301	1020	63.8	551	37.1	5090
GRAND TOTAL	862	861	1720	174	727	276	5440

TABLE I-6

SAN FRANCISCO BAY AREA AIR BASIN
COMPARISON OF EMISSIONS BY COUNTY
(Tons per Day)
1970

County	Total Organic Gases	Particulate Matter	Nitrogen Oxides	Sulfur Dioxide	Carbon Monoxide	Total Emissions
Alameda	408	30	140	13	1,190	1,780
Contra Costa	273	41	170	187	689	1,360
Marin	61	5	27	2	237	332
Napa	49	5	12	1	133	200
San Francisco	194	16	95	8	671	984
San Mateo	183	24	87	8	706	1,010
Santa Clara	387	33	145	11	1,320	1,900
Solano[1]	67	11	25	44	192	339
Sonoma[1]	97	9	26	2	300	434
Total	1,720	174	727	276	5,440	8,340

[1]That portion of the county within the San Francisco Bay Area Air Basin.

The information in Table I-6 was derived by using the county percentage breakdown of the district's jurisdiction sources obtained from the San Francisco Bay Area Implementation Plan (SFBARPCD) plus motor vehicle emissions estimated by the Air Resources Board.

TABLE I-7

OCCURRENCES OF EMISSIONS HAVING VALUES GREATER THAN
THE AMBIENT AIR QUALITY STANDARDS
1972

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
	OCCURRENCES OF OXIDANTS HAVING A VALUE OF GREATER THAN 0.08 ppm												
San Francisco													
Hours	0	0	0	0	0	0	0	0	0	0	0	0	0
Days	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Bay Area Basin													
Hours	0	5	54	60	162	214	323	254	118	100	5	0	1295
Days	0	4	28	21	58	67	86	76	58	30	1	0	429
	OCCURRENCES OF NITROGEN DIOXIDE HAVING A VALUE OF GREATER THAN 0.25 ppm												
San Francisco													
Hours	0	0	0	0	0	0	3	0	0	0	0	0	3
Days	0	0	0	0	0	0	2	0	0	0	0	0	2
Total Bay Area Basin													
Hours	0	0	0	0	0	0	3	0	0	0	0	0	3
Days	0	0	0	0	0	0	2	0	0	0	0	0	2
	OCCURRENCES OF CARBON MONOXIDE HAVING AN 8-HR MOVING AVERAGE OF GREATER THAN 9 ppm												
San Francisco													
Hours	21	0	35	0	0	0	0	0	0	12	8	8	84
Days	2	0	4	0	0	0	0	0	0	2	2	2	12
Total Bay Area Basin													
Hours	214	52	35	0	0	0	0	0	0	56	172	112	641
Days	24	9	4	0	0	0	0	0	0	9	19	13	78
	DATA FROM STATE AIR RESOURCES CONTROL BOARD AND SAN FRANCISCO BAY AREA AIR POLLUTION CONTROL DISTRICT												

CHAPTER II

EXISTING WATER MANAGEMENT

WATER SUPPLY

The City and County of San Francisco has owned and operated a water and power system for many years. Through long-range planning and construction, San Francisco has continued the development of its overall water and power resources. The municipal system, including impounding and storage reservoirs, aqueducts, water distribution facilities, hydroelectric power plants, and electric transmission facilities, extends almost completely across the State of California, from the summit of the Sierra Nevada to the San Francisco Bay Area. Up to the present time, nearly 500 million dollars has been spent or committed on these facilities.

An average of more than 225 million gallons of water daily, with a system peak of more than 300 million gallons per day, is delivered to two million consumers directly through the distribution facilities of more than 40 other municipal and water distributing agencies. Water is supplied for residential, commercial, and industrial use in a 500 square-mile service area comprising San Francisco as well as neighboring communities in most of San Mateo County and in parts of Santa Clara and Alameda Counties. In fact, more than half of the consumption is in suburban areas outside of San Francisco.

San Francisco Water Department System

The San Francisco Water Department operation is largely based on the privately-owned Spring Valley Water Company system purchased and taken over by the City in 1930. For operating purposes this system is broken down into three divisions: Alameda, Peninsula, and City Distribution.

Alameda County Components. The Alameda system includes four water producing units, all located within the drainage area of Alameda Creek in the Coast Range Mountains east of San Francisco Bay. The principal sources of supply are Calaveras and San Antonio Reservoirs, which are supplemented by two underground sources, the Sunol Infiltration Galleries in Sunol Valley and the Pleasanton Well Field in Livermore Valley.

Peninsula Components. The Peninsula system, consisting of three reservoirs, transmission mains, and pump stations, is located in San Mateo County immediately south of the City and County of San Francisco on the Peninsula. The reservoirs-Pilarcitos, San Andreas, and Crystal Springs (upper and lower)--have a combined watershed area of 32 square miles, which is for the most part covered with a heavy growth of trees and brush.

City Distribution Facilities. Making up the City Distribution System are terminal reservoirs receiving water from the Peninsula transmission mains, and the distribution reservoirs, tanks, pumps, and mains delivering water to consumers within San Francisco. The San Francisco Water Department is one of the few major suppliers in the United States which is supported by revenues from consumers.

Hetch Hetchy System

The Raker Act was passed by both Houses of Congress and signed into law on December 19, 1913, by President Wilson, who made the following written comment about the Hetch Hetchy Plan:

> ". . . it seems to serve the pressing public needs of the region concerned better than they could be served in any other way, and yet did not impair the usefulness or materially detract from the beauty of the public domain."

The Raker Act, taking its name from California Congressman John Edward Raker, granted to San Francisco rights-of-way and the use of public lands in the areas concerned for the purpose of constructing, operating, and maintaining reservoirs, dams, conduits, and other structures necessary or incidental to the development and use of water and power.

The mountain water supply system includes three impounding reservoirs: Hetch Hetchy on the Tuolumne River, Lake Lloyd on Cherry River, and Lake Eleanor on Eleanor Creek. The latter two streams are tributaries of the Tuolumne River. Each year the runoff from rainfall and melting snow is collected behind the dams. Water stored in Lakes Lloyd and Eleanor is used to generate power at Dion R. Holm Powerhouse and to meet downstream irrigation needs. Storage in Hetch Hetchy Reservoir is drawn upon mainly for San Francisco's domestic and suburban water supply, and in the course of its journey it generates electric power at Robert C. Kirkwood and Moccasin Powerhouses.

Water released from Hetch Hetchy flows through a series of tunnels, pipelines, inverted siphons, and powerhouses. It is led down the Sierra slopes, through the foothills, across the great San Joaquin Valley, through the Coast Range Mountains, under and around San Francisco Bay to finally reach Crystal Springs, a terminal reservoir on the Peninsula.

The water flows 149 miles through the system entirely by gravity. The water supply route is free from the great and unending expense of pumping; a system in which mountain water is completely enclosed and protected--except for regulating reservoirs--for the entire distance. This source supplies over three-quarters of the total consumption in the City's water service area.

In passing through the Hetch Hetchy System, water is used to generate electrical energy on its downhill journey. The City's three power plants generate approximately two billion kilowatt-hours of electrical energy a year which produces annual gross revenues of about $13,000,000.

Under present contractural arrangements, Hetch Hetchy electrical energy is sold to the following customers:

1. Various municipal departments of the City and County of San Francisco,

2. Modesto and Turlock Irrigation Districts, and

3. Certain large industrial firms in the San Francisco Bay Area whose electric service contracts have been assigned to the City by the Pacific Gas and Electric Company.

When, at any time, demand of the above customers exceeds the capacity of the Hetch Hetchy system, standby service and supplemental power is furnished by Pacific Gas and Electric Company under contractural provisions.

Future Water Supply Demands

Gross future demand for water depends ultimately on three basic factors: future population within the present service area boundaries, future per capita consumption, and possible changes in service area boundaries. In 1969, the San Francisco Water Department published a report entitled "An Analysis of Water Demand, Supply and System Improvements." This analysis concluded that population and water demand growth rate of the service area would be as follows:

Year	Population 1000's	Average Demand mgd
1970	1,716	267
1975	1,862	299
1980	1,999	342
1990	1,950	354
2000	2,030	396

In addition, the City Department of Public Works has projected average water demands for the City based on City Planning Department's population projections as follows:

Year	Population 1000's	Average Demand mgd
1970	714	98
1975	725	100
1980	735	103
1990	755	110
2000	764	115

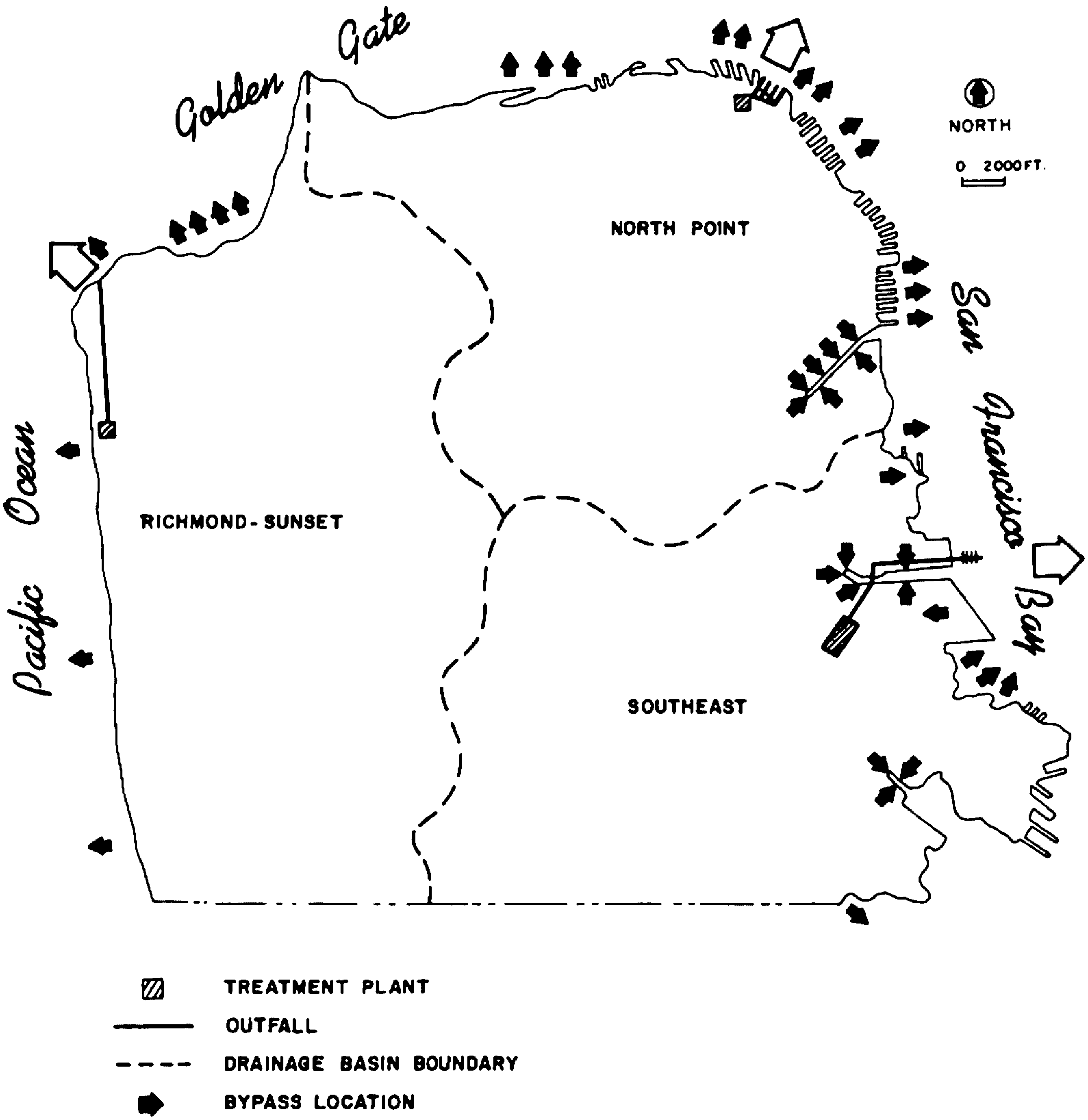
Based on these projections, the present supply of water provided by the Hetch Hetchy Water System and the San Francisco Peninsula and East Bay sources will be adequate to meet the anticipated San Francisco and suburban demands projected for the foreseeable future.

WASTEWATER MANAGEMENT

The construction of sewers in San Francisco dates from about 1850. From that time until 1899 when the first Master Plan for a citywide sewer system was prepared approximately 250 miles of sewers were constructed. Then the system was rapidly developed to include about 700 miles of sewers by 1935. At that time a new Master Plan was developed which divided the City into three major sewerage districts as shown on Figure II-1. Plans were developed for a large wastewater treatment plant plus the necessary diversion structures, intercepting sewers, and pumping stations for each district.

The three primary treatment plants were located around the perimeter of the City to accommodate natural drainage basins. The actual sites were selected with consideration to the then existing residential development and governmental establishments, predicted population trends, geology, tidal and wind induced currents, and the availability of deep water for disposal.

FIGURE II-1
SEWERAGE DISTRICT BOUNDARIES



The Richmond-Sunset Water Pollution Control Plant was completed in 1939 and the North Point and Southeast Water Pollution Control Plants were completed in 1951 after delays caused by World War II. However, it was 1966 before interceptors had been completed to deliver all of the dry weather wastewater flow to the treatment plants. Table II-1 presents general data on the physical and hydraulic characteristics of the three plants. In addition, a more detailed description of each plant is contained in the following paragraphs.

Richmond-Sunset Water Pollution Control Plant

Description of Facilities. The Richmond-Sunset Water Pollution Control Plant was completed in 1939 and subsequently enlarged in 1948 and 1966 to its existing design capacity of 26 mgd. The average dry weather flow through this facility is presently about 20 mgd from a tributary area of about 10,470 acres of which approximately 9,000 acres are sewered, the rest being park land.

TABLE II-1

DATA ON EXISTING TREATMENT PLANTS

	Richmond-Sunset	North Point	Southeast
Plant location	Golden Gate Park	Northeast Waterfront	Southeast Sector
Average dry weather flow, mgd	20	60	20
Design capacity, mgd	26	65	30
Population served, resident	220,000	350,000	166,000
Area served, acres	10,400	9,300	10,200
% Residential	56	39	43
% Industrial & Commercial	6	31	17
% Public & Government	38	30	40
Discharge location	Lands End	Piers 33,35	Offshore Pier 80
Receiving waters	Pacific Oc.	S. F. Bay	S. F. Bay

The Richmond-Sunset Plant provides conventional primary treatment plus chemical coagulation with ferric chloride. Individual processes include screening, grit removal, primary sedimentation with chemical coagulation and chlorination. Effluent is discharged to the Ocean via the 9-foot by 11-foot Mile Rock outfall which tunnels under Fort Miley and Lincoln Park and discharges to the beach southwest of Lands End about one foot below mean lower low water. Solids removed during treatment are processed by two-stage anaerobic digestion, elutriation (a process of washing and decanting), chemical conditioning, and vacuum filtration. Most of the sludge cake is utilized as ground fill and soil stabilization in Golden Gate Park.

Environmental Setting. The Richmond-Sunset Plant occupies four acres in the southwest corner of Golden Gate Park, between John F. Kennedy and South Drives, just north of the old Murphy windmill.

Together with the rest of the park before development, the site originally was a wasteland of rolling sand dunes. It now supports a variety of growth, the most prominant being Monterey cypress, with blue gum eucalyptus furnishing contrast. Hydrangea, Pittosporum, Dracaena, and Myoporum flourish near the facilities.

As shown on Figure II-2, the plant site is surrounded by an adjacent green. Public use of the area for picnicking and games is not inhibited by the presence of the nearby treatment facilities. However, on occasion, the plant may be identified by an odor-causing malfunction.

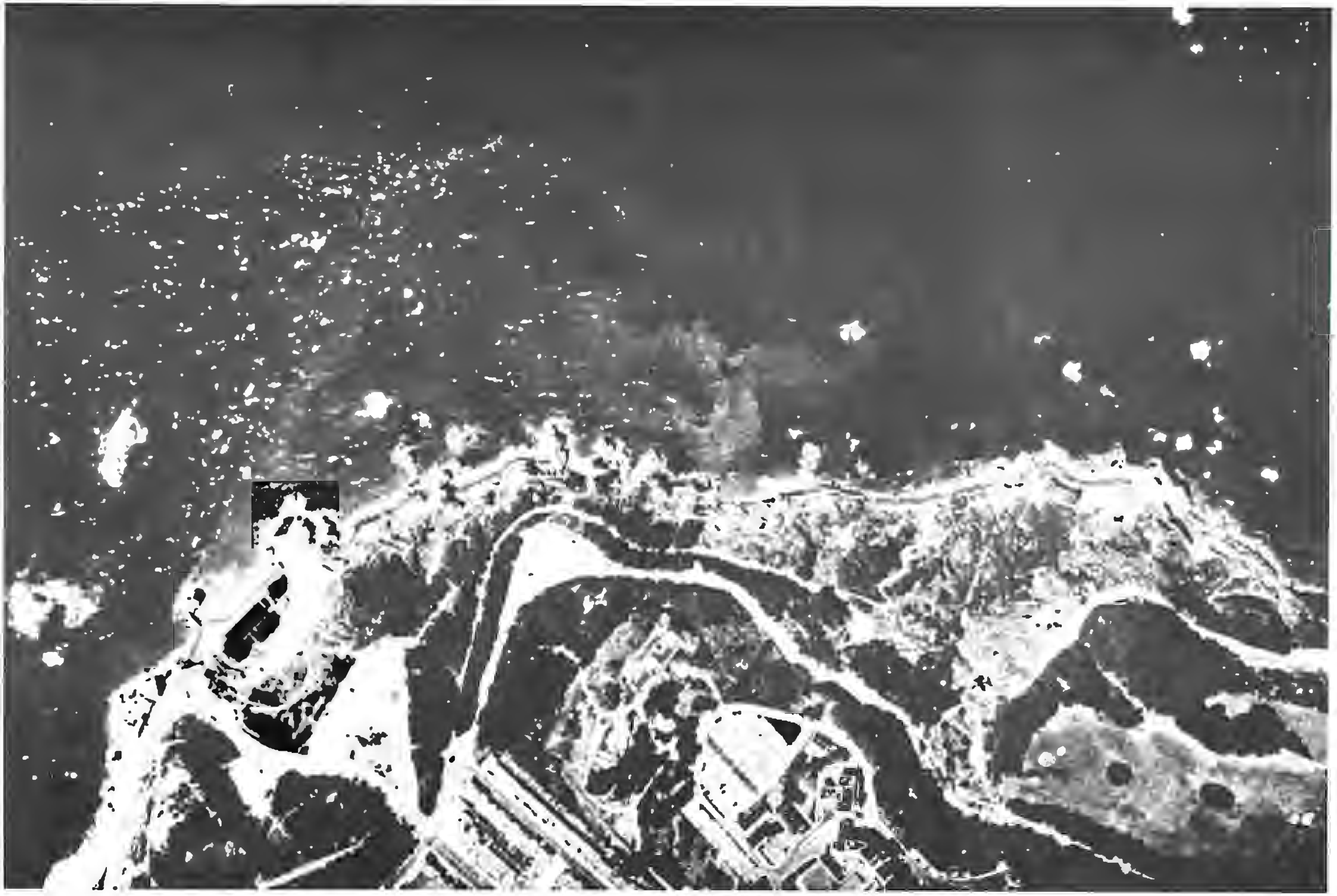
The largely residential area of the Sunset district begins about 0.1 mile south of the plant. No plant-generated noise can be detected here. West of the site is the Great Highway, and farther north along this road is the southern boundary of the Outer Richmond community area.

Effluent is discharged into the Pacific Ocean through an outlet a short distance northeast of Point Lobos, approximately 7,000 feet north of the plant. The outlet is a 9 foot x 11 foot culvert located in shallow water at the foot of steep headlands which rise over 200 feet. The area is a state beach and is being considered as an Area of Special Biological Significance (Seal Rocks) by the State Water Resources Control Board. This designation, in effect, prohibits all waste discharges in this area. Particulate matter is often observed on the beaches and discoloration of the receiving water is evident at all times as shown on Figure II-3.

FIGURE II-2

RICHMOND - SUNSET WATER POLLUTION CONTROL PLANT

FIGURE II-3
RICHMOND-SUNSET OUTFALL EFFLUENT FIELD



Being at the beach near the entrance to San Francisco Bay, the effluent is subject to dilution in large swells and in currents which may be wind induced as well as tidal. The tidal ebb and flow through the Golden Gate assures an abundant supply of diluting water. However, no actual measurements have been made of dilutions at the Richmond-Sunset discharge.

The stronger ebb current results in a net seaward displacement of the surface layer of water. Further dispersion and diffusion is provided by the violent swirls and eddies which characterize the Golden Gate area. Dissolved oxygen content of the Ocean surface is generally near saturation. Water clarity varies both diurnally and seasonally because of the Bay ebb, the lowest recorded clarity value being 1.5 feet as measured by the Secchi disc. The Ocean bottom near shore is primarily coarse sand.

Among the important fish species in the waters adjacent to the outfall are the king and silver salmon, rockfish, striped bass, and sole. The major commercial fishing resources in the area are salmon and the Dungeness crab.

During a diving survey conducted at Lands End directly off the Richmond-Sunset outfall in October 1970, ten plant species and 102 animal species were recovered. The largest numbers of organisms present were polychaetes, barnacles, amphipods or pelecypods. In the immediate vicinity of the outfall, the faunal species diversity was reduced, but returned to background levels within 100 feet of the shore. Laterally, the influence of the outfall was confined to approximately 50 feet on each side.

An intertidal survey conducted in the vicinity of the outfall showed that within the immediate area of the discharge there was a significant reduction in biota numbers and luxuriance. Recovery to normal abundance and diversity was rapid with distance from the outfall. The influence of the outfall was not observed greater than 400 feet from the point of discharge.

Waste Discharge Requirements. On January 19, 1967, the California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB) adopted Resolution No. 67-2 which prescribed requirements as to the nature of waste discharge by the City's Richmond-Sunset Sewage Treatment Plant. A copy of Resolution No. 67-2 is included in the appendix. Subsequently, the RWQCB recommended that the State Water Resources Control Board designate the receiving waters in this area (Seal Rocks) as an Area of Special Biological Significance. This designation, in effect, prohibits waste discharges in this area.

For this reason, the RWQCB adopted Order No. 73-54 on September 25, 1973, which requires the City to complete construction of all Phase I facilities by about September 30, 1978 (See Chapter V for a detailed description of Phase I facilities). A copy of Order No. 73-54 is also included in the appendix. This Order requires the City to construct Level I (chemical treatment using a low ferric chloride dosage) waste treatment facilities plus filtration facilities at the Richmond-Sunset Plant by June 30, 1977, and the southwest ocean outfall plus transportation facilities from the Richmond-Sunset Plant to the outfall by September 30, 1978.

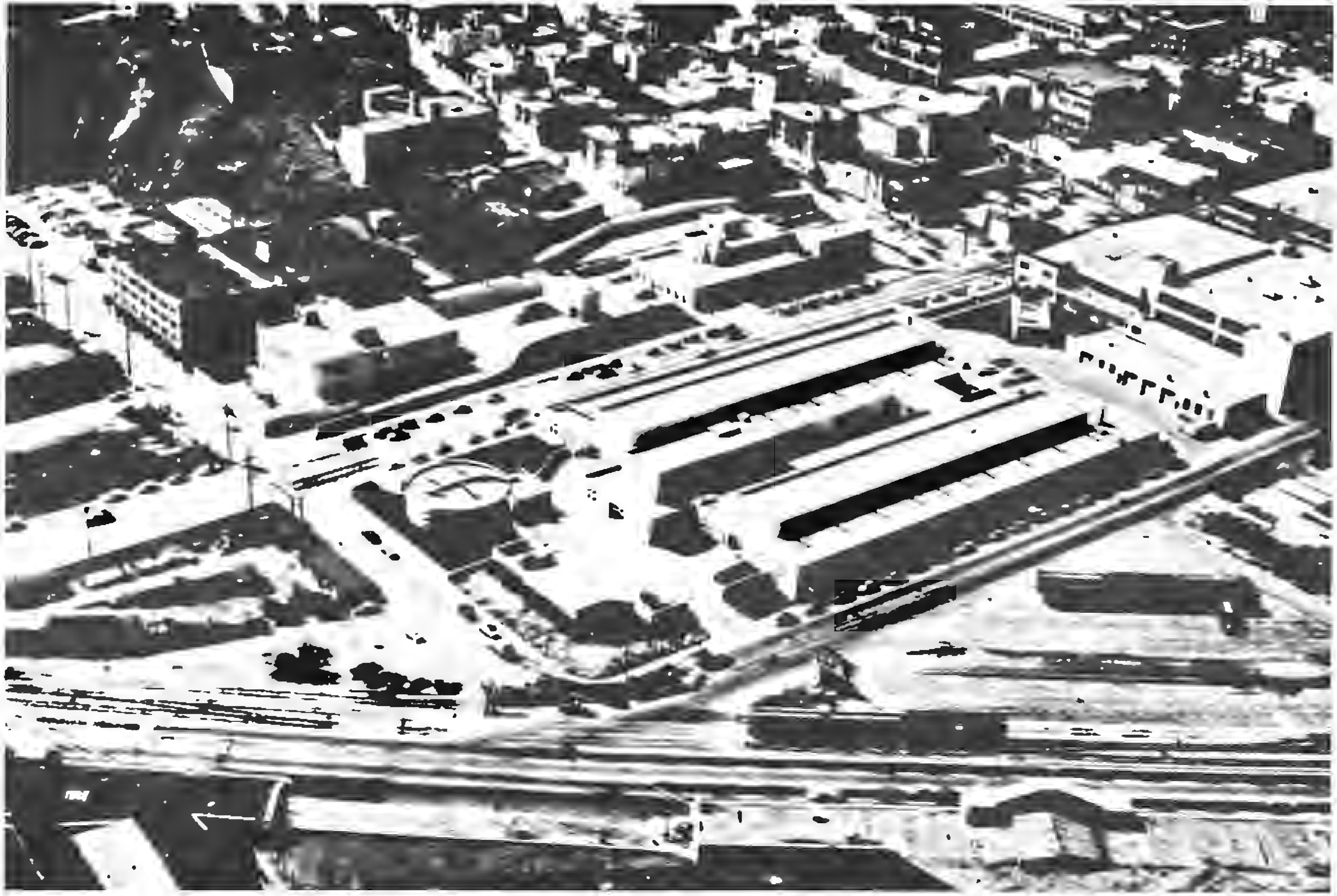
North Point Water Pollution Control Plant

Description of Facilities. The North Point Water Pollution Control Plant serves the main downtown section of San Francisco. The North Point facility provides conventional primary treatment plus chemical coagulation with ferric chloride for an average dry weather flow of approximately 65 mgd. Individual processes include prechlorination, screening, grit removal, preaeration, primary sedimentation with chemical coagulation, and dechlorination. The effluent is presently discharged through four 48-inch cast iron lines under Piers 33 and 35 which terminate without diffusers about 800 feet offshore and 10 feet below mean lower low water. Diffusers are now under construction (cost of about $690,000) which will achieve a dilution of about 10:1. Solids removed during threatment are conveyed through a force main to the Southeast Water Pollution Control Plant for processing.

Environmental Setting. The North Point Water Pollution Control Plant, as shown on Figure II-4, is situated on Bay Street between the foot of Telegraph Hill and the Embarcadero. The treatment units are arranged in two groups of buildings with the pretreatment building, influent pumping station, and administration building on the south side of Bay Street and the remaining buildings on the north side.

The major streetside planting is the London plane tree or sycamore. Site landscaping also includes Leptosperum, Abelia, Hebe, Pittosporum, and lawns.

FIGURE II-4
NORTH POINT WATER POLLUTION CONTROL PLANT



Noise generated by the plant operation is not detectable at the street, and there is rarely, if ever, any identifying odor.

The immediate vicinity of the plant is given to a variety of uses. New apartment buildings are adjacent to the west, and a new commercial structure to the north. On the south, some Telegraph Hill apartments look directly over the plant toward Alcatraz and Angel Islands. The Belt Line railroad operates on the nearby Embarcadero.

Within two or three blocks of the plant may be found warehouses, parking garages, gas stations, car wash and the truck and bus yards of the Municipal Railway, Golden Gate Disposal Company, Greyhound, Pacific Far East Lines, and Santa Fe.

The four 48-inch outfalls suspended under Port Piers 33 and 35 discharge effluent into the waters of San Francisco Bay about 800 feet offshore and 10 feet below mean lower low water. The boil from the discharge is clearly visible at the pier ends at all times and the effluent field extends from the discharge point for quite a distance as shown in Figure II-5. Discoloration of the receiving waters is evident at all times. Floating material is frequently seen.

The piers are active shipping facilities. Passenger liners, such as the SS Mariposa of Pacific Far East Lines and the SS Orsova of P & O Lines, are a common sight at Pier 35, with hundreds of passengers either boarding or disembarking, and large volumes of United States mail being handled.

The effluent discharge is subject to the tidal ebb and flow, a massive movement of water parallel to the San Francisco shoreline through the channel between North Point and Alcatraz. This is a portion of the tidal exchange through the Golden Gate, which, on the average during dry weather, brings approximately 24 billion cubic feet of new Ocean water into the Central Bay during each 25-hour tidal cycle. The average total flood tidal prism, including both new and return waters, is about 100 billion cubic feet. The seaward displacement of the surface water layer is stronger than the bayward movement, resulting in a net flushing action.

FIGURE II-5
NORTH POINT OUTFALL EFFLUENT FIELD

Dissolved oxygen values near Blossom Rock, about two-thirds mile offshore of the outfalls, and in the Central Bay, are consistently about 7 mg/l; the minimum value measured was 6 mg/l. In a recent field study, a high water clarity reading of 1.6 Jackson Turbidity Units was recorded near Blossom Rock. All reported Secchi disc readings for Central Bay range between 0.6 and 10 feet, with summer and fall values being generally greater than 3 feet. Surface drift studies indicate that floatable material released within the Central Bay moves rapidly seaward without significant effect on the shoreline of the Bay itself.

During field measurements in April 1970, minimum dilutions in the discharge boil ran about 3 or 4 to 1. Within about 50 feet of the boil concentrations were in the range of 20 to 1 and within about 600 feet were about 30 to 1. During slack water, dilutions less than 100 to 1 encompassed a field approximately circular and about 3,000 feet in diameter.

An attempt was made to assess the toxic effect of the North Point effluent by suspending fish in cages in the effluent field. Test results were inconclusive in determining the effect of the effluent field on fish survival. There was some evidence that Bay water along the San Francisco shoreline was more toxic than at a control site at Horseshoe Bay. The source of this apparent toxicity was not identified.

During April 1970, diving studies were conducted at the ends of Piers 33 and 35. A total of 44 species were observed within the study area. At sample sites directly adjacent to the outfalls very few species or numbers of organisms were found. Five sediment collections were made in the sampling area within 200 feet of the outfalls. The collections made directly adjacent to the outfalls had a low species diversity and contained only testate protozoa, peanut worms, and a few clams. At more distant sample locations the diversity increased with addition of various polychaetes, harpacticoid copepods and nematodes. Sediment at all stations was composed largely of medium grained sand.

The Bay waters near the outfalls are well used by both young and adult salmon. Central San Francisco Bay is considered a nursery area for sport and commercial fish species. Adult Dungeness crab are found in Central Bay, although these waters are no longer the commercial fishery. Large numbers of juvenile crabs are frequently sampled at near-shore locations.

Waste Discharge Requirements. On March 26, 1970, the California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB) adopted Order No. 70-17, "Revised Waste Discharge Requirements for City and County of San Francisco, North Point Sewage Treatment Plant." Among the beneficial uses of San Francisco Bay that the RWQCB intends to protect are swimming; wading; pleasure boating; marinas; launching ramps; fishing and shellfishing; firefighting and industrial washdown supplies; industrial cooling water; fish, shellfish and wildlife propagation and sustenance; waterfowl and migratory bird habitat and resting; navigation channels; port facilities; and aesthetic enjoyment. In order to protect these uses the RWQCB requires that the discharge does not cause, in waters of the State, floating or deposited macroscopic particulate matter, alteration of color, oil, dissolved oxygen below 5 mg/l, dissolved sulfide concentrations greater than 0.1 mg/l, or any substance in concentrations that impair the beneficial uses or make aquatic life unfit for consumption. A copy of Order No. 70-17 is included in the appendix.

Subsequently on October 26, 1972, the RWQCB adopted Order No. 72-90 which required the City and County of San Francisco to cease and desist discharging wastes from its North Point plant contrary to the Board's requirements. Then on January 11, 1973, the RWQCB adopted Order No. 73-1 which amended Order No. 72-90 to include a time schedule for compliance. Order No. 73-1 ordered the City to demonstrate compliance with all requirements by September 1, 1977. Copies of Order No. 72-90 and Order No. 73-1 are included in the appendix.

Southeast Water Pollution Control Plant

Description of Facilities. The Southeast Water Pollution Control Plant serves the heavily industrialized southeast area of the City plus about 600 residential acres in San Mateo County. The facility may be more accurately described as two separate plants, constructed on each side of Jerrold Avenue at Quint Street, south of Islais Creek Channel (See Figure II-6). The first section of the plant provides low level chemical treatment and conventional primary treatment for the sewage flow from the Southeast tributary area, and has a treatment capacity of 30 mgd. The average dry weather flow through the first section is 20 mgd. The second section consists of the sludge digestion and processing facilities, which handle not only the sludge from the Southeast plant but also the sludge transferred from the North Point plant.

On the liquid side, individual treatment processes include prechlorination, screening, grit removal, preaeration, primary sedimentation with chemical coagulation, and post chlorination. Capability is available for use of lime, ferric chloride, and polymers. Effluent is discharged to San Francisco Bay about 800 feet offshore of Pier 80, the Army Street terminal.

Solids removed in the process, along with the solids transferred from the North Point plant, are treated by gravity thickening, anaerobic digestion, elutriation, chemical conditioning, and vacuum filtration. Sludge cake is disposed of at the Mountain View sanitary landfill which is scheduled to be developed into a regional park upon termination of the landfill operation.

Environmental Setting. The Southeast Water Pollution Control Plant is within an industrial district in the Southeast section of San Francisco. Additional city-owned acreage at the primary plant is presently being leased to a trucking firm and a general contractor. Somewhat southerly and easterly rise the hills of the residential districts known as Silver Terrace and Hunters Point. Towards the west are the Southern Pacific Railroad tracks, the Southern freeway, and the produce market. Industries in the vicinity of the plant include iron works, concrete manufacture, building material supplies, and automobile junkyards.

Both sides of the street are landscaped. The plantings include lawns, pyracantha, pines, palms, and boxwood hedges, Irish yews, metrosideros, and blackwood acacias.

Occasional odors at street level identify the primary treatment operation. Little or no noise generated by the plant can be detected at the street.

The Southeast booster pump station is a small building located near the Third Street drawbridge on the south side of Islais Creek Channel. The structure is consistent with the industrial environment. Pumping energy is sometimes needed to overcome friction losses in the submarine outfall which extends about 800 feet offshore of the Army Street terminal. The effluent generally surfaces discoloring the receiving water. In addition, floating material from the discharge is sometimes observed on the water.

FIGURE II-6
SOUTHEAST WATER POLLUTION CONTROL PLANT

As might be expected, tidal ebb and flow is the most important factor in the movement of water in the vicinity of the Southeast outfall. The concentration of dissolved oxygen in this part of the Bay runs well over 6 mg/l. Measurements taken throughout an April day at several locations within two-thirds mile of the outfall indicated a salinity of about 27 parts per thousand (sea water has a salinity of about 30 parts per thousand) and water temperatures around 55°F.

The existing outfall diffuser has 18 pairs of ports spaced at 16-foot intervals. The ports average 5.1 inches in diameter. A field test has indicated that the minimum dilution is in excess of 100 to 1, except during the slack water period, when a minimum dilution of 53 to 1 was measured. Under the maximum current condition during flood tide, the minimum measured dilution was 140 to 1; after about one mile of travel from the outfall the minimum dilution was 1000 to 1.

Along the eastern intertidal areas of the City, as typified by the Army Street terminal, pier construction has drastically limited the availability of marine habitats for wildlife. In these areas attached organisms on pilings and rocky breakwaters constitute the major biota.

Waste Discharge Requirements. On September 25, 1969, the California Regional Water Quality Control Board, San Francisco Bay Region adopted Resolution No. 69-44 prescribing requirements for the waste discharge by the City and County of San Francisco from its Southeast treatment plant. That resolution set forth the following beneficial uses that would be protected from this discharge: swimming, boating, fishing, shellfishing, industrial cooling water, fish and wildlife propagation, navigation channels, port facilities, and aesthetic appeal. It is also noted that beds suitable for shellfishing are located along the Bayshore south of Candlestick Point.

In order to protect these uses, the RWQCB requires that the discharge shall not cause, in respect to the receiving waters, atmospheric odors, floating or deposited macroscopic particulate matter, oil, grease, aquatic growths, dissolved oxygen below 5 mg/l, dissolved sulfide concentrations greater than 0.1 mg/l, or substances in concentrations that impair any of the beneficial uses or make aquatic life unfit for consumption. A copy of Resolution No. 69-44 is included in the appendix.

Then on October 26, 1972, the RWQCB adopted Order No. 72-91 which ordered the City and County of San Francisco to cease and desist from continued violation of waste discharge requirements. Subsequently, on January 11, 1973, the RWQCB adopted Order No. 73-2 amending Order No. 72-91 by adding a time schedule for compliance. The amended order requires the City and County of San Francisco to demonstrate compliance with all requirements by September 1, 1977. Copies of these two orders are included in the appendix.

Sludge Disposal. Sludge derived from the present treatment plant operations is ultimately disposed of either by use as a soil conditioner in the City's parks or in the sanitary landfill operation in Mountain View (Santa Clara County). Anaerobically digested sludge will continue to be used as a soil conditioner as the City's need demands. All excess sludge plus the residues from the recalcination and carbon regeneration operations as well as the screenings and grit will continue to be disposed of in a sanitary landfill with the City's other solid wastes.

The present Mountain View landfill site is estimated to have a remaining life of eight to nine years. However, the City's existing contract to use this site expires in about three years. Prior to the termination of this site, another suitable use will be developed (e.g. regional park is presently planned). No information is presently available regarding possible althernative disposal sites.

Presently, about 50,000 tons of excess sludge are disposed of annually at the Mountain View site along with a total of 700,000 tons of solid wastes. Although the volume of sludge from the treatment plants may increase by 50 percent in the future due to additional treatment processes, the additional constituents to be removed are not anticipated to create new problems relative to toxicant concentrations in the sludge. The City, however, will do the necessary testing to determine the extent to which precautionary measures must be taken; any necessary measures will be taken.

Industrial Waste Ordinance. San Francisco City Ordinance No. 15-71, relating to the regulation of the quality and quantity of discharges of industrial waste substances, went into effect in July 1971.

Enforcement of the ordinance will achieve the following:

1. Prohibition of the discharge of certain materials into the sewer system, i.e., mineral oils, grease or other products of petroleum origin. (The disposal of these materials will comply with the requirements of appropriate regulatory agencies.)

2. Setting of numerical limits on certain characteristics of discharges, i.e., toxicity (96-hour TLm bioassay) of the waste as discharged has a limiting value of 75 percent. (In bioassay work, the term 96-hour TLm is used to designate the concentration of waste materials required to kill 50 percent of the test organisms in 96 hours.) Toxicity and heavy metal control will have a high priority.

3. Flexibility in meeting new state or federal requirements by authority to limit when necessary the concentration of any substance in any industrial waste discharge to the concentration of said substance in Richmond-Sunset (primarily domestic) raw sewage.

4. Establishment of fee schedules in order that industrial waste dischargers shall support the administration of the industrial waste control program and shall pay a fair share of the cost of treatment based on the concentration of certain substances in excess of the concentration of such substances in normal raw sewage.

The development of a program for implementation of the ordinance required a tremendous effort to identify actual or potential dischargers and to establish administrative procedures. As of December 31, 1973, almost 6,000 dischargers were identified, and a departmental master file system suitable for computer application has been developed. Inspection and discharge fees have been billed by the Water Department along with water use charges.

A review board of five members has been established to hear and decide appeals arising as a consequence of the ordinance. A waste discharge report form has been developed for dischargers to furnish information on process, volume, flow, substances, concentrations, etc. At the present time, emphasis is being placed on inspection of dischargers and the collection of fees. Future emphasis will be placed on source control.

The ordinance was initially applied to restaurants. This action was challenged by the restaurant group and litigation is currently underway. Because of this and other complex problems encountered in implementing the ordinance, another two years may be required before the operation is fully implemented.

SUMMARY OF CURRENT STATE AND FEDERAL REGULATIONS

The Master Plan is primarily influenced by the plans and policies of the Federal Environmental Protection Agency, the State Water Resources Control Board, and the California Regional Water Quality Control Board, San Francisco Bay Region. A summary of the more important regulations of these agencies is presented in the following paragraphs.

Receiving Water and Effluent Quality Requirements

On October 18, 1972, Congress passed the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) which have been acclaimed as "one of the most significant, most comprehensive, most thoroughly debated pieces of environmental legislation ever to be considered by the Congress." As stated in the 1972 Act, it is the national goal that the discharge of pollutants into navigable waters be eliminated by 1985, and that, as an interim goal whenever attainable there be achieved by July 1, 1983, water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water.

The 1983 goal is an objective which carries with it defined, specific enforcement mechanisms while the 1985 goal is an ideal toward which Congress intended the country to strive. To reach these goals, the Act requires that a discharge of waste or waste-containing water be of a specified, improved quality before its release from a point source to the receiving water, or in some cases that the discharge be prohibited. To assure that the improved quality is attained, the Act provides a new authority to the Federal and State governments to continue and fully develop a national permit system.

The new permit system is called the National Pollutant Discharge Elimination System (NPDES). It is a national system because it is effective nationwide and involves Federal and State participation, with the objective being State-administered permit programs. California has implemented a NPDES program; however, the Federal Environmental Protection Agency (EPA) will continue to review and monitor the program to insure that the purposes of the Act are carried out.

The Act also requires that by July 1, 1977, all publicly owned waste treatment facilities must utilize "secondary treatment" and, if an industrial discharger sends its waste through a publicly owned treatment works, certain "pretreatment standards" must be met. In addition, not later than July 1, 1983, effluent requirements must be met which represent the application of the "best practicable waste treatment technology." Any other applicable pretreatment standards must also be met by that date. The Act also directs EPA to promulgate special standards for toxic materials which must be complied with within one year of promulgation.

The Environmental Protection Agency has defined the minimum level of effluent quality attainable by "secondary treatment" to be as follows:

1. Biochemical Oxygen Demand (5-day)

    a. The arithmetic mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 30 mg/l.

    b. The arithmetic mean of the values for effluent samples collected in a period of 7 consecutive days shall not exceed 45 mg/l.

    c. The arithmetic mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 15 percent of the arithmetic mean of the values for influent samples collected at approximately the same times during the same period (85 percent removal).

2. Suspended Solids

    a. The arithmetric mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 30 mg/l.

    b. The arithmetric mean of the values for effluent samples collected in a period of 7 consecutive days shall not exceed 45 mg/l.

    c. The arithmetric mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 15 percent of the arithmetric mean of the values for influent samples collected at approximately the same times during the same period (85 percent removal).

3. Fecal Coliform Bacteria

   a. The geometric mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 200 per 100 ml.

   b. The geometric mean of the values for effluent samples collected in a period of 7 consecutive days shall not exceed 400 per 100 ml.

4. pH

   The effluent values for pH shall remain within the limits of 6.0 to 9.0

These limits must be met at all times; however, there is a special provision for communities with combined sewers which is as follows:

> Secondary treatment may not be capable of meeting the percentage removal requirements of above during wet weather in treatment works which receive flows from combined sewers. For such treatment works, the decision must be made on a case-by-case basis as to whether any attainable percentage removal level can be defined, and if so, what that level should be.

Compliance with these regulations can only be achieved by major capital expenditures for new secondary treatment facilities.

The Environmental Protection Agency has also proposed the following definition for the allowable concentration of pollutants in the effluent consistent with the application of "best practicable waste treatment technology" for publicly owned treatment works discharging into navigable waters:

	Units of Measurement	Monthly	Weekly
Ultimate Combined Oxygen Demand (UCOD)*	mg/l	50	75
Suspended Solids	mg/l	30	45
Chemical Oxygen Demand	mg/l	50	75
Fecal Coliform	number/100 ml	200	400
pH	units	within limits of 6.0 to 9.0	

*UCOD= 1.5 (BOD_5) + 4.6 (NH_3-N) - 1.0 (D.O.)

Two exceptions are made to the definition. The first is if the influent wastewater has a weekly or monthly average temperature below 20°C, then the criterion for UCOD does not apply. However, in such cases, the following is the allowable ultimate Biochemical Oxygen Demand (UBOD) in the effluent.

	Units of Measurement	Monthly	Weekly
Ultimate Biochemical Oxygen Demand (UBOD)*	mg/l	30	45

*UBOD= 1.5 (BOD_5) - 1.0 (D.O.)

The second exception is made for discharges into the Territorial Seas and the Contiguous Zone or the adjacent saline tidal waters where it can be demonstrated that the hydrographic and ocean-orgraphic conditions provide sufficient depth and have hydrodynamic properties such that any discharge will be rapidly mixed and will be dispersed in a predominately seaward direction. In such cases, "secondary treatment" defines the effluent quality consistent with the application of "best practicable waste treatment technology" for publicly owned treatment works.

In order to comply with the proposed definition of best practicable waste treatment technology, it will be necessary for the City to provide treatment capability beyond that of secondary treatment (i.e., ammonia removal) for a discharge to the Bay. However, secondary treatment would be adequate for an Ocean discharge. The added treatment cost for the Bay discharge would be about $1.2 million per year.

In addition to the above Federal requirements, the California Regional Water Quality Control Board, San Francisco Bay Region has also adopted specific requirements for the discharges from the City's three wastewater treatment plants and from the wastewater system during wet weather periods. The controlling provisions of these requirements are summarized in the previous section.

Clean Water Grant Program Regulations

The primary purpose of the Clean Water Grant Program is to implement the Clean Water Bond Law of 1970 which was enacted in November 1970 by the passage of a $250 million bond issue. The objective of the bond issue was to make funds available to assist local governments in correcting and avoiding pollution of California waters. This program, administered in cooperation with Federal administration of the Federal Water Pollution Control Act, assists in the financing of treatment works necessary to prevent water pollution and thereby to protect the health, safety, and welfare of the inhabitants of the State. However, it is intended that municipalities should continue to have primary responsibility for the construction, operation and maintenance of the treatment works necessary to protect or enhance waters of the State.

Presently, this joint program does provide grants for 87½ percent of the eligible project costs of treatment works which include collection systems, interceptor sewers, pump stations, and outfalls in addition to treatment systems. The definition of treatment works also includes combined stormwater and sanitary sewer systems, and separate stormwater systems. Since the costs of facilities necessary to control these latter sources of pollutants far exceed the availability of funds, it is not likely that the State will give early high priority for full control of combined wastes.

However, it is possible that substantial grant participation can be attained for: 1) consolidated wet and dry weather facilities since the cost allocatable to dry weather control is eligible and of high priority; or 2) a high benefit/cost early stage of the Master Plan.

In order to be considered for a Clean Water Grant pursuant to the Clean Water Bond Law of 1970, the applicant must submit a facilities plan ("Project Report") to the State Water Resources Control Board. The facilities plan must provide sufficient information to permit evaluation of the proposed project pursuant to all applicable State and Federal regulations. In addition, Section 2118 of the Clean Water Program Grant Regulations requires the submittal of an Environmental Impact Report as one of the supporting documents to the facilities plan.

The Environmental Impact Report must be prepared in accordance with the provisions of the California Environmental Quality Act of 1970 and guidelines established by the State Water Resources Control Board. San Francisco's Administrative Code, Chapter 31, also requires Environmental Impact Reports for all projects which may have a significant impact on the environment.

In accordance with the provisions of the Clean Water Grant Program Regulations, the comprehensive Environmental Impact Report must be prepared by the grant applicant.

In addition, the National Environmental Policy Act of 1969 requires that all agencies of the Federal Government prepare detailed environmental impact statements on major Federal actions significantly affecting the quality of the human environment. EPA considers the Environmental Impact Report prepared by the grant applicant pursuant to State law to be an "assessment." EPA reviews the "assessment" to determine whether it is a thorough and comprehensive analysis of each alternative project under consideration as well as of the recommended plan.

Grant Eligibility and Availability

The vast majority of facilities contained within the Master Plan are eligible for State and Federal grants; however, the availability of funds is dependent upon future appropriations. Grant eligibility for wet weather discharges will depend upon cost-effective analysis showing the desired level of control.

State priority lists indicate that funds will not be provided for wet weather control for at least five years. Beyond that time, funds may be allocated depending on national priorities.

Despite State regulations promoting wastewater reclamation and new reclamation emphasis in recent Federal legislation, treatment level and compliance with receiving water standards will continue to be higher priority for State and Federal grants than reclamation. Limited grant funds will result in emphasis on secondary treatment for all dry weather discharges. The availability of funds for a separate dry weather treatment system is reasonably assured if a project is approved for grant participation within the next three years.

Consolidation of the wet and dry weather programs into one all-weather wastewater management system, staged to provide the most cost-effective solution, could maximize State and Federal grant allocations and minimize the City's need for funding separate wet weather facilities.

Compliance of the Master Plan with State and Federal Regulations

The Master Plan is a concept which involves the location and sizing of storage basins, plus the construction of dry weather and wet weather treatment facilities, transportation systems, and disposal facilities in a series of stages to achieve any desired level of control. Therefore, the Master Plan is flexible and will be able to comply with changing regulations. The following paragraphs, however, contain a discussion of the ability of the Master Plan to comply with existing regulations.

Wet Weather Overflows. The Master Plan provides for the ultimate elimination of all dry weather discharges to the Bay and 90 percent elimination of all untreated wet weather discharges. These wet weather discharges will not comply with present receiving water standards of the Regional Board.

Treatment Degree. Secondary treatment must be achieved by July 1, 1977, to comply with the Federal Water Pollution Control Act Amendments of 1972. It will not be possible to comply with this provision until all Phase I facilities are constructed.

Discharge Location. The Master Plan provides for ocean discharge rather than Bay discharge. All studies to date and the implication of the State's Ocean Plan as compared with proposed Bay water quality objectives indicate that for a given degree of treatment and assuming proper outfall construction, ocean discharge is far less environmentally harmful than Bay discharge.

Reclamation. The environmental advantages of ocean discharge must be weighed against the possible advantages of a Bay discharge when considering future wastewater reclamation potential.

The Master Plan is compatible with the State's policy that requires consideration of reclamation potential in that future reclamation is not precluded by ocean disposal and no market presently exists for reclamation particularly during winter months. The probability of developing a major reuse scheme for San Francisco that would eliminate the advantages of ocean disposal is small.

Cost-Effective Program. To achieve dry weather and wet weather goals in the most expeditious and cost-effective manner, it is important for the regulatory agencies to consider the benefits of implementing an all-weather control system rather than concentrating exclusively on a high degree of control of separate dry weather flows.

SYSTEM STUDIES

In seeking the most efficient and effective system for controlling San Francisco's wastewaters, a large amount of data has been gathered and analyzed and exotic control methods considered. Following development of the general control plan, information necessary to optimize design and assure proper operation of the system is being gathered. Further studies are planned to gather information about wastewater treatment and effluent quality, design and operation of upstream retention basins, and the feasibility of automatic control with the proposed central management software-hardware system.

A brief description of each of the continuing studies follows:

Pilot Treatment Plant Study

In 1973, the City initiated a pilot treatment plant study to determine the effectiveness of alternative treatment processes in meeting the requirements of the various regulatory agencies for a discharge to either the Bay or Ocean. However, the Pilot Treatment Plant Study encompassed more than a pilot plant study of treatment processes. It also included monitoring of wastewater quality to characterize the influent wastewaters at the three treatment plants in terms of over 100 constituents.

Based on this investigation, a physical/chemical plant and an activated sludge plant using both air and high purity oxygen were piloted.

The following information was developed by the pilot plant portion of the study: (1) compliance of effluent with the State Water Resources Control Board's Ocean Plan and anticipated similar plans for bays and estuaries as well as the Environmental Protection Agency's secondary treatment requirement, (2) process reliability information for selected constituents, (3) design loading rates, and (4) estimated capital, operation, and maintenance costs.

Following analysis of the above data a preliminary plant layout and equipment list are to be prepared by mid-1974 for a selected process and an alternate.

Pilot Retention Basin Project

In March 1972 the City submitted an application to the Environmental Protection Agency for a $3.14 million demonstration grant project to demonstrate the feasibility and effectiveness of historical-based event prediction, solid/liquid pre-separation, and upstream retention facilities to effect the control and management of combined wastewater overflows. However, in February 1973, EPA rejected the grant application due to lack of funds.

Subsequently, the City requested that the State Water Resources Control Board place an upstream retention basin on its 1974-75 Project List for construction projects. From the construction and operation of this basin it should be possible to obtain:

- A better idea of costs.
- First-hand experience in maintenance and cleaning required.
- Data on effectiveness as a treatment basin, or diversion of solids and floatables around the storage compartment depending on the design concept adopted.
- Data for design of an effective outlet control system.
- Information on odors produced in the basin during and following rains and during the summer dry season.
- Data for design of an adequate ventilation system.

By proper selection of the installation site, direct pollution abatement benefits and flooding relief will be realized. Results should also be transferable to the design and operation of shoreline basins.

Control System and Central Management Plan

Colorado State University is assisting in a control and modeling project to evaluate the potential and effectiveness of automatic control of the storage and transport facilities of the Master Plan.

Storm Behavior. The American Society of Civil Engineers Urban Water Resources Research Program in its Technical Memorandum No. 15 defines the need for automated surveillance and control as follows:

> "Because combined sewer overflows occur over a very small part of a year, any facilities provided for treatment of potential overflows must be put on the line almost instantaneously. This means that not only would such plants be idle more than around nine-tenths of the year, but that they would have to be activated immediately with the occurrence of any stormwater flow that would exceed interceptor sewer capacity. Effectiveness of overflow pollution abatement using treatment facilities designed specifically for that purpose therefore will require some form of automatic operational control. Remote supervisory control would quite likely not be adequately responsive. The control logic required has yet to be developed, and it is possible that different metropolitan sewer systems will require their own fairly unique logic development."

In the case of San Francisco, the above description is more appropriate to the operation of the proposed retention basins and tunnel storage elements which will be capable of variable feed and withdrawal rates. The objective of the control system will be to optimize the containment and treatment of storm runoff with actions dependent upon the treatment and storage availability and projected storm and system behavior. When overflows to receiving waters are necessary, system controls will permit the releases to occur in the least damaging manner.

Although the currently envisioned automatic control system is a highly sophisticated central computer operated system, such complex facilities may not be necessary. An important aspect of any control system study should be to evaluate and compare less complex automatic controls ranging from computer aided supervisory control to completely local control at individual units responding directly to local hydraulic flow and retention basin head.

For the proposed control system, the most difficult task is the real time prediction of storm behavior. Has the peak intensity passed? Will the storm cell move progressively from area A to B to C or by some other route? Will it increase or decrease in intensity with movement? Is a second cell developing? Has the storm stalled severely stressing a limited area? These are but a few of the questions to be studied in executing a control logic (i.e., if we know what the storm is going to do next, then we can implement the most effective counter-measures). Likewise, if an initial prediction proves to be false, can it be detected and corrected before the problem is compounded? Obviously, the success of such a program will be largely dependent on a nearly instantaneous monitoring and data scan capability and a carefully compiled, catalogued, and interpreted body of extensive historical data.

Even with the best of systems, it must be anticipated that the storm behavior prediction will only be partially successful (one need only to recall the difficulties of hurricane tracking and prediction); however, as the library of historical data grows performance should improve. In order to collect, file, and access the data, computer usage is essential.

It is proposed to install a pilot retention basin for study of design and operation throughout a minimum of one entire rainy season following complete tune-up and testing.

<u>The San Francisco System</u>. On September 1, 1970, the City of San Francisco awarded a $420,000 contract to Control System Industries, Santa Clara, California, for a hydrologic and hydraulic data acquisition and recording system. This contract resulted in a system involving 30 remote recording rain gages and 113 (since increased to 120) sewage flow level monitors all reporting to a Honeywell H-316 mini-computer (16,384 word core memory) with teletype printout and magnetic tape recording (2 tape drives) capabilities. The remote signals are transmitted over leased telephone lines to the computer located in the Department of Public Works, Bureau of Engineering offices, at 15-second intervals. All data is recorded in chronological or time-ordered sequence for future use on magnetic tape and selected data is printed out for system performance evaluation and engineering analyses. The system first became operational

in March 1971. The data are transferred selectively to a larger computer system for sorting and analyses (i.e., the identification of the maximum 5 minute, 10 minute, 15 minute, etc., rainfall accumulations by gage) and for the production of SYMAP (a computer plotting program) displays. The SYMAPs graphically show simultaneous storm intensities, accumulations in discrete intervals, and the movement of storm cells across the City. They may be printed on the basis of any repetitive time period.

The flow depth monitoring within the sewer system is to be used to develop time varying runoff coefficients, times of concentration, and fluid flow behavior for each identifiable storm pattern, drainage basin, and antecedent condition.

From the above, repeated over a great number of storms and continuously updated, it is intended that a series of historical response functions be prepared. Finally, based on the historical response records, a series of predictive functions will be developed as a control decision base.

Control Devices. Control will be exerted on the San Francisco system by regulating the withdrawal rates from the basins. The preliminary sizing of the retention basins indicates that they will have a nominal storage capacity of 0.10 inches of runoff which corresponds to 0.16 inches of rainfall. There are on the average (based on Federal Office Building gage) 381 hours of rainfall per year, 27 hours of which exceed 0.16 inches of rainfall (i.e., would fill the basins in less than 1 hour if uncontrolled and no withdrawal). The preliminary withdrawal rates from each basin will be capable of being adjusted to the runoff equivalent of between 0.0 and 0.30 inches per hour of rainfall. The 0.30 inches per hour rainfall rate for an hour's duration is exceeded on the average in only 5 hours per year.

The above figures are presented to set the facility sizes and capacities in real world perspective. It is recognized that over shorter time frames rainfall intensities could be considerably greater and that the one-hour time interval is merely a convenient but arbitrary time interval. Also, the use of the Federal Building gage as representative of average citywide rainfall, while the best available data at the time if this report, is questionable in light of the new data being collected. However, the figures do indicate the high importance and potential of control.

The actual control devices would be motor operated gates upstream of the basins to control the rate of inflow and bypass and motor operated gates or pumps controlling the basin dewatering rates. The sum of the dewatering rates from all basins at any instant, corrected for transit times and in transit storage, would equal the storm flow treatment rate. Limit switches and level recorders would transmit via leased telephone lines instantaneous status data to the central management console to identify basin performance.

Control Logic. The control logic will be developed over three phases: development, prediction, and real time control. Using mass balance techniques, and taking variability of the rainfall into account, rainfall and runoff data will be sorted and classified until a significant number of similar experiences can be grouped for consistency and uniformity of response. If a degree of consistency can be attained thus permitting storm runoff behavior prediction, then a problem identification matrix will be developed. This matrix will initiate real time corrective procedures in response to the identified storm pattern.

The remote monitoring of the system will permit continuous comparison of real time status versus predicted status and corrected system updates where necessary. Experience alone will set the limits at which actions are initiated, otherwise a condition of over-control could easily develop. The goal throughout is the maximum containment and treatment of runoff before overflows are allowed, and when overflows cannot be avoided to permit selection of the overflow location(s).

Implementation Plan

A 5-year program has been targeted for the development and testing of the control system concepts and hardware: running approximately from June 1972 to June 1977. The program is already underway with the rainfall runoff data collection and analysis now in its third year. In addition to the major effort being expended by the City with staff personnel, three contributory projects are of special significance: The Colorado State assisted studies, the Pilot Retention Basin project, and the American Society of Civil Engineers (ASCE) Urban Water Resources Research Program assistance.

Colorado State University Project. Under a research grant from the Office of Water Resources Research CSU is developing control logic for automation of combined sewer systems for overflow abatement. Within this study, CSU has pledged a minimum of 6 months effort for assistance in the San Francisco Plan. The City has agreed and is supplying CSU with relevant available data for one catchment area, Vicente Street. The physical components, control-actuation devices, storm inputs (approximately 12 storms total), and flow routing are being simulated on a computer. A matrix of control criteria is to be investigated and control logic for the most feasible developed. Responses to system malfunctions and erroneous signals will be considered.

Pilot Retention Basin Project. The objectives and scope of this project were discussed in the previous section. Of particular benefit to the Central Management Plan will be the expansion and real time testing of the data base and control logic. Delays in undertaking the project will significantly set back the implementation plan schedule.

ASCE Urban Water Resources Research Program Assistance. ASCE, under its contract with the Office of Water Resources Research to "facilitate research on rainfall runoff quality of sewered urban catchments," has pledged a minimum of 2 man-months of effort to the project. This provides a broadly researched and highly professional input to the project and effects the liaison between the City and CSU project personnel.

Comparisons with Other Cities. No city has yet demonstrated a program of automated real-time control of wet weather flow management. The two most advanced systems reviewed are those at Seattle and Minneapolis-St. Paul. The Seattle system has been operated under remote supervisory control (system status displayed at a central control facility where decisions are made by an observer and controls implemented) since April 1972. The first attempts at hands-off computer control will be made this spring, 6 years after the project initiation. The Minneapolis-St. Paul system similarly has been operated under supervisory control since April 1969 with the intent of eventual fully automated control. A mathematical model of the interceptor system has been developed and is used for the supervisors' guidance, but the additional step of automated decision-making has not been fully implemented.

CHRONOLOGY OF MASTER PLAN DEVELOPMENT

In December 1967, the California Regional Water Quality Control Board, San Francisco Bay Region adopted a resolution requiring the City and County of San Francisco to submit a Sewerage Master

Plan. Initial approval of the concept of Stage I was made by the Board of Supervisors, on July 2, 1973. The following chronology details the significant actions by the City and regulatory agencies in the development of the San Francisco Master Plan for Wastewater Management.

January 19, 1967. Regional Water Quality Control Board adopted Resolution No. 67-2 prescribing requirements for wet and dry weather discharges from the Richmond-Sunset Plant and Zone.

December 21, 1967. Regional Water Quality Control Board adopted Resolution No. 67-64 calling for the San Francisco Board of Supervisors to adopt a sewerage Master Plan by June 1, 1971.

February 2, 1968. San Francisco Board of Supervisors adopted Resolution No. 68-68 approving RWQCB Resolution No. 67-64.

October 28, 1968. San Francisco Board of Supervisors Resolution No. 716-68 declared intents to comply with RWQCB requirements in accordance with the following schedule:

1. Dry weather requirements on or about July 1, 1975.

2. Wet weather requirements for those Bay and Ocean waters westerly of Pier 45, on or about July 1, 1981.

3. Appropriate wet weather requirements for those Bay waters easterly of Pier 45 which are mutually agreed to be water contact sports area at dates to be established.

October 30, 1968. RWQCB acknowledged San Francisco Resolution No. 716-68.

September 25, 1969. RWQCB adopted Resolutions No. 69-43 and No. 69-44 prescribing requirements for dry and wet weather discharges from the North Point and Southeast plants.

October 23, 1969. RWQCB adopted Orders No. 69-52 and No. 69-53, orders to cease and desist from violations of requirements contained in Resolutions No. 69-43 and 69-44.

January 29, 1970. RWQCB adopted Resolutions No. 70-2 and 70-3 prescribing discharge requirements for wet weather discharge structures in San Francisco's North Point and Southeast sewerage zones, respectively.

March 14, 1970. SWRCB adopted Order 70-1, a building permit ban for a majority of the Southeast area of San Francisco and on March 26, 1970 by Resolution No. 70-18 the building ban was expanded to downtown and the majority of the remainder of San Francisco.

May 19, 1970. RWQCB by Resolution No. 70-42 lifted the San Francisco building ban.

December 1970. Design of NPWPCP outfall initiated with Brown and Caldwell Consulting Engineers performing design.

June 17, 1971. RWQCB adopted Interim Water Quality Control Plan - San Francisco Bay Basin.

July 13, 1971. Federal government adopted requirement requiring 85 percent removal of 5-day BOD, with a possible waiver for Ocean discharges.

September 1971. San Francisco Master Plan for Waste Water Management distributed.

September 15, 1971. First hearing of the Master Plan before a joint committee meeting, Health and Finance, of the San Francisco Board of Supervisors. Action tabled for a review of the report.

November 30, 1971. Project Report for 1971-72, Dry Weather Wastewater Treatment and Ocean Discharge, submitted to SWRCB recommending level II treatment for all dry weather flows and Ocean discharge.

December 31, 1971 and January 3, 1972. EPA representatives met with City staff to solicit a grant application for demonstration of upstream retention basins.

January 26, 1972. City formally requested a waiver of the 85 percent BOD requirement for the NPWPCP discharge.

February 3, 1972. SWRCB modified 1971-72 Project List to allow the City to study alternative projects for the NPWPCP, Ocean or Bay discharge.

February 1972. Master Plan presented to members of San Francisco Capital Improvement Advisory Committee.

March 1, 1972. Master Plan presented to the members of San Francisco's Interdepartment Committee on Water Pollution Control.

March 10, 1972. Grant Application for upstream retention basins submitted to EPA.

March 18, 1972. The Board of Supervisors' joint committee, Health and Finance, held a second hearing during which the Master Plan was referred to City Planning and Recreation and Park Departments for their review.

March 19, 1972. Master Plan presented to the Recreation and Park Commission, who formed a review committee.

April 21, 1972. Waiver for NPWPCP outfall for 85 percent BOD removal denied by EPA.

April 28, 1972. Dry Weather program project application sent to SWRCB. First level treatment and Ocean disposal contemplated.

May 15, 1972. Environmental Protection Agency notified City that it was withholding grant funds until a City Plan for sewage treatment was approved by the RWQCB.

June 28, 1972. San Francisco presented a recommended Dry Weather Plan at a RWQCB hearing on the Interim Basin Plan.

June 29, 1972. EIS and Project Report sent to SWRCB. Recommended project included level II treatment for NP and SE combined, abandoning NP site, and Ocean discharge of NP-SE-RS waste.

July 6, 1972. State Water Resources Control Board adopted a Water Quality Control Plan for Ocean Waters.

July 11, 1972. SWRCB certified Phase I of dry weather program, including NP to SE transport and solids handling improvements at SE.

July 13, 1972. City Planning Commission adopted Resolution No. 6877 approving basic concepts of Master Plan for Wastewater Management.

August 22, 1972. J. B. Gilbert & Associates appointed to review Master Plan for Wastewater Management.

August 1972. Army Corps of Engineers released information bulletin on 'Triple S' study (San Francisco Bay and Sacramento-San Joaquin Delta Water Quality and Waste Disposal Investigation). Four of five schemes included single wet and dry weather treatment plant at Lake Merced site.

August 30, 1972. City revised EIS to reflect review of the Department of Fish and Game submitted to SWRCB.

October 5, 1972. Contract with State for construction grants signed by City.

October 18, 1972. Federal Water Pollution Control Act Amendments of 1972 passed over Presidential Veto.

October 26, 1972. RWQCB adopted Orders No. 72-90 and No. 72-91 requiring the City to cease and desist from discharging wastes contrary to requirements prescribed by Resolutions No. 69-43 and No. 69-44 and included a detailed time schedule for compliance.

October 30, 1972. Grant Contract with State modified to include wet weather program submission to SWRCB.

December 4, 1972. City submitted to the RWQCB the anticipated 5-year project needs for updating and extending the Municipal Project Lists 1973-78.

December 4, 1972. RWQCB tentatively designated areas of biological significance. Seal Rocks are included.

December 13, 1972. SWRCB amended grant contract with City to separate Phase I into two portions. Solids handling portion is approved. Transport portion is being held by EPA pending EPA completion of EIS.

December 14, 1972. Recreation & Park Commission adopts Resolution No. 9204 approving in principle the Master Plan for Wastewater Management.

December 19, 1972. AB 740 signed into law. Bill made Porter-Cologne Act consistent with 1972 Federal Amendments and established State grant percent contribution of 12½ percent.

December 19, 1972. RWQCB presented tentative objectives for San Francisco Bay Basin Plan.

December 26, 1972. Board of Supervisors adopted resolution establishing a citizens committee for public participation in wastewater project evaluation and continuing review of the Master Plan concepts.

January 4, 1973. SWRCB adopted 1972-73 priority list for grant funding due to lack of funds to finance all proposed State projects.

January 11, 1973. RWQCB adopted Orders No. 73-1 and 73-2 amending Cease and Desist Orders for the North Point and Southeast plants.

January 30, 1973. Board of Supervisors adopted a resolution agreeing to time schedules in RWQCB Resolutions No. 73-1 and 73-2 for both interim and future facilities.

February 1, 1973. EPA rejected upstream retention basin grant application due to lack of funds.

March 1973. J. B. Gilbert & Associates submitted its "Evaluation, San Francisco Wastewater Master Plan" recommending a staged program of implementation.

May 15, 1973. City published Supplement I to its Master Plan which included J. B. Gilbert & Associates' recommendations.

June 26, 1973. RWQCB adopted Order No. 73-35 which required the City to cease and desist violations of Resolution No. 67-2 in accordance with a detailed time schedule.

July 2, 1973. Board of Supervisors adopted the concept of Stage I of the Master Plan for Wastewater Management.

September 25, 1973. RWQCB adopted Order No. 73-54 amending Order No. 73-35 requiring completion of Phase I by September 1977.

November 2, 1973. City initiated its Draft Wastewater Master Plan Environmental Impact Report.

CHAPTER III

ENVIRONMENTAL GOALS

WATER QUALITY

As stated in the Federal Water Pollution Control Act Amendments of 1972, it is the national goal that the discharge of pollutants into navigable water be eliminated by 1985, and that, as an interim goal, whenever attainable there be achieved by July 1, 1983, water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water. The 1983 goal is an objective which carries with it specific enforcement mechanisms, while the 1985 goal is an ideal toward which Congress intended the Country to strive.

Near the end of 1972, the California Legislature passed Assembly Bill 740 which amended the Porter-Cologne Water Quality Control Act (the basic law governing water pollution control in California) to provide compliance with national legislation. Consequently, California's goals with respect to water quality are similar to the national goals. To reach these goals, it will be necessary that all waste discharges be of a specified, improved quality before their release from point sources to the receiving waters or, in some cases, that the discharges be prohibited.

The San Francisco Master Plan for Wastewater Management was developed with these goals as its primary objective which is expressed in the following priorities:

Priority A--Protection of Aquatic Life
(Aquatic life must be protected by reducing the discharge of toxic substances, biostimulants, and pathogens.)

1. Continuous waste discharges fully within the Bay should receive secondary treatment (combined North Point and Southeast discharge).

2. Continuous waste discharges to the Ocean should receive secondary treatment (Richmond-Sunset discharge).

3. Continuous waste discharges to the Bay should be eliminated (combined North Point and Southeast discharge).

Priority B--Recreation and Aesthetic Enhancement (Shoreline waters and beaches must be free of fecal material, grease, and pathogens and waste fields must not be unsightly.)

1. Intermittent bypassing of untreated wastes that affect North area beaches should be eliminated.

2. Intermittent bypassing of untreated wastes that affect the Ocean beaches should be eliminated.

3. Intermittent bypassing of untreated wastes that affect the East Shore area should be eliminated.

4. All waste discharges to the Bay should be eliminated to the extent feasible.

AESTHETICS

In developing a project as large as the Master Plan, it is extremely important to consider its aesthetic impacts. Therefore, the Master Plan facilities are planned to be developed in accordance with the following guidelines:

1. All facilities should be architecturally designed and landscaped to blend harmoniously with existing improvements and surrounding neighborhoods.

2. All structures should be of low profile where practical.

3. All construction areas should be restored to their original condition to the extent feasible.

4. All facilities should be designed to adequately control odor producing substances.

LAND USE

The Master Plan is based on some of the more important land use considerations including:

1. Land such as in Golden Gate Park and the north waterfront area should be released from wastewater treatment uses.

2. New and replacement facilities should be constructed as multipurpose use facilities where practical.

3. Open space land should not be considered for facility sites purely on the availability or price of the land, but on the values of its present and projected uses.

4. The facilities should be designed for flexibility to accommodate changes in land use.

GROWTH FACTORS

To assure that the program is capable of adapting to changes in growth patterns without incurring significant financial loss, the Master Plan facilities are planned to be developed within the following guidelines:

1. Be capable of being an element of, and compatible with, any Bay Area regional wastewater management plan.

2. Be capable of accepting wastewater flows from other dischargers, especially those in San Mateo County.

3. Be capable of accommodating changes in growth patterns within the City of San Francisco.

AIR QUALITY

Although prevailing winds give San Francisco unusually pure air, the Bay Area has one of the more serious air quality problems in the nation. Existing and anticipated air quality control programs of the Environmental Protection Agency and the San Francisco Bay Area Air Pollution Control District will affect San Francisco since the City contributes to regional problems. The Wastewater Master Plan will be designed in accordance with these programs.

IMPLEMENTATION

The Master Plan should be implemented as rapidly as possible in accordance with the following guidelines:

1. The Master Plan should provide secondary treatment for all dry weather flows prior to 1978 (regulatory restriction).

2. The Master Plan should provide early control of wet weather overflows in the north shore and Ocean beach areas.

3. The expenditure of funds necessary for implementation should not affect the City's capability to provide other necessary public works and recreational facilities.

PART II

WASTEWATER MANAGEMENT PROGRAM

PART II - WASTEWATER MANAGEMENT PROGRAM

CHAPTER IV - ALTERNATIVES

With its extreme variation in topography and high exposure to ocean storms, considerable variation exists in rainfall intensities across the City at any time during a storm. This concept is extremely important in developing the Master Plan as the optimum sizing of all facilities is dependent upon this variability in rainfall intensities. Recognizing this, the City initiated two programs to develop reliable rainfall-runoff relationships for the optimum design of a wet weather overflow control system. Toward these ends, the City, in 1969, initiated a rainfall monitoring network which now consists of 30 rain gauges throughout the City (approximately one gauge per 1½ square miles). Augmenting the rainfall gauges was a companion network of 120 flow measuring devices at critical points in the collection system.

The data collected at these 150 monitoring stations are telemetered to a small computer which is capable of producing raw data records, five-minute summary records, and one-hour summary records depicting the status of the system at any given time. This information describes the specific rainfall-runoff relationships of major drainage and sub-drainage areas and will be utilized to provide the basis for the final design of the selected Master Plan. Ultimately, the data collected by this system, together with various control devices, will be used to manage the wastewater system during rainfall occurrences.

This system provided the basic data upon which the Master Plan was developed. During the development of the "San Francisco Master Plan for Wastewater Management" many concepts of wastewater management were considered. Among those concepts considered were: no project, individual treatment plants at each of the 41 overflow structures, expanding the three existing treatment plants, one regional plant, reclamation, a combination of storage and treatment, and separating the sewer system. Not all of these concepts may be considered viable solutions (e.g., the concept of no project is certainly not a viable solution to the City's wastewater problems). Solutions of this nature were considered for comparison purposes only. Brief descriptions of these concepts are presented in the following sections.

NO PROJECT

During dry periods all wastewater in the combined sewer system is collected and treated at three separate treatment facilities. However, when it rains, untreated wastewater is discharged from the collection system at 41 overflow structures located along the periphery of the City.

The average removal efficiency of the three separate treatment facilities, which were explained in detail in Chapter II, is presented in Table IV-1.

TABLE IV-1

EXISTING TREATMENT EFFICIENCIES

Parameter	North Point		Richmond-Sunset		Southeast	
	Effluent mg/l	% Removal	Effluent mg/l	% Removal	Effluent mg/l	% Removal
Biochemical Oxygen Demand	102	47	138	32	82	56
Suspended Solids	46	74	72	51	50	78

In each case, the effluent quality and treatment efficiency is superior to that of conventional primary treatment; however, neither the effluent qualities nor the treatment efficiencies are adequate to meet the present State requirements or provisions of the 1972 Federal Water Pollution Control Act. Compliance with those regulations, which require at least 85% removal efficiencies for BOD and suspended solids, can be achieved only by major capital expenditures for new secondary treatment facilities. If the no project concept were implemented, there would be continued violations of waste discharge requirements and water quality objectives of the California Regional Water Quality Control Board, San Francisco Bay Region, the State Water Resources Control Board, and the Federal Environmental Protection Agency.

This is not acceptable to the City since the State and Regional Boards would initiate formal enforcement actions by issuing the City "building bans" and cease and desist orders.

Advantages to the no project concept are: no capital costs, no disruption to the community caused by construction of new facilities, and no need for additional land. However, the environmental disadvantages were considered to greatly outweigh the advantages.

INDIVIDUAL TREATMENT PLANTS

As previously discussed, during periods of rainfall exceeding 0.02 inches per hour in each watershed, untreated wastewater is discharged from the collection system at 1 or more of the 41 overflow structures located on the periphery of the City. Therefore, separate treatment facilities for wastewaters bypassed during storms at the 41 overflow structures, or at some consolidation of those sites, were considered.

The costs to achieve an acceptable level of control for the individual treatment plants concept is estimated at three billion dollars. The high cost is primarily due to the large number of separate treatment facilities located throughout the City. Reliability of operation would be inadequate due to the seasonal use, long periods of shutdown, and need to "come on line" almost immediately at very high flow rates because of the high runoff rates. High rate treatment systems for removal of floatables, solids, and pathogens have not yet been fully developed to provide an effluent of suitable quality for discharge around the periphery of San Francisco.

However, in October 1970, the City and County of San Francisco completed the construction of the 24-mgd dissolved air flotation plant at the Outer Marina Beach for treatment of wet weather overflows. The effectiveness of this plant has not been determined to date due to initial startup problems at the facility and unforeseen hydraulic conditions in the sewerage system and bypass structure tributary to the plant. Engineering Science, Inc., under contract to the City, is still in the process of evaluating the effectiveness of this facility.

Even if this high rate treatment system proves effective, the environmental protection for this concept probably would not be suitable by today's standards due to the continued Bay discharges.

EXPAND THREE EXISTING PLANTS

There are three distinct watersheds within the City and County of San Francisco--Richmond-Sunset, North Point, and Southeast. In addition, the City presently operates separate treatment facilities within each watershed. Therefore, a logical apparent concept would be to expand the existing three plants in capacity to enable the treatment of all wet weather flows. It would also be necessary to provide at least secondary treatment facilities and new deep water outfalls at all three plants.

This concept was rejected for further analysis because of the high capital cost (greater than $1 billion excluding collection system modifications). In addition, two major discharges to the Bay would be continued which would be less environmentally desirable than Ocean discharge. Furthermore, local sites, particularly at Richmond-Sunset and North Point, are not conducive to major expansion as required by this concept due to land availability.

ONE PLANT WITHOUT WET WEATHER STORAGE

The concept of one treatment facility without wet weather storage was also considered. The necessary hydraulic capacity of the plant would be about 16 billion gallons per day which is approximately 50 times greater than the combined capacity of the three existing plants. Evaluation of this concept indicates that to provide this much treatment capacity would be too costly ($2.0 billion for plant only) and would be impractical from an operational point of view since flows would increase up to 50 times during storm periods.

STORAGE/TREATMENT

Another alternative would be to provide sufficient storage to control wet weather overflows up to some selected rainfall design occurrence. The City investigated this concept; however, it was found to be too costly when using only the existing treatment capacity.

Therefore, the City investigated the concept of providing a combination of storage and increased treatment capacity to limit uncontrolled wet weather overflows to a design frequency. It was concluded that the proper design balance point is to provide a maximum of 1,000 mgd of treatment capacity and nine million cubic feet of storage which is the Master Plan concept. The results of the evaluation that led to this conclusion are illustrated in the Master Plan report and the Master Plan is described in detail in Chapter V.

SEWER SEPARATION

During storms when rainfall intensity exceeds 0.02 inches per hour (70 percent of all storm time), the City's combined sewer system overflows a mixture of sewage and stormwater to the Bay and/or Ocean without any treatment. The combined waste contains varying amounts of human fecal material and grease solids. When bypassing occurs, these materials can be found in nearshore waters and on the beaches.

A solution to this problem would be to construct separate storm and sanitary sewers throughout the City. Separation of sewers would cost about $3 billion and result in major disruption throughout the City for many years. The water quality benefits which could be achieved by separation would be questionable since some type of stormwater treatment system might be necessary, due to the pollutants in the highly urban stormwaters.

RECLAMATION

San Francisco Bay Area communities are currently dependent on imported water supplies as much of the area's water is derived from development of water supplies in the high Sierra-Nevada Mountains. The waters imported from those sources are passed through the water distribution system, used, collected, and discharged to saline waters. This type of once-through water use is equivalent to total consumption of the water supply as opposed to upstream uses with discharges back to fresh water streams or to groundwater where the wastewater can be reused or, in the case of stream discharges, serve as a fresh water source for the estuary.

The Bay Area's need for fresh water will continue to increase in the future. These needs can be met by development of new sources of fresh water such as: construction of reservoirs, reclamation of existing wastewater sources, desalination of ocean water, or conservation of existing supplies.

Development of additional supplies by construction of reservoirs is limited by the lack of economical sites, the desire to retain some streams in their natural state, and a fuller understanding of the impact of dams and diversions on the environment. Desalination will not become economically attractive until a relatively cheap source of energy is found. The cost of operating a 10-mgd desalination facility is about $1.2 million per year plus the cost of any necessary pretreatment.

Increased treatment of wastewater required prior to discharge to the environment and increased difficulty of developing new water sources are making wastewater reclamation for some uses more economically feasible. Therefore, reclamation must be considered in any comprehensive water resources management program.

A study of the potential for reclamation of San Francisco wastewater is included as Appendix 1 of this report. The findings of that study are summarized in the following paragraphs.

Potential Uses of Reclaimed San Francisco Wastewater

There are numerous potential uses of reclaimed San Francisco wastewater. Some of the more likely uses are for landscape irrigation, salinity control, and agricultural irrigation.

Local Landscape Irrigation. It appears feasible to produce a limited amount of reclaimed water at the proposed Southwest treatment plant site for use at The Olympic Club, Harding Park, and Lake Merced golf courses and at the Richmond-Sunset Plant for use in Golden Gate Park. Reclaimed water can be produced at these two sites at very competitive rates assuming that secondary effluent from the Richmond-Sunset Plant would be the source of supply for the reclamation facilities.

After the Phase I Master Plan facilities are completed, it appears feasible to construct a 4.0 mgd advanced waste treatment facility (rapid sand filtration and disinfection) at the Richmond-Sunset plant. The reclaimed water could be used for irrigation purposes within Golden Gate Park. The unit cost of reclaimed water for this alternative would be about 17¢/1000 gallons as compared to 25¢/1000 gallons of existing irrigation water.

It also appears feasible to construct a 1.0 mgd advanced waste treatment facility (rapid sand filtration and disinfection) at the proposed Southwest treatment plant site. The source of water for this facility would be the effluent line from the Richmond-Sunset plant. The reclaimed water produced by this facility could be used for irrigation of The Olympic Club, Harding Park, and Lake Merced golf courses. The unit cost of the reclaimed water would be about 22¢/1000 gallons.

Salinity Control. The Department of Water Resources and State Water Resources Control Board have initiated a San Francisco Bay Area Wastewater Reclamation Study to determine the feasibility of intercepting and reclaiming treated Bay Area wastewater for transport and reuse to augment Delta outflows, either directly or indirectly by substituting reclaimed water for irrigation and groundwater recharge demands in the Bay Area or adjacent areas.

In its September 19, 1973 progress report, the Interagency Study Group made the following comments:

> "The additional water required by the Central Valley Project and the State Water Project to meet contracts and future water demands can be expressed as an outflow deficiency expected at the Delta under projected conditions.
>
> "Water with a salinity of 4,000 to 6,000 ppm of total dissolved solids could be used to meet this water deficiency by direct augmentation of Delta outflow at about Chipps Island, with provision for treatment to avert toxicity and biostimulation effects in the estuary."

Preliminary results of this study indicate that reclaimed water could be made available for about $90 per acre-foot (28¢/1000 gallons) for this purpose. However, if extended treatment (nutrient and toxicity removal) were required to produce water which would not create biostimulation and toxicity problems in the estuary, this unit cost would escalate to approximately $130 per acre-foot (40¢/1000 gallons).

Agricultural Irrigation. Irrigated agriculture is by far the largest user of fresh water in California. In 1965 for instance, a total of 8,435,000 acres were irrigated in the State requiring approximately 30,000,000 acre-feet (about 10,000 billion gallons) of fresh water. If reclaimed wastewater could be used for this purpose, it might be possible to release an equal quantity of fresh water for uses demanding a higher quality (e.g., domestic uses). However, the use of reclaimed water for crop irrigation is not without problems which include seasonal water use, quality considerations, public acceptance, and the possibility of cross-connection with the potable supply.

Two large agricultural areas in relatively close proximity to the Bay Area are the Delta-Mendota and San Luis service areas within the San Joaquin Valley. The projected import water requirements under the 2015 level of development for these areas are as follows:

Service Area	Quantity, acre-feet
Delta-Mendota	1,675,000
San Luis	1,279,000
total	2,954,000

As a part of its study, the Interagency Group investigated the possibility of using reclaimed Bay Area wastewaters to supplement the imported supplies for these two areas. Three of the alternatives studied by this group included utilization of San Francisco wastewaters. The unit costs of these three alternatives range from $108 to $143 per acre-foot (33¢ to 44¢/1000 gallons).

To date the Interagency Group has not made any conclusions regarding the feasibility of implementing any of its alternatives. However, it would appear that the costs of delivering reclaimed water to the point of use are very high.

Other Possible Uses for Reclaimed Water. Other possible uses for reclaimed water include municipal reuse (complete recycle) and industrial cooling. Municipal reuse in San Francisco and areas to the south on the Peninsula is not considered feasible at this time. San Francisco's water supply is adequate to meet the anticipated needs through 2020, and with reduced population growth rates that date will likely be extended. Although it is not desirable by today's standards, it may be feasible at some later date to blend reclaimed water with fresh water in or near Crystal Springs Reservoir for use in the south peninsula area where groundwater supplies are declining in quality. However, such reuse would require change in the State Health Department's policy toward municipal reuse and development of more economical and reliable treatment systems. It should be pointed out that this type of municipal reuse has been effectively practiced at Chanute, Kansas, and Windhoek, South Africa, where local needs required this approach.

Another possible use of reclaimed water is for cooling purposes. However, at present there are no power plants or other major water using industries in San Francisco where reclaimed water could be used for cooling purposes. The existing power plants in San Francisco utilize once-through Bay cooling water systems which would have to be converted before reclaimed water could be used for cooling purposes.

Throughout the Bay area, wastes generated locally exceed the local reuse potential. Therefore, transportation of San Francisco waste to another area near the Bay for reuse would eliminate the more economical alternative of reuse of locally generated wastes.

Wastewater Reclamation Potential Summary. The most promising potential market for reclaimed San Francisco wastewater is for landscape irrigation within Golden Gate Park and the three golf courses near Lake Merced--The Olympic Club, Harding Park, and Lake Merced. A summary of these and other uses of reclaimed wastewater is presented in Table IV-2.

TABLE IV-2

SUMMARY OF THE POTENTIAL FOR USING RECLAIMED SAN FRANCISCO WASTEWATER

Reclamation Program	Quantity (mgd)	Possible Year of Implementation	Other Responsible Agencies	Cost ¢/1000 gal	Current Cost Cheapest Alternative ¢/1000 gal	Regulatory Constraints
Golden Gate Park Irrigation	1.0 4.0	existing 1980	none none	30 17	25[1] 25[1]	Restrictive bacteriological requirements
Golf Course Irrigation	1.0	1980	Owners of individual golf courses	22	25[1]	Restrictive bacteriological requirements
Delta Salinity Control	Total dry weather	2000	USBR[5] DWR[6]	28-40	3[2]	Restrictive toxicity and biostimulation requirements
Agricultural Use Delta-Mendota Service Area	Total dry weather	2000	USBR DWR	33	3[2]	Possible health restrictions due to intermittent cross-connection
San Luis Service Area	Total dry weather	2000	USBR	44	3[2]	Restrictive bacteriological requirements
Groundwater Recharge Santa Clara Valley	90	Prohibited	Santa Clara CFC&WD,[7] DWR	Not calculated due to regulatory constraints	10[3]	Presently prohibited by State Department of Health
Industrial Use	Total dry weather	Prohibited	Industrial users	Same as above	1.5	Subsequent toxicity and biostimulation requirements
Direct Reuse		Not possible			25	Prohibited by State Department of Health

[1]Cost of San Francisco water to large users.
[2]Existing cost of Delta-Mendota Canal water; if new supplies were developed this cost could double or triple.
[3]Cost of South Bay Aqueduct water (Reference 2).
[4]Cost for pumping brackish water.
[5]United States Bureau of Reclamation
[6]Department of Water Resources
[7]Santa Clara County Flood Control and Water District

Effect of Reclamation on the Master Plan. It appears that the most economical method of producing reclaimed water for landscape irrigation would be to provide advanced waste treatment facilities (rapid sand filtration and disinfection) at the Richmond-Sunset and Southwest plant sites that would utilize secondary effluent from the Richmond-Sunset plant as their source of supply. However, the total seasonal demand for these uses is only 5.0 million gallons per day, compared to a total average dry weather waste flow of 125 mgd. Therefore, reclamation for local uses would not have any effect on the size, location, or type of facilities as envisioned in the Master Plan.

The San Francisco Bay Area Interagency Wastewater Reclamation Study investigated the feasibility of aggregating wastewaters within the Bay Area, providing some form of extended treatment, and producing reclaimed water that would be direct input into the Delta channels at Chipps Island to repel salinity, into the Delta Mendota Canal to serve irrigation demands in the Delta Mendota service area, and into a proposed canal to serve irrigation needs in the San Luis service area.

The basic assumption in all the Interagency Study alternatives was that the San Francisco Wastewater Master Plan had already been implemented and that the effluents of the Richmond-Sunset and Southeast plants were combined at the Southwest plant site. It should be pointed out, however, that all these alternatives were based on average daily dry weather flow conditions of 125 mgd since the irrigation demands are seasonal. Therefore, the need of the 1,000 mgd wet weather treatment facility would still exist even if one of the Interagency alternatives were implemented. In fact, all the facilities envisioned in the Master Plan would be required whether or not large-scale reclamation projects were implemented.

In summary, it appears that reclamation, either through large-scale export of wastes or small-scale local use, has no effect on the Master Plan with respect to the size, location, or type of facilities proposed.

CHAPTER V

THE WASTEWATER MASTER PLAN

The Wastewater Master Plan is designed to provide a given measure of control of the combined sanitary sewage and stormwater runoff collected in the City's system. Sanitary sewage has a relatively constant flow rate throughout the year. Stormwater runoff, which occurs at infrequent intervals and highly variable flow rates, increases flows in localized areas by approximately an order of magnitude during nearly half of the storms.

This can be illustrated as follows:

> Average daily flow of sanitary sewage from San Francisco is approximately equivalent to runoff which would be produced by a rainfall of 0.01 inches per hour occuring simultaneously over the entire City. In contrast, 94 percent of the rain, considering the Federal Office Building gage as representative of intensity, occurs at a rate greater than 0.01 inches per hour, and 50 percent of the rain fell at a rate nine times greater than the rainfall equivalent of sanitary flow. However, on an annual basis more flow is contributed by the sanitary flow. During an average year an estimated 81 percent of the total wastewater is sanitary sewage, while 19 percent is stormwater runoff.

Most of the wastewater is of sanitary sewage origin and is discharged during dry weather periods at a relatively constant rate. During rains the waste characteristics vary greatly and normally consist of much higher proportions of stormwater than sanitary sewage. Since San Francisco has a combined sewer system, the flow pattern is a steady, fairly predictable base flow with a superimposed highly variable series of surge flows which occur during a very small percentage of the year. This flow pattern presents numerous problems in the development of an effective system for transportation, treatment, and disposal.

Deleterious material contained in the sanitary and combined wastes which can affect the Ocean and Bay environments include:

- Material that is floatable or will become floatable upon discharge.

- Settleable material or substances that form sediments which degrade benthic communities and other aquatic life.

- Substances toxic to aquatic life due to increases in concentrations in water or sediments.

- Substances that significantly decrease the natural light available to benthic communities and other aquatic life.

- Materials that result in aesthetically undesirable discoloration of the water surface.

- Substances that upon discharge result in reduction of dissolved oxygen concentrations and subsequent harm to aquatic life.

- Substances which serve as nutrients for certain aquatic microorganisms thereby stimulating eutrophication of receiving waters.

- Disease-causing organisms or indicator organisms which represent a real or potential health hazard.

Pollutants contained in San Francisco's wastewaters from sanitary sources and from stormwater runoff have similar characteristics. More specifically, the quality is sufficiently similar that the effects of these wastes on the receiving waters are more dependent on flow patterns than on differences in wastewater quality. As in the case of total flow the major source of annual pollutant mass emissions is the continuous discharge of sanitary sewage. During periods of stormwater runoff the mass emission rates for pollutants is far higher than during dry weather; for some parameters, dramatically higher. However, the short duration limits the impact of these high rate emissions of pollutants.

Differing control methods may be most effective in handling the constant sanitary flows and the variable storm flows. Historically, sanitary flows have been collected and treated to reduce emissions of pollutants and contamination problems while during storm runoff the wastewater that could not be treated was conveyed to the nearest receiving water for discharge. Treatment of these variable storm flows was not considered practical or necessary.

In San Francisco when flows exceed that which can be transported and treated they are discharged at 41 bypass locations scattered around the entire perimeter of the City. The result of these discharges is that the nearshore waters surrounding the entire city are polluted to a degree where beaches are aesthetically objectionable and waters are not acceptable for swimming for a significant number of fall, spring, and winter days. These problems are directly related to the wastewater discharge quality and quantity and the location of discharge points.

Solution of the problem, theoretically, can be achieved by treatment of all wastes, by collecting these wastewaters and discharging at a more suitable location, or by various combinations of these alternatives.

The major water quality problems associated with the dry weather sanitary discharges are related to the constant emission of potentially environmentally hazardous pollutants. Reduction of pollution load and impact on receiving waters can be achieved only by upgraded treatment and careful location of discharge points to minimize concentrations in receiving waters. In San Francisco, the option is available to discharge to the Ocean or the Bay. Protection of the Ocean environment generally requires a lower level treatment than is necessary to protect the Bay. Emphasis for dry weather control should be directed at both reducing mass emissions and discharging at the optimum available location.

The Master Plan concept incorporates collection, storage, transportation, treatment, and disposal into one overall system designed to achieve the most cost-effective control of all wastewaters. Available information is sufficient to proceed with final design of some elements of the Plan; however, additional information is necessary and is being developed to permit necessary refinements of other elements.

GOALS OF THE MASTER PLAN

The Wastewater Master Plan was developed to implement the following goals:

> "That the treated waste be discharged to the Bay or Ocean through properly designed outfalls so as to have no adverse effect on marine life, the water, or beaches.
>
> "That treatment rate can be varied to meet special flow or available dilution changes.
>
> "That there be flexibility to meet changing water quality requirements and needs for reclaimed wastewater and a 'building block' concept is included to minimize premature abandonments due to changing plans.
>
> "That direction of the City Planning Commission, the Bay Conservation and Development Commission, and other agencies be reflected to avoid adverse effects on the future development of San Francisco, particularly waterfront or water areas and that use of valuable property for treatment facilities be avoided.

"That valuable land such as Golden Gate Park and the north waterfront area be released from sewage treatment use as replacement facilities with multi-use potential are constructed in more appropriate locations.

"That financing of the Plan implementation be feasible and recognize increasing maintenance and operation costs and the time-span relating to San Francisco financing alone or being expedited by Federal and State funding.

"That a cost-benefit relationship be included so that policy on the degree of wet weather treatment can be established.

"That immediate upgrading of the effluents from the treatment plants can be undertaken.

"That substantial reduction in flooding of City streets can be obtained.

"That the degradation of receiving waters by combined overflow be substantially reduced.

"That a viable industrial waste program be provided to control toxic discharges at the source with supplemental treatment as necessary and technically feasible.

"That there be long-range capability for the consolidation of the three treatment plants into one plant.

"That an undue investment in facilities need not be prematurely abandoned if it proves necessary in the next century to prohibit all discharges to the Bay.

"That there be capability to effectuate an agreement for San Francisco to accept effluent from agencies in northern San Mateo County to facilitate a regional consolidation plan.

"That there be compatibility with the anticipated Bay area regional sewerage plan.

"That there be capability of conversion to rail transport of solids (dried sludge) in the event a local or regional rail haul plan for solid waste is implemented.

"That advantage be taken of the City's hilly topography for underground storm storage.

"That there be direction toward a central control system so that dry weather flow, wet weather flow, and street drainage can be managed with high-speed decisions on assignments of flow increments to varying transport and treatment facilities to make the maximum use of available capacity with changing storm patterns."

PROPOSED MASTER PLAN CONCEPT

The general concept of the Master Plan is that there exists a combination of transport, storage, treatment, control, and disposal location which most effectively reduces the detrimental effects of waste discharges from the City. Specific components of the ultimate wastewater system contained in the Master Plan are as follows:

- A system of rain gages to monitor a storm continuously as it approaches and traverses the City.
- Continued utilization of combined sanitary and storm sewers throughout the City.
- Consolidation of the existing 41 overflows to 15 shoreline collection points and construction of retention basins at those points. These basins will receive waste from upstream areas, store, and release flows at controlled rates. Wastes from the 15 shoreline basins are released into either the crosstown tunnel or the ocean side transport pipeline.
- Upstream retention basins within most of the 15 major watersheds. These basins will permit regulation of flows to downstream sewers and the 15 shoreline retention basins.
- A crosstown tunnel beginning in the North Point region, extending south into the Southeast drainage area, then turning west to the Lake Merced area. The tunnel will transport all storm and sanitary waste from the north and east portions of the City to the Lake Merced area.
- A major pipeline or tunnel from the southern Presidio boundary south to the Lake Merced area. This line will transport all waste from the west side of San Francisco to the Southwest Treatment Plant near Lake Merced.
- Regional storage facilities associated with the crosstown tunnel to further control flows.

- An all-weather treatment plant (Southwest Treatment Plant) near Lake Merced for sanitary and storm flows designed to operate with split-flow alternative treatment levels depending upon plant inflow.

- A dual-purpose ocean outfall designed to transport dry weather flows four miles and storm flows two miles into the Ocean.

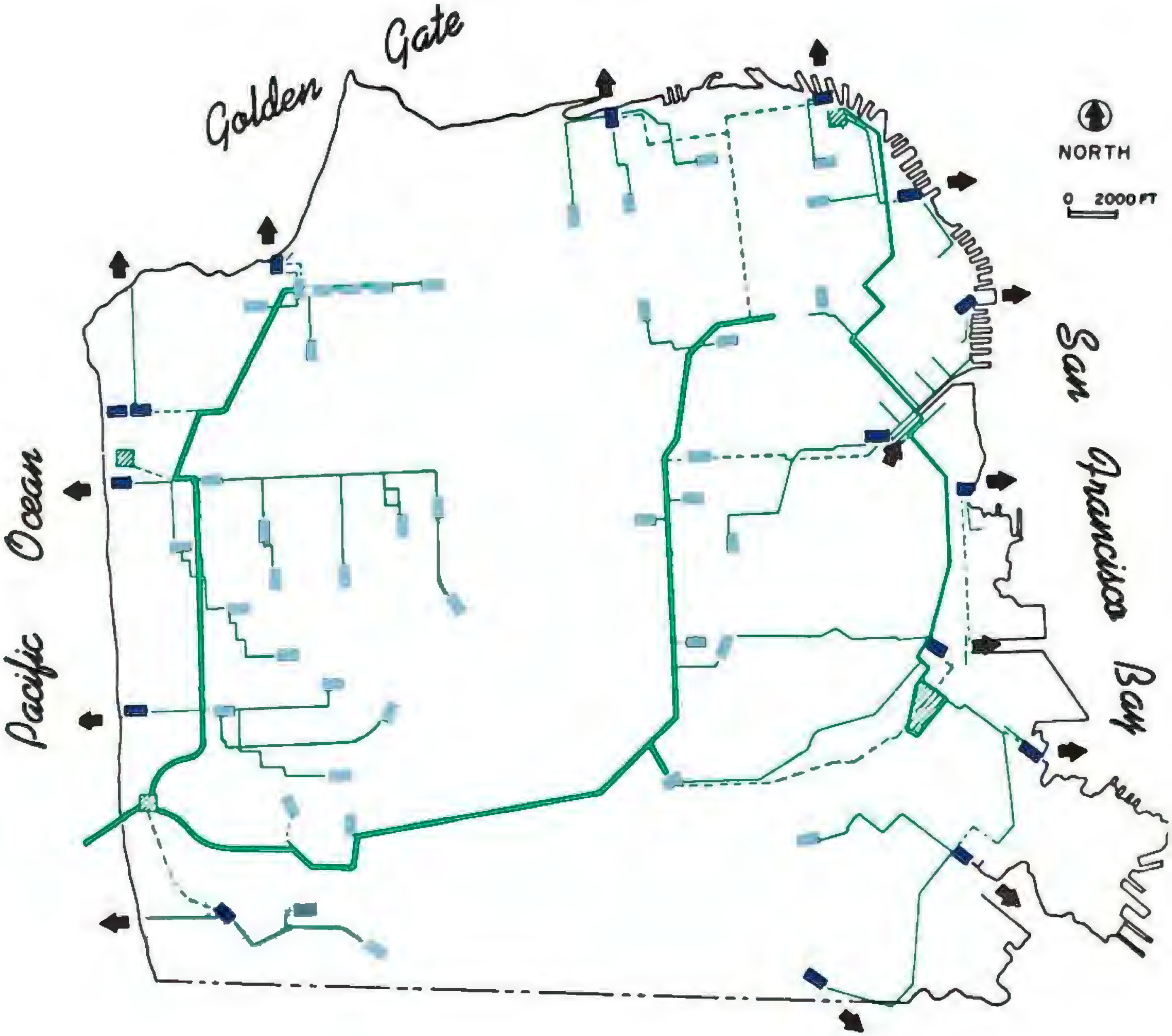
- One central computer-operated control system to characterize storms and regulate withdrawal rates from all retention basins.

The major physical features of the proposed long-range system are shown on Figure V-1. At the present level of design data, the Southwest Treatment Plant is to serve a maximum flow of 1,000 mgd which is equivalent to runoff from 0.1 inches per hour of uniform rainfall over the entire City. Citywide storage capacity of 9.0 million cubic feet is also provided. The capacity of the main transport system is not yet determined but is presently sized at a rainfall rate of 0.3 inches per hour from the tributary area with a 1,000 mgd maximum. Maximum release rates from the individual retention basins cannot be established without additional data but are preliminarily sized to handle runoff from a rainfall rate of 0.3 inches per hour on the tributary area.

The proposed operation of the completed Master Plan facilities will be as follows:

> Storms will be characterized by a system of rain gages and wastewater flow meters. Control of storage utilization, transport rate, and treatment rate will be based on the spatial and temporal characteristics of the particular storm. Storm flows will be stored in retention basins and withdrawn at selected rates for transport to the Southwest Treatment Plant. However, should both the storage and transport capacity from any of the 15 drainage basins be exceeded, an untreated overflow to the Bay or Ocean would occur at that particular shoreline retention basin. On the average, there will be 8 such overflows per year.
>
> During the major portion of the year, wastes will receive secondary treatment at the Southeast and Richmond-Sunset Plants. These treated effluents will be transmitted through the tunnel and pipeline systems to the Southwest Treatment Plant site and discharged approximately four miles offshore. During storm conditions, flows exceeding the capacity of the secondary treatment plants will be transported to the 1,000 mgd Southwest Treatment Plant

Figure V-1
MASTER PLAN



The complete Master Plan for wastewater management is shown above. Retention basins (upstream — light blue, shoreline — dark blue) provide storage, control flooding, and allow regulation of flow to the transportation system (green). During the major portion of the year, wastes will receive secondary treatment at the Southeast and Richmond-Sunset plants. These treated effluents will be transmitted through the tunnel and pipeline systems to Lake Merced where they will be discharged approximately 4 miles offshore. The North Point Plant will be abandoned. During storm conditions, flows exceeding the capacity of the secondary treatment plants will be transported to a 1000 million-gallon-per-day capacity treatment plant at Lake Merced. The effluent will be discharged 2 miles offshore. The system will provide secondary treatment of all waste during a major part of the year and the bypassing of untreated waste will be virtually eliminated.

where they will undergo advanced primary treatment. This effluent will be discharged about two miles offshore.

To assure adaptability to various treatment needs, the Southwest Treatment Plant is designed for easy addition of more advanced treatment processes if needed.

Staging Program

Regulatory restrictions and time schedules limit control options and establish certain early high priorities. The primary regulatory restriction is secondary treatment of dry weather flows by July 1, 1977. The next priority is the control of bypasses in the north shore and Ocean beach areas. In order to comply with these regulations as rapidly as technically and financially feasible, the Master Plan will be implemented in accordance with the following staging program.

Stage I. The Stage I facilities are shown on Figure V-2 and summarized below:

Element	Cost Million Dollars	Estimated Completion Date
Southeast Plant Solids Handling	10.0	1/76
Richmond-Sunset Plant Interim Improvements	0.2	10/73
Southeast & North Point Interim Improvements	1.4	6/74
Pilot Plant & Toxicity Studies	1.7	6/74
Transport System--North Point to Southeast	23.5	6/78
Southeast Primary Plant Expansion	24.7	6/77
Secondary Facilities for SE Flow	18.0	1/79
Secondary Facilities for NP Flow	36.0	1/80
Richmond-Sunset Level I (advanced primary) plus Filtration	13.0	1/77

Element	Cost Million Dollars	Estimated Completion Date
SE Interim Bay Outfall	7.0	9/77
Lake Merced 2-Mile Ocean Outfall	30.0	1/81
Transport System (Richmond Sunset-Lake Merced)	24.0	1/81
North Shore Wet Weather Treatment & Transport (retention basins in North Shore and transport to North Point & Southeast)	41.0	1/83
Total	230.5	

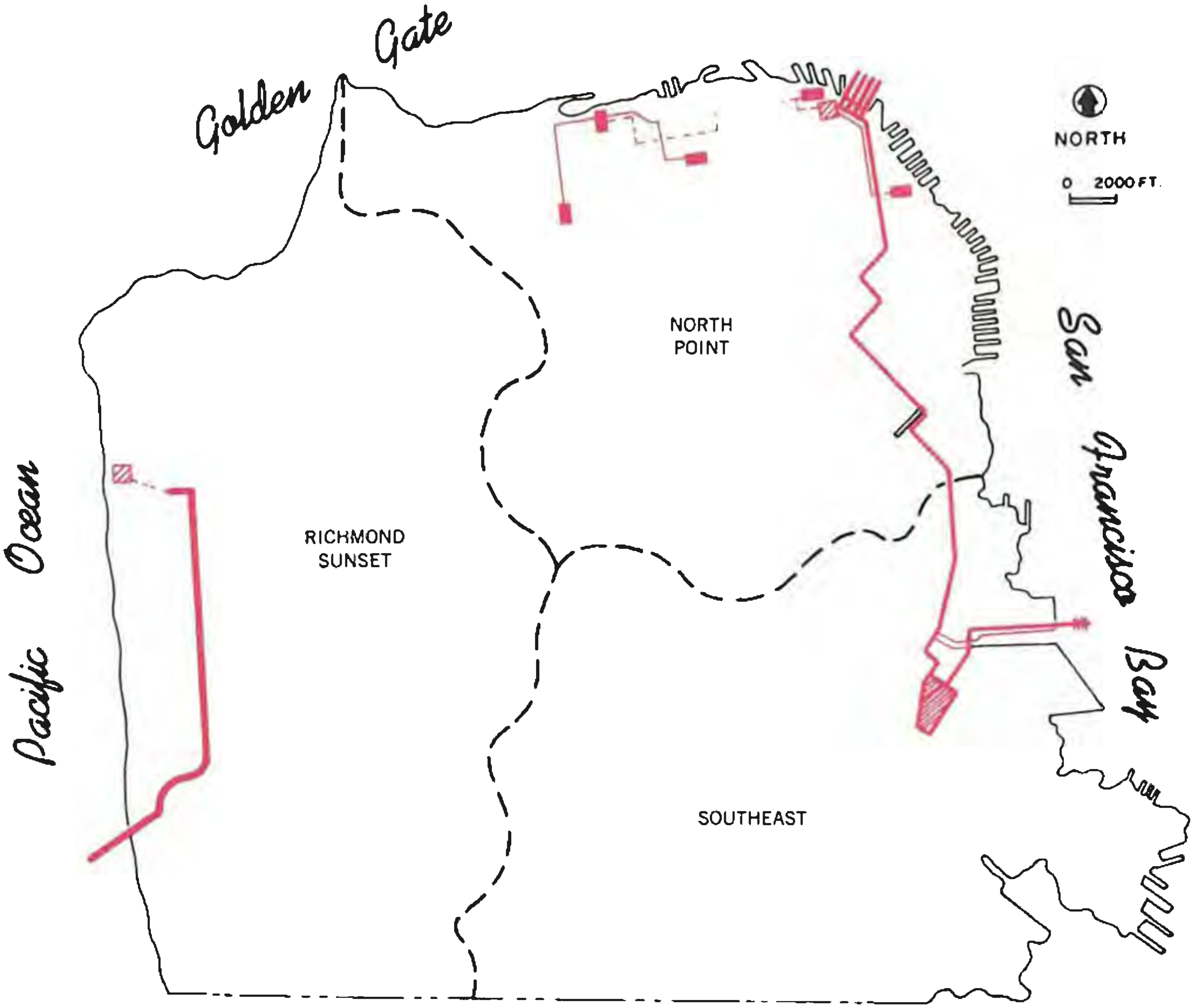
Upon completion of these facilities, waste from the North Point service area will be pumped to the Southeast Treatment Plant which will provide secondary treatment for dry weather flows from the North Point and Southeast areas. The effluent will be discharged to the Bay through an improved outfall. Wet weather waste control facilities will be constructed to control overflows in the North shore area. The North Point plant will be converted to a wet weather facility to treat wastewaters from the area during storm periods. The Richmond-Sunset wastewater treatment plant will be improved to provide an effluent quality acceptable for continual Ocean disposal. Effluent from the Richmond-Sunset plant will be transmitted to the Lake Merced area for Ocean disposal.

Completion of Stage I facilities will result in compliance with secondary treatment requirements for all dry weather flows, near elimination of overflows to important North area beaches (to an average of less than six overflows per year), and significant reduction of overflows to Ocean beaches.

Operation of Stage I facilities, in conjunction with improvements to other wastewater discharges to the Bay, will result in substantial improvement of the aquatic environment of the Bay, particularly in nearshore waters adjacent to San Francisco during the winter and spring months. Annual number of days in which bacteriological swimming standards are exceeded will be greatly reduced. At North shore beaches violations on less than 10 days per year are expected. Normally these days will occur during the least desirable periods for swimming and beach recreation. Also, the aesthetic quality of waters and beaches in the Marina, Aquatic Park, and Fisherman's Wharf areas should be substantially improved except during the worst storm conditions.

Figure V-2

FIRST PHASE OF MASTER PLAN



The improvement program designed to achieve early compliance with State and Federal treatment standards and to reduce overflows in the critical north shore and ocean beach areas is shown in red. Raw waste from the North Point service area will be pumped to the Southeast Treatment Plant. The Southeast Plant will provide secondary treatment for the dry weather flows from the North Point and Southeast areas. The effluent will be discharged to the Bay through an improved outfall. Wet weather waste control facilities will be constructed to control overflows in the north shore area. The North Point Plant will be converted to a wet weather facility to treat wastewaters from the area during storm periods. The Richmond-Sunset wastwater treatment plant will be substantially improved to produce an effluent quality acceptable for continued ocean disposal. Effluent from the Richmond-Sunset Plant will be transmitted to the Lake Merced area for ocean disposal.

Completion of the Master Plan. It is anticipated that the Master Plan will be completed in three additional stages as shown in Figure V-3. Stage II facilities include the remainder of the west side tunnel and all remaining shoreline retention basins together with the upstream west side basins. With the completion of this stage all of the City's shoreline will be afforded some measure of protection. The estimated cost of Stage II facilities is $149 million.

Stage III facilities include the construction of the crosstown transport facilities with storage for the west side areas plus the Southwest Water Pollution Control Plant with 1,000 mgd of wet weather advanced primary treatment. Completion of this stage will result in further reductions of overflows and provide for a treated wet weather discharge to the Ocean. The estimated cost of Stage III facilities is $161 million.

Stage IV which represents the final phase of construction presently contemplated in the Master Plan includes the remaining upstream storage basins, the Ocean outfall extension, and dry weather secondary treatment facilities at the Southwest Water Pollution Control Plant. The estimated cost of Stage IV facilities is $131 million.

A summary of estimated costs of the complete Master Plan is presented below:

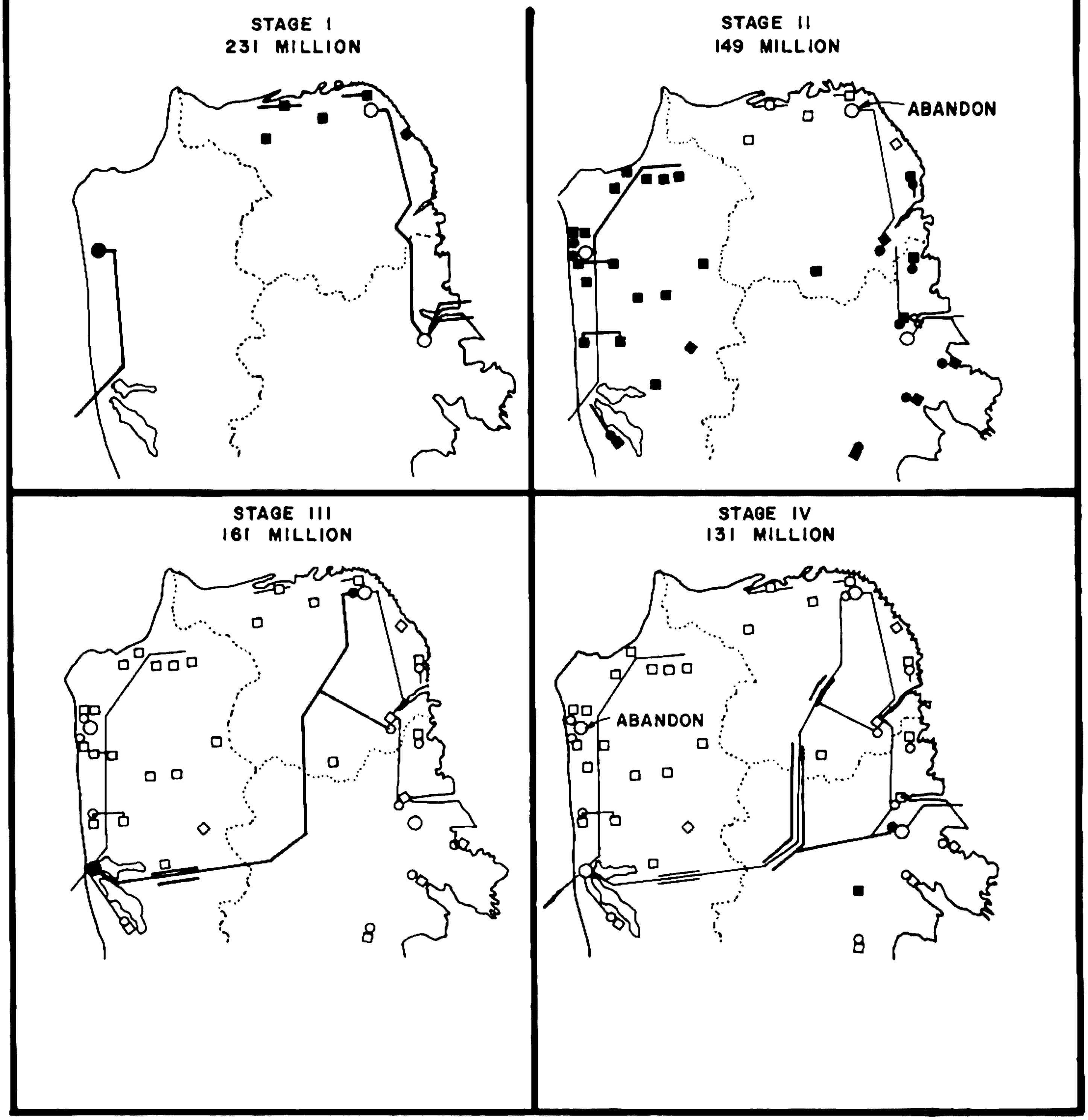
Stage I	$231,000,000
Stage II	149,000,000
Stage III	161,000,000
Stage IV	131,000,000
Total	$672,000,000

STORAGE

The fundamental purpose of storage in wastewater management is flow control; that is, to provide a means of moderating the high flow rate variations associated with rainfall events. This moderation is accomplished by providing a volumetric capacity (a storage basin) with controlled feed (flow in) and withdrawal (flow out).

When flows in the sewerage system are too high to be treated directly, the feed rate to the basins is increased until the demand ceases or the basin becomes full. When flows in the sewerage system are below the treatment capacity, the basins are dewatered in preparation for the next storm. If high flows continue after a basin is full, an overflow will occur.

FIGURE V-3
STAGING PROGRAM



As developed in the Master Plan Report the following design features may be associated with each basin or tunnel storage unit:

- A means of diverting all sewage flow around the basin during dry weather periods.
- A crude pretreatment system (baffles and weirs) to minimize solids and floatables accumulations within the basin.
- A remotely operated rate control on the filling or bypassing of the basin.
- A remotely operated rate control on the dewatering of the basin.
- Connection of all drainage areas to a single treatment plant (the capacity of the existing interceptors is estimated as equivalent to 0.03 inches per hour of rainfall; whereas the desired withdrawal rate varies from 0.10 to 0.30 inches per hour).

The first two features are primarily designed to avoid or minimize odor and maintenance problems. The third and fourth permit the operational use of the storage units on a total systems basis and the fifth increases operational flexibility to provide increased relief to areas highly stressed by local cells of intense rainfall.

Storage Location

The Master Plan concept utilizes a combination of three types of storage: upstream basins, shoreline basins, and tunnel storage. The approximate locations of the retention basins, identified by street intersections are listed on Table V-1.

Upstream Basins--Upstream storage basins have been employed to relieve surface ponding by reducing peak flows to inadequate sewers, thus eliminating or reducing their inadequacy. The upstream basins are located at an elevation that in most cases permits gravity drainage to the outlet sewer. The storage volumes and release rates are dependent upon the areas served and hydraulic capacity of downstream sewers.

Shoreline Basins--The Master Plan concept includes shoreline basins at the proposed 15 grouped overflow points. This grouping effectively reduces the 41 existing overflow points to a manageable number. Withdrawals from the shoreline basins will be pumped

TABLE V-1

RETENTION BASIN LOCATION AND DIMENSIONS

APPROXIMATE LOCATION	DIMENSIONS Length (ft)	Width (ft)	Depth (ft)	Volume $ft^3 x 10^6$
RICHMOND-SUNSET				
John Muir Drive Pump Station	102	60	18	0.11
Vicente and Great Highway	94	50	30	0.14
Vicente and Sunset Boulevard	196	75	17	0.25
Eucalyptus and Melba	45	75	30	0.10
Wawona and Ulloa	85	50	26	0.11
Lincoln Way and Great Highway	180	100	30	0.54
Lawton and 41st Avenue	70	60	24	0.10
Lincoln Way and 39th Avenue	195	100	20	0.39
Noriega and 29th	77	50	26	0.10
Noriega and 20th	154	25	26	0.10
Judah and 7th Avenue	69	50	32	0.11
Fulton and La Playa	135	60	17	0.14
Fulton and 48th Avenue	184	60	19	0.21
Sea Cliff Outfall	123	60	30	0.22
Lake and 24th Avenue	111	60	15	0.10
Lake and 22nd Avenue	119	60	14	0.10
Lake and 17th Avenue	118	60	17	0.12
California and 28th Avenue	50	50	40	0.10
	RICHMOND-SUNSET VOLUME SUBTOTAL			3.04
NORTH POINT				
Marina Outfall	111	60	30	0.20
Baker and Union	63	50	32	0.10
Lombard and Franklin	80	60	25	0.12
Beach Street Outfall	89	60	30	0.16
Jackson Street Outfall	96	60	35	0.20
Brannan Outfall	67	50	30	0.10
Division Street Outfall	302	90	35	0.95
Valencia and 20th Street	193	20	26	0.10
	NORTH POINT VOLUME SUBTOTAL			1.93
SOUTHEAST				
Mariposa Outfall	111	30	30	0.10
Selby Outfall	166	150	35	0.87
Evans and Griffith	125	40	20	0.10
Yosemite Outfall	117	100	30	0.35
Sommerset and Wayland	104	40	26	0.15
Sunnydale and Bayshore	143	60	35	0.30
	SOUTHEAST VOLUME SUBTOTAL			1.89
			TOTAL	6.98

to the interceptors or tunnels leading to the Southwest Treatment Plant during and immediately following storms. Shoreline basins under the Master Plan concept could be reduced in volume by the volume of additional upstream basins. The system within an individual drainage basin is designed such that waters containing the highest concentrations of solids and floatables are diverted directly to the interceptor and thus the treatment plant rather than flowing to the shoreline basin. The shoreline retention basins are designed to provide a degree of removal of solids and floatables from any wastes which must be bypassed.

Tunnel Storage--The crosstown tunnel will convey an estimated 68 percent of San Francisco's storm runoff to the Southwest plant. The tunnel provides both conveyance and storage which permits it to act as an equalization basin ahead of treatment. This concept permits the operational use of spatial and temporal variation of rainfall to greatest advantage. By effectively utilizing this equalization storage and capitalizing on the nonuniformity of rainfall at any point in time, significant reductions in treatment capacity, and perhaps local storage, may be realized.

Storage Volume

The storage volume necessary to contain overflows depends on the peak runoff, the volume and shape of the runoff hydrograph, and the rate of withdrawal from storage to treatment. The runoff hydrograph is related to the rainfall hyetograph if the effect of storage is neglected. Consequently, the 62-year hourly rainfall records of the Federal Office Building gage maintained by the U. S. Weather Bureau and the 21-year hourly record at the Richmond-Sunset gage maintained by the City were analyzed by computer. The average number and volume of overflows, the hours of overflow, and the volume treated in an average year for various combinations of treatment rates, and storage volumes were developed from the analysis. The results permit the plotting of the number of overflows versus storage capacity for treatment rates from 0.02 to 0.10 inches per hour as well as storage capacity versus treatment rate for constant number and volume of overflows.

This type of analysis allows evaluation of the overall effect of the entire yearly rainfall under average conditions on runoff quantity and number and volume of overflows for different treatment rates and storage volumes, including existing conditions of 0.02 inches per hour treatment rate and zero storage. The results of this analysis are shown on Figures V-4 and V-5. When using these figures it is important to note that the treatment rates are expressed as equivalent uniform rainfall rates and the

FIGURE V-4
OVERFLOW FREQUENCY FOR VARIOUS TRANPORTATION RATES AND STORAGE VOLUME

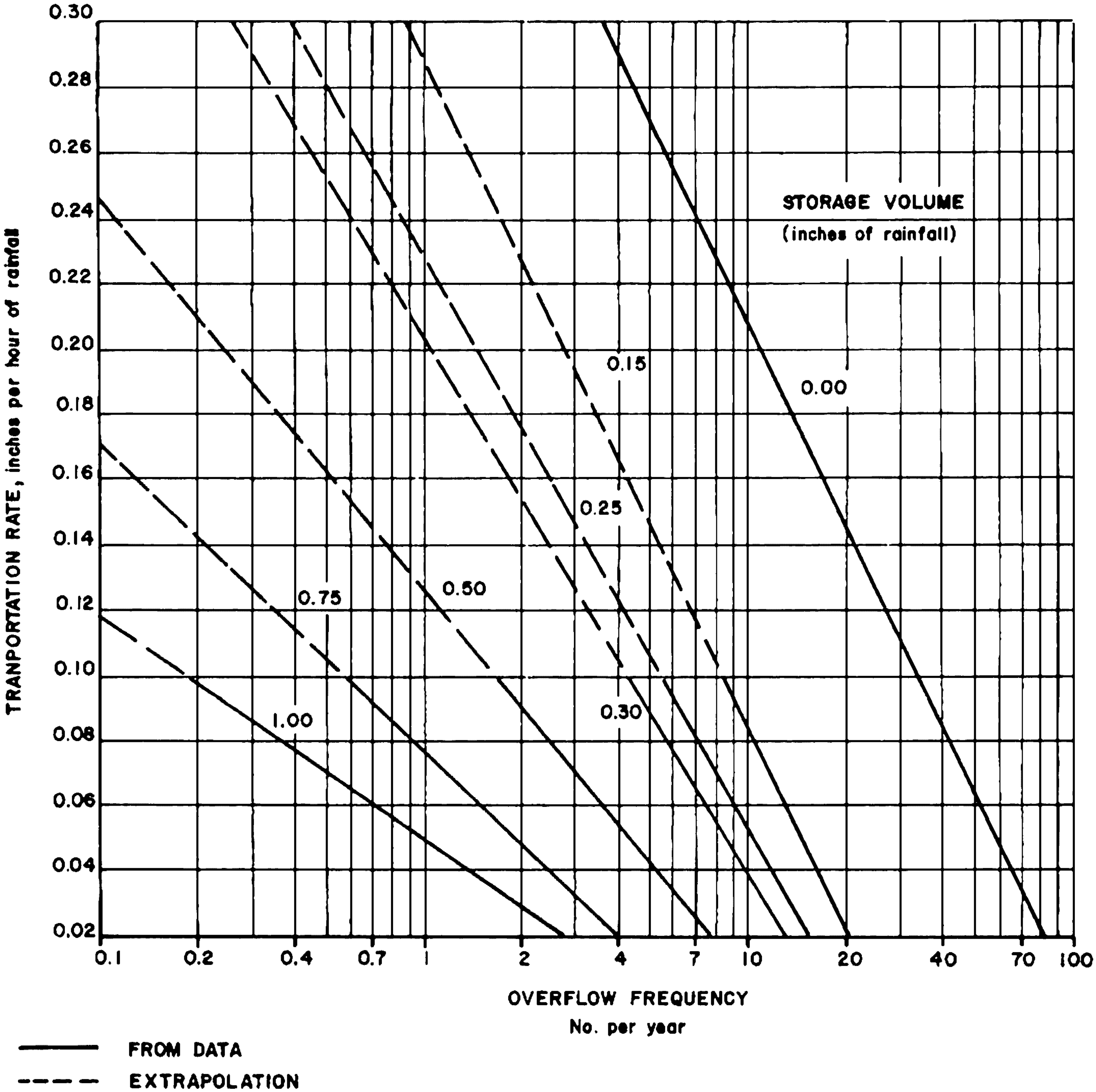
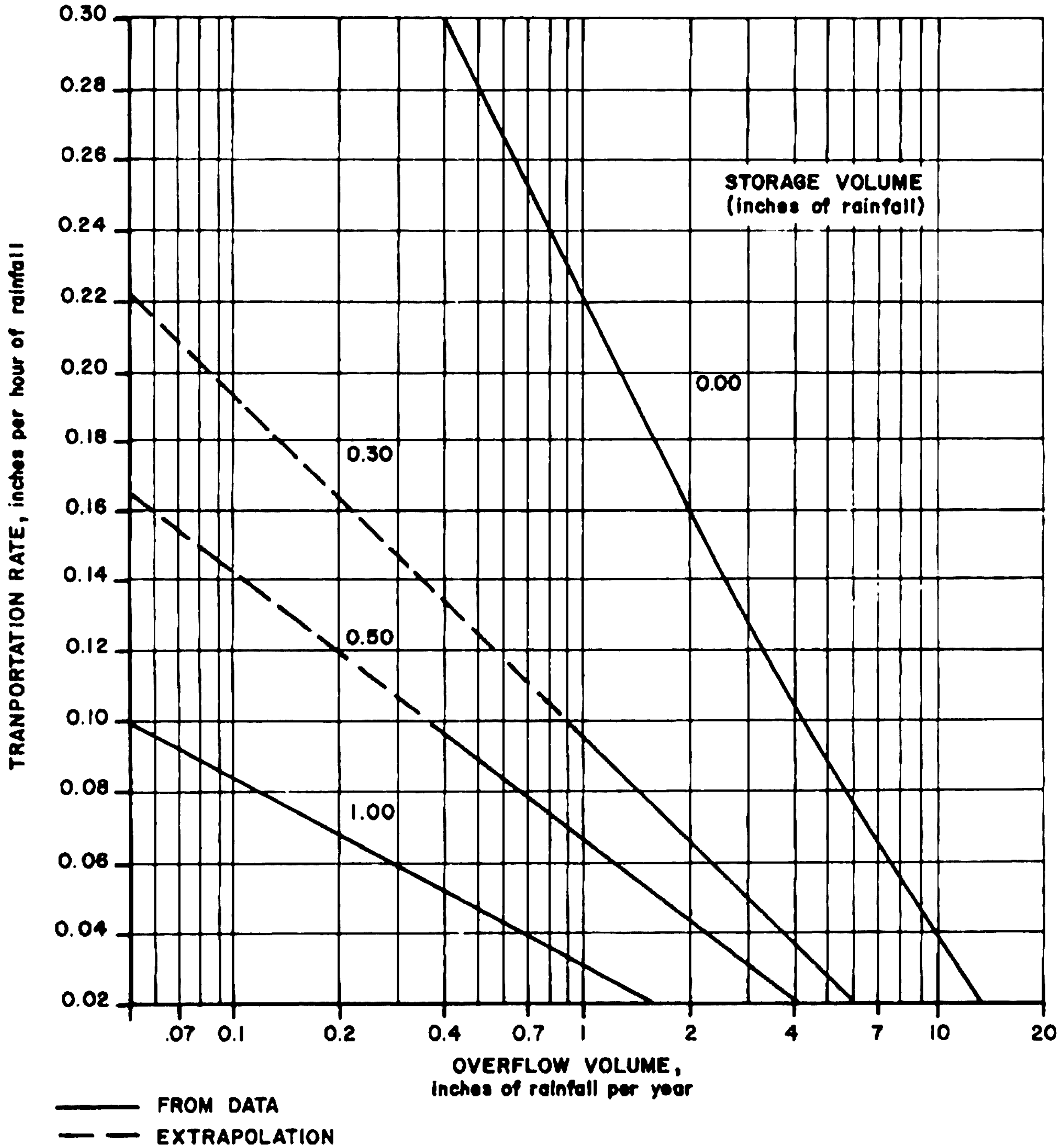


FIGURE V-5
OVERFLOW VOLUMES FOR VARIOUS TRANSPORTATION RATES AND STORAGE VOLUMES



storage volumes, volumes of overflow, and volumes treated are expressed as equivalent inches of rainfall, and that true estimates of volumes and rates require multiplication by an appropriate runoff coefficient. This is assumed to be 0.65 for the City as a whole.

Based on this type of analysis, the Master Plan concept provides storage for 0.15 inches of uniform rainfall over the entire City.

An additional source of available storage volume which has not been fully investigated is that available in the wet weather transport system and treatment plant. In considering available volume, no allowance is made for storage available at the treatment plant due to empty tanks which must be placed in service or for storage in the existing sewers or proposed transport conduits. For conceptual analysis this was satisfactory; however, substantial savings can be realized and in final design these factors will be considered.

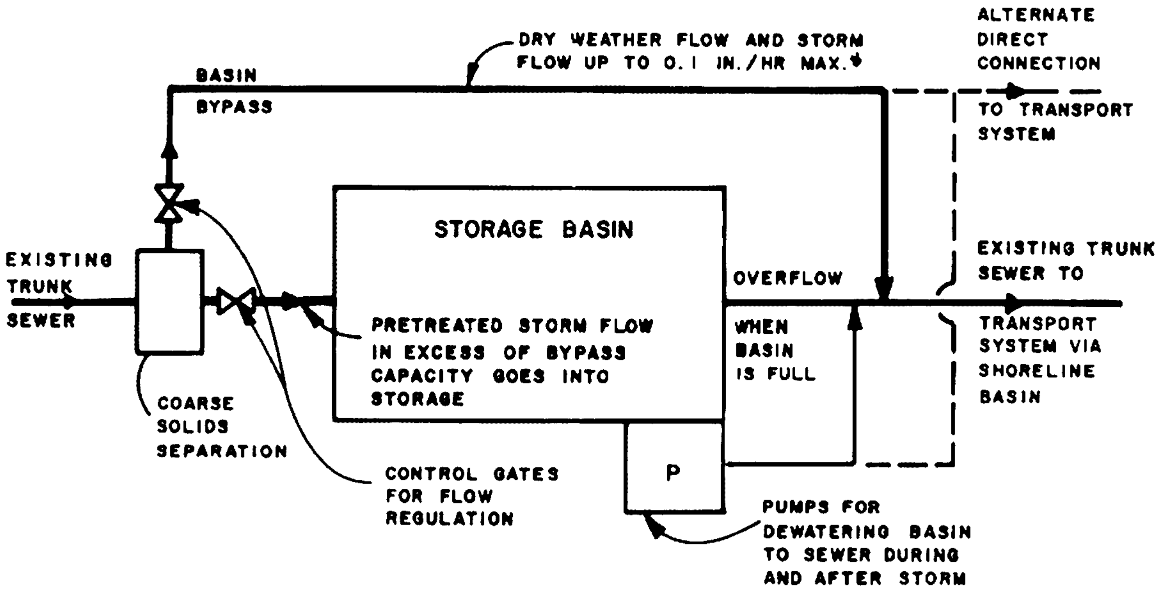
This additional storage can be most effectively utilized only if the transport capacity from the area of runoff collection through the crosstown and oceanside tunnels to the treatment plant is significantly higher than the preliminary design transport rate (0.1 in/hr). Further consideration will be given to the storage source in the final selection and sizing of the storage and transport system.

In operating the wet weather treatment tanks, small batteries of parallel tanks will be allowed to fill and overflow at their design treatment rate before additional batteries are brought into service. The resultant simultaneous withdrawal of treated effluent as tanks are being filled will increase their effective storage capacity.

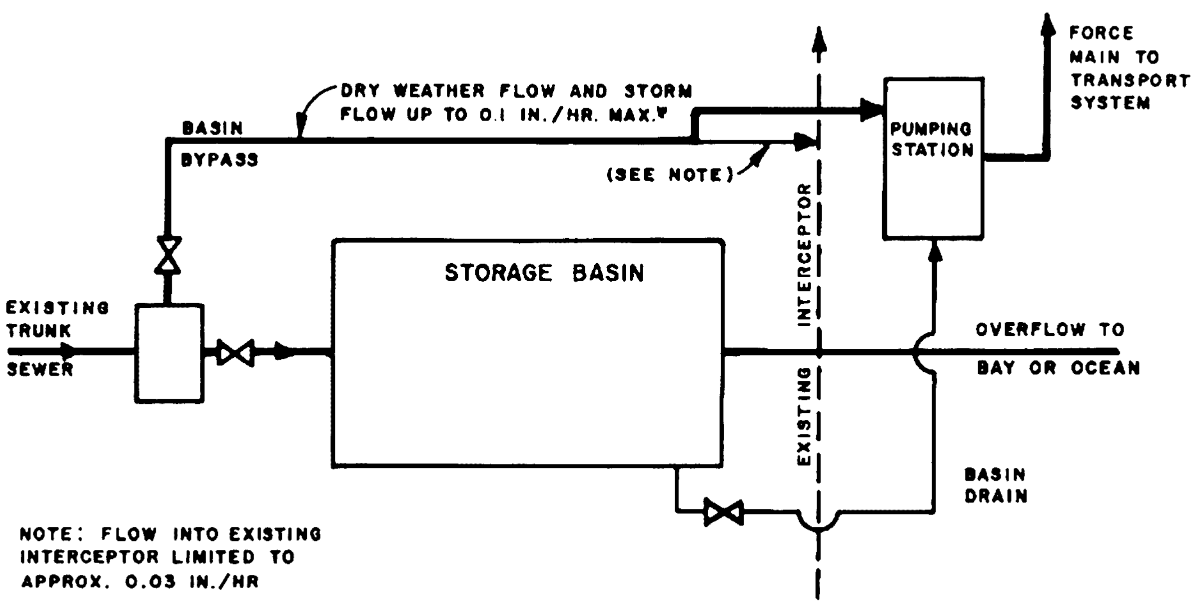
Storage Facility Design

Simplified operational schematic drawings of storage basins and tunnel storage as conceived in the Master Plan are shown in Figures V-6 and V-7, respectively. Features of the shoreline basins are similar to the upstream basins except for the increased provisions for pumping. The typical arrangement of basins and tunnel storage with respect to the transport and treatment systems is shown in Figure V-8.

FIGURE V-6
SIMPLIFIED OPERATIONAL SCHEMATIC DRAWINGS



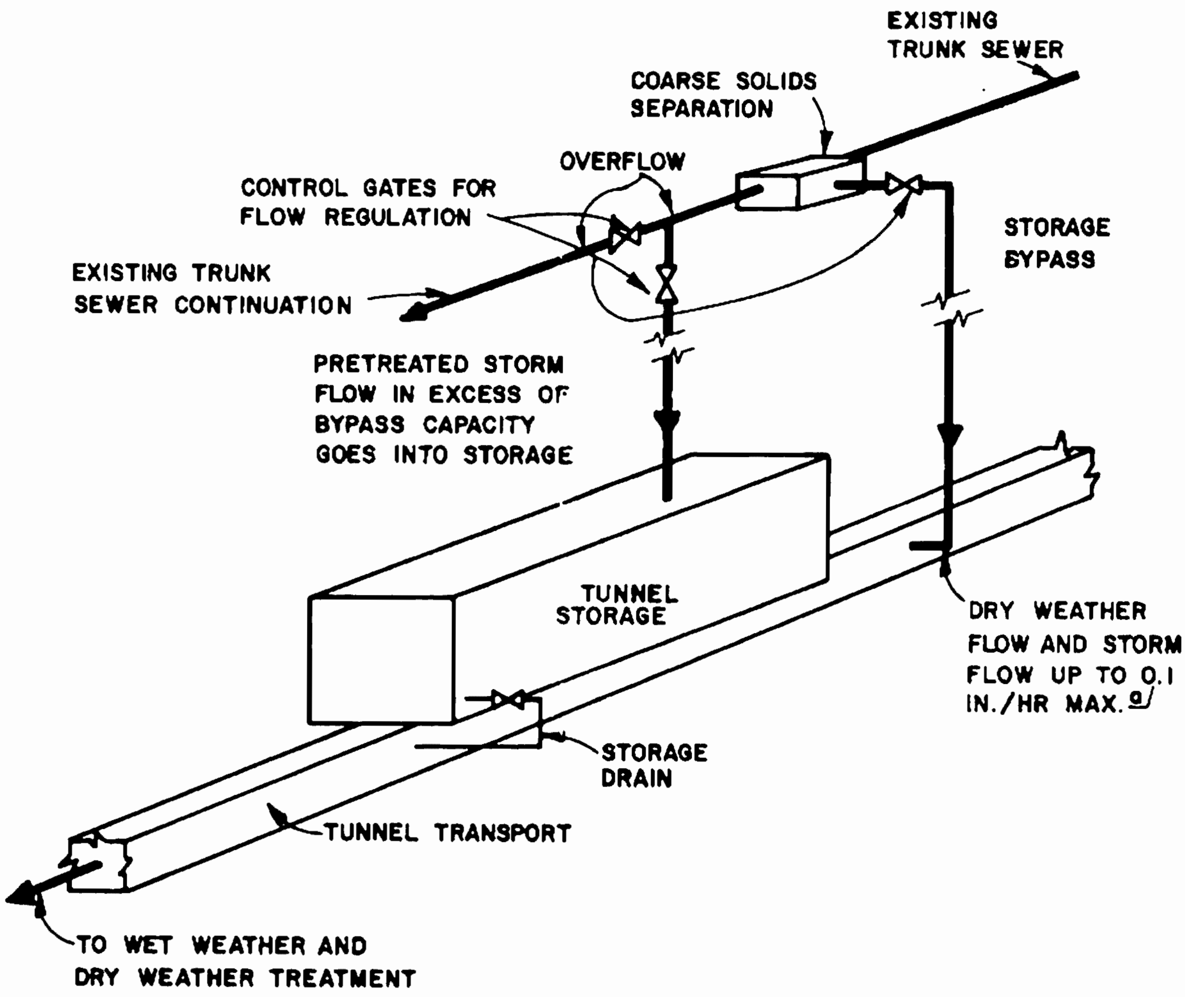
TYPICAL UPSTREAM BASIN



TYPICAL SHORELINE BASIN

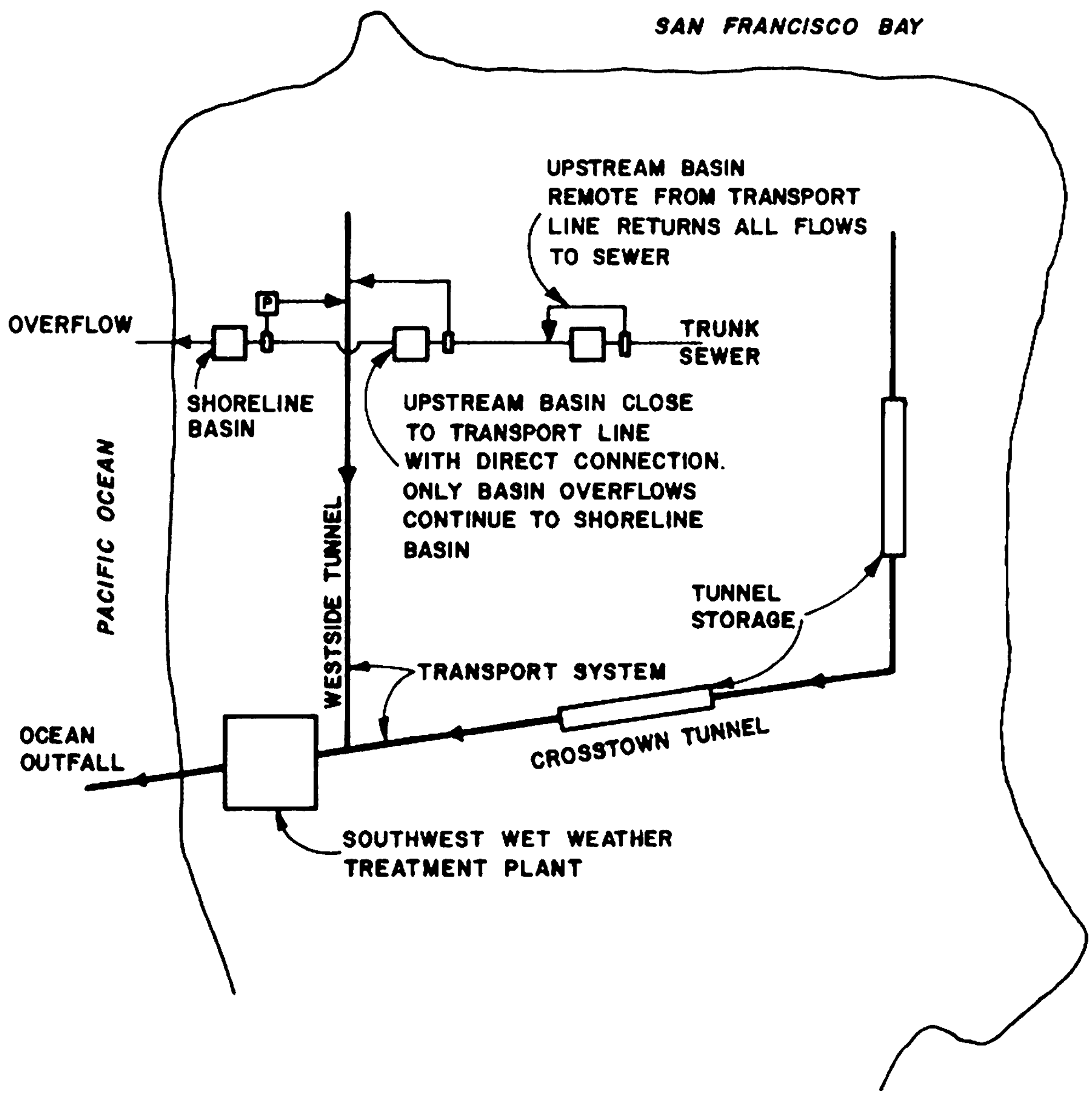
* MODIFIED SYSTEM WILL ALLOW UP TO 0.3 IN./HR

FIGURE V-7
SIMPLIFIED OPERATIONAL SCHEMATIC
OF TUNNEL STORAGE



[a]MODIFIED SYSTEM WILL ALLOW UP TO 0.3 IN./HR

FIGURE V-6
CONCEPTUAL BASIN AND
TUNNEL STORAGE ARRANGEMENT

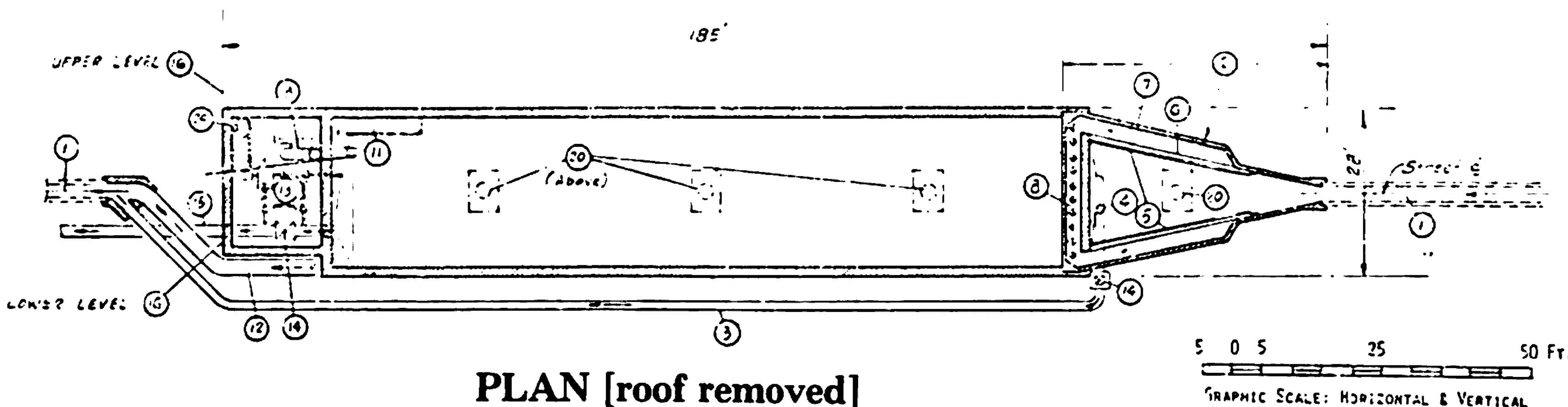


Retention Basins--The conceptual design of an upstream basin is shown on Figure V-9. A flow control structure allows bypassing of the dry weather flow and some storm flow to a bypass conduit during maintenance and also to eliminate fouling of the basin and possible odors during dry weather. An expansion chamber will be incorporated in all storage facilities to slow the velocity. A dropout in the bottom of this chamber will conduct the normal dry weather flow and the heavier solids during storm flows beneath the basin to a continuation of the sewer downstream, or where practicable, directly to an interceptor. The main storm flow will pass under baffles and over weirs to keep heavy settleable and floatable solids out of the basin. The flow then enters a distributor channel, which during low flow will drop the influent to the bottom of the tank through a manifold of pipes extending across the entire width of the basin to assist in flushing settled solids towards the outlet. The stored flow is withdrawn through controlled gates in the outlet pipes which are located in the bottom of the end wall. The flow passes to the downstream sewer or directly to the interceptor depending on location. When the storage capacity is exceeded, the excess flow will pass over weirs and flow to the downstream sewer, which in the case of shoreline basins leads directly to the receiving waters. A system of washdown pipes, an emergency dewatering pump, automatic control equipment, and ventilating fans are included in a two-story control structure at the outlet end of the basin. In the case of shoreline basins, this structure would contain the pumps for pumping the stored flow to the interceptor, and where practicable, high-level gravity drawoffs.

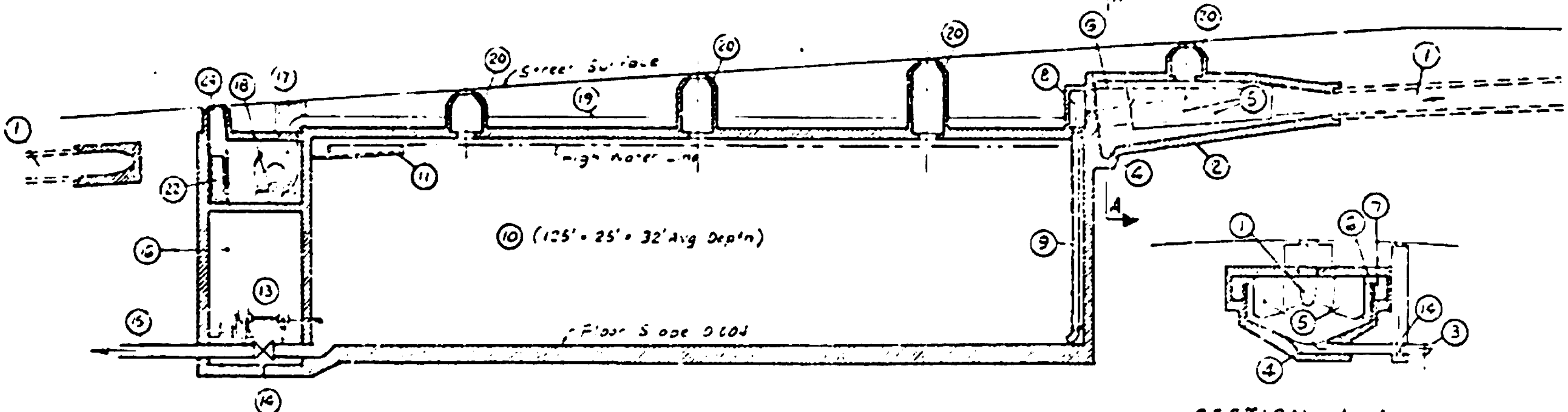
The last inland basin just across from the wastewater interceptors and all shoreline basins are designed to discharge the concentrated waste flows only to the interceptors. Flows reduced by interception but in excess of basin capacity must first pass through those basins before overflowing and continuing downstream. This method permits only the cleanest waters to overflow in cases where overflows cannot be avoided.

A schematic diagram of the wet weather control system is shown in Figure V-10. The design shown on Figure V-9 and described above may be unnecessarily elaborate. This is caused in large measure by the attempt to keep heavy solids and floating material out of the retention basin. An end weir and baffle across the expansion chamber with a side outlet to the bypass conduit for dry weather flow may be sufficient. This would permit flow over the weirs to drop vertically behind a baffle wall instead of through a manifold of pipes. It may be

FIGURE V-9
CONCEPTUAL DESIGN OF UPSTREAM RETENTION BASIN



PLAN [roof removed]



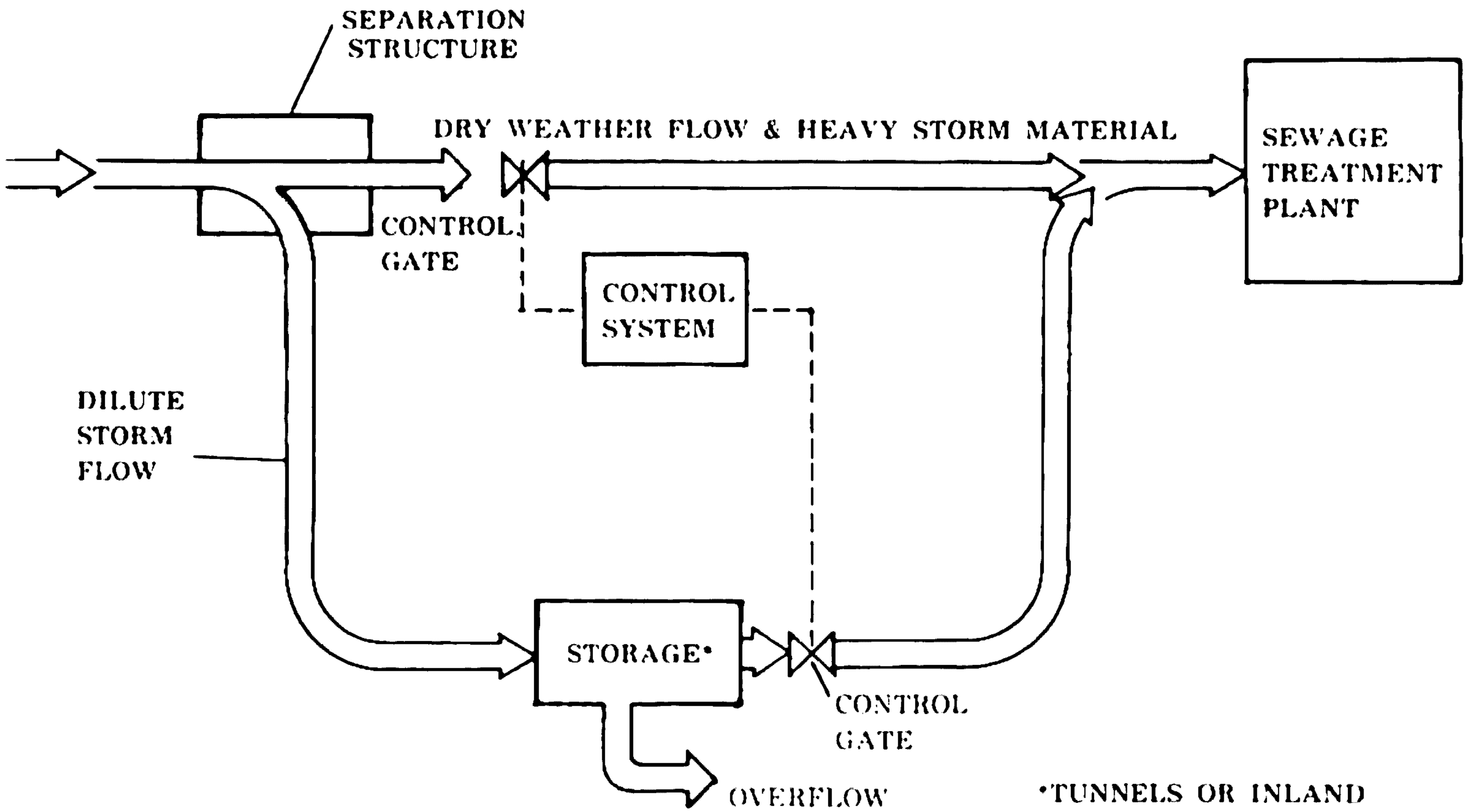
LONGITUDINAL SECTION

SECTION A-A

KEY

1. Existing combined sewer (2'-6"x3'-9")
2. Material separation structure.
3. Dry weather sanitary & optional storm flow bypass
4. Drain to bypass-shunts heavy & floatable fractions past storage.
5. Baffles-entraps floatables until after storm.
6. Weir-retains heavy material, passes dilute storm flow to storage.
7. Influent to storage
8. Distribution channel
9. Downcomers
10. Storage compartment (100,000 cu.ft.)
11. Overflow trough
12. Overflow discharge conduit
13. Emergency dewatering pump system
14. Control gate
15. Gravity discharge-reconnects with combined sewer downstream.
16. Underground service area
17. Air intake
18. Fan
19. Forced air conduit
20. H.P. washdown system vault
22. Local automatic & remote control station- controls valves, pumps, ect. receives signals from central control station
24. Station access manhole

FIGURE V-10
SCHEMATIC DIAGRAM OF WET
WEATHER CONTROL



possible to permit the basins to overflow over a concrete end wall instead of into a series of weir troughs.

Tunnel Storage--The Master Plan proposes a crosstown tunnel in rock from the northeast section of the City through high ground at an elevation sufficient to discharge by gravity at the proposed Southwest Treatment Plant. Storm flow from sewers crossing or adjacent to the route of the tunnel would drop by gravity into enlarged sections of the tunnel serving as storage chambers and storm flows would be pumped from retention basins situated on sewer outlets along the eastern waterfront at suitable rates for treatment into a transport section in the bottom of the tunnel. A perspective cut-away drawing of the tunnel is shown in Figure V-11 and a schematic cross-section is shown in Figure V-12. Storage sections of the tunnel would be approximately 32 feet in diameter and the transport section would be equivalent to a 10-foot diameter conduit at the head end increasing to 16-foot diameter at Southwest. Storage sections would be divided into a lower transport section, central storage compartments serving individual watersheds, and an upper section for ventilation, hose-down piping, and access. It is proposed to provide separation of the heavy and floating materials in a separation chamber on the combined sewer and discharge the flow containing this material directly to the transport section with the cleanest water going into the storage chambers. Controlled gates would control the discharge of water from the storage chambers to the transport section at rates suitable for treatment.

FIGURE V-11
TUNNEL PERSPECTIVE

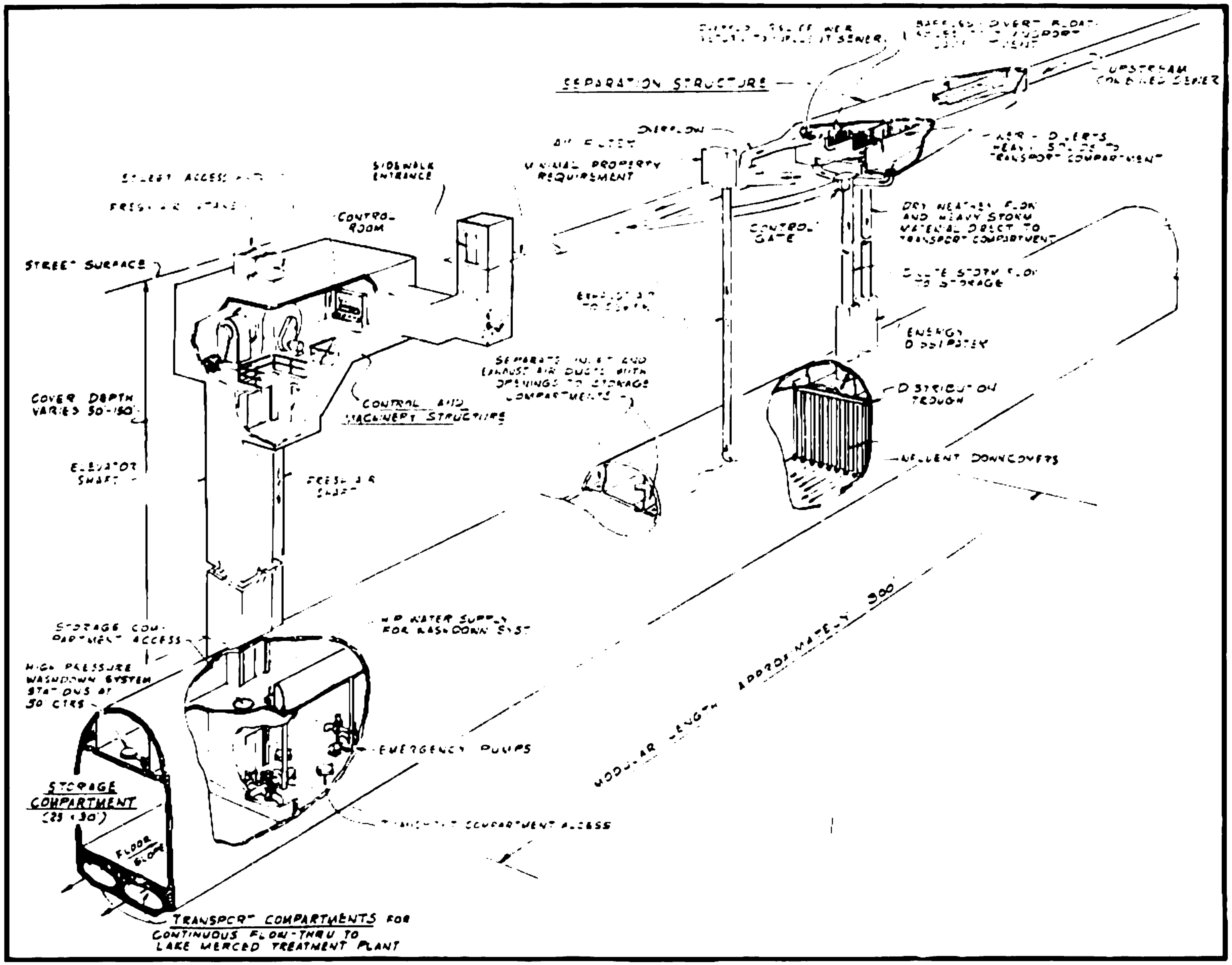
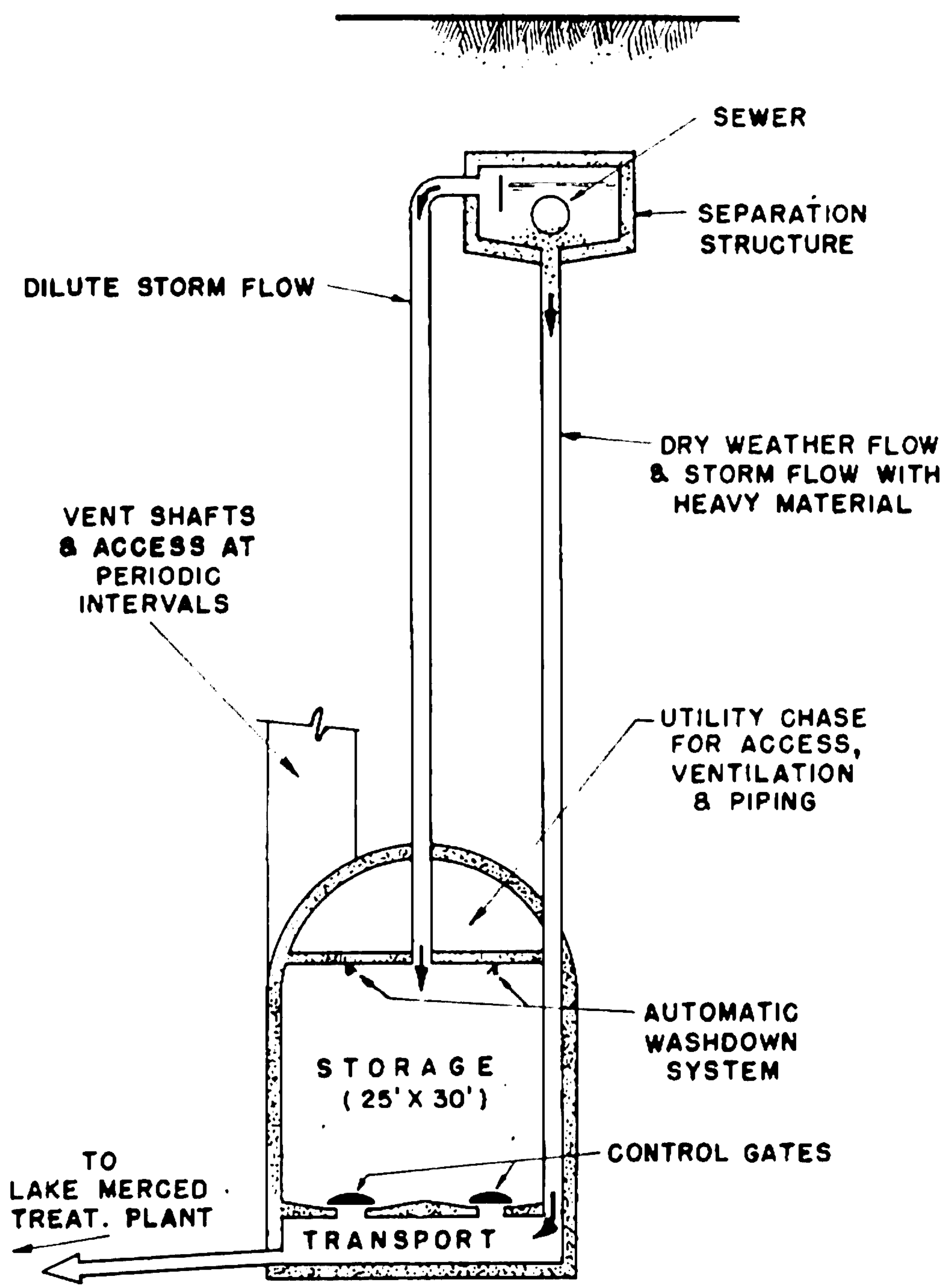


FIGURE V-12
SCHEMATIC SECTION OF TUNNEL



The cross-sectional tunnel area required for storage and the area required to transport the peak dry weather flow from the tributary area is shown below:

Tunnel Storage Required, mil. cu. ft.	2.51
Avg. Cross-Sectional Area Required for Storage, sq. ft.*	68
Cross-Sectional Area Required for Peak Dry Weather Flow**	65
Total Cross-Sectional Area Required, sq. ft.	133
Avg. Diameter Required, ft.***	13
Slope Required for 5.0 fps**** Velocity at n = .013 Flowing Full	.00040

*Based on a length of 37,000 ft.

**1.5 x the projected average flow of 98 mgd from the North Point and Southeast Treatment Plant zones at 3.5 fps.

***Minimum diameter required at outlet end to transport combined flow treatment rate of 991 cfs from North Point and Southeast Treatment Plant zones at 5.0 fps velocity is 16 ft.

****Manning's "n".

The sum of these two areas determines the average cross-sectional area of a possible simple tunnel design. As the storage fills, transport capacity for the wet weather treatment rate could be automatically established without requiring additional storage area. The table also shows the minimum slope required to maintain suitable velocities. The total fall in the 37,000-foot length of tunnel is 15 feet.

The nearly vertical walls of the tunnel would be self-cleaning, and the grade of the tunnel would provide self-cleansing velocities for the dry weather flow. This alternative would provide common storage volume for the North Point and Southeast drainage areas. A regulating gate at the tunnel outlet near Southwest may provide the necessary flow control. Every effort will be made to simplify the tunnel design to minimize initial cost and potential maintenance and operation problems.

The tunnel storage and transportation system will be evaluated in detail to determine if a less complex design would provide dependable service at less cost and with fewer operation and maintenance problems. Master Plan facilities will be evaluated to assure that the proposed system offers the most economical balance of local storage, transportation, centralized storage, and storage available at the treatment plant.

There are still many unresolved questions with respect to total implementation of the Master Plan with respect to storage alternatives. Therefore, data being gathered by the rainfall gages, wastewater flow meters, and the retention basin will be used to determine the most economical balance between localized and tunnel storage for each watershed.

TREATMENT

The Master Plan Report studied wet weather treatment from two viewpoints: a dual functioning facility combining both storage and treatment and physically separated units.

Dual Functioning (Treatment/Storage) Facilities

The comprehensive report notes that to provide multiple treatment units at the shoreline for maximum storm flows without storage would require large volumes of tankage. For example, at an overflow rate of 1,740 gallons per square foot per day (the peak rate selected for the Master Plan's Southwest facility for Level I treatment) and a 10-foot water depth, equivalent to a detention period of 60 minutes, capacities would be required as shown below:

Storm Frequency	Volume
5 year	79 million cubic feet
10 year	94 million cubic feet
25 year	111 million cubic feet
50 year	119 million cubic feet
100 year	139 million cubic feet

Such volumes would function as storage basins up to the time that the tankage became full, after which the treatment operation would be initiated. Thus the provision of adequate treatment capacity to handle high flow rates also provides large storage volumes.

It is interesting to note that the storage capacity provided by the Master Plan is approximately 9 million cubic feet or only 11 percent of the 5-year dual functioning facility value.

Further complications associated with providing dual storage/ treatment units are that they would logically have to be located on the shoreline to fully capture area flows, thereby compounding land acquisition problems. Also the problems of dewatering the basins after storms and solids disposal would still have to be resolved.

Physically Separated Units

The alternative to providing such large treatment capacities, is to consider the use of storage to retain the excessive flow for treatment through intermediate capacity plants when runoff exceeds the available capacity. The reduction in peak flows can be considerable if the basin has capacity to retain all flow until the peak has passed.

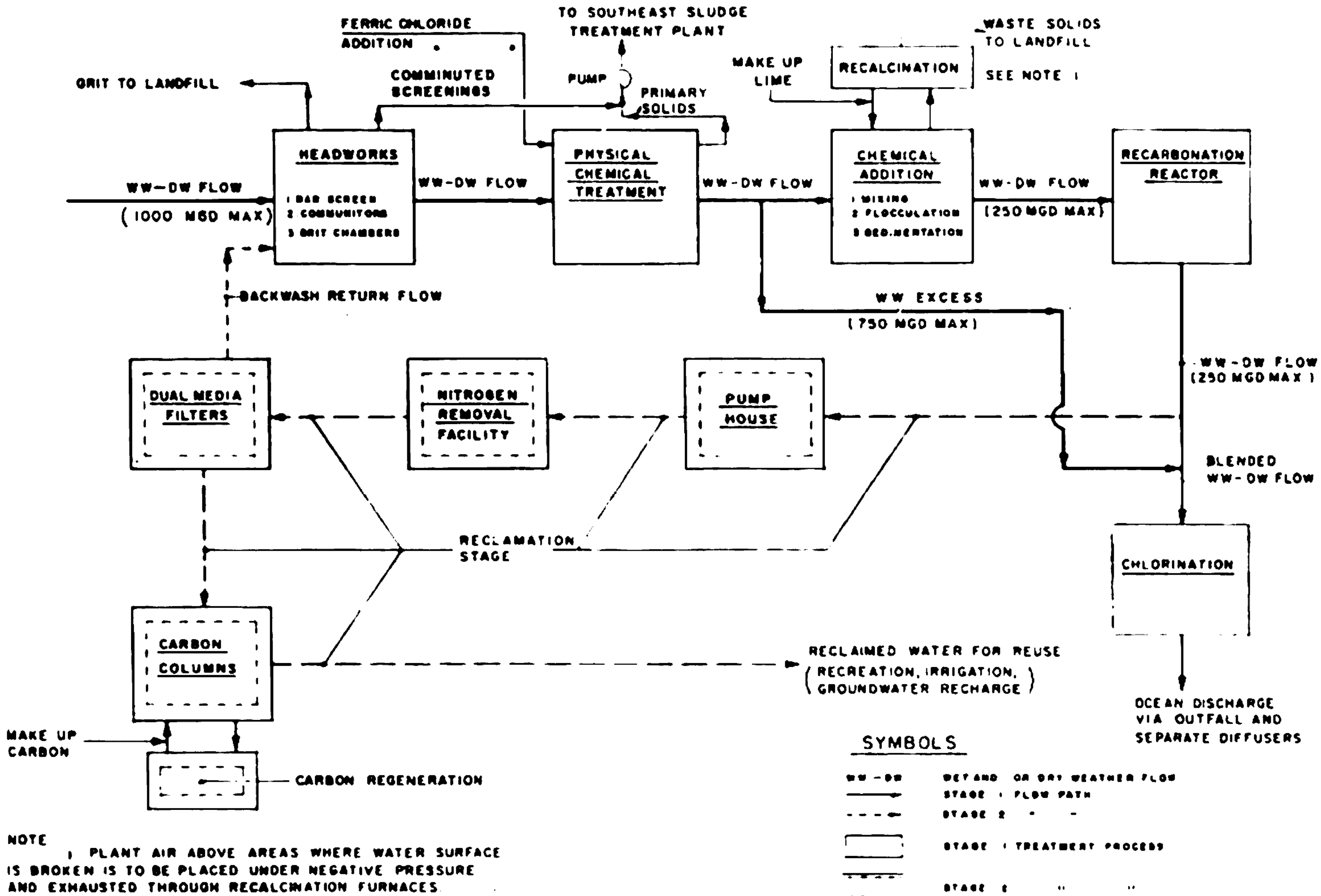
The Master Plan considered treatment capacities varying from 340 mgd (the maximum hydraulic capacity of the existing plants and equivalent to 0.02 inches per hour of rainfall plus the existing dry weather flow) to 1,000 mgd (equivalent to 0.10 inches per hour of rainfall) operating in conjunction with storage. Larger treatment capacities were analyzed with zero storage.

The treatment rate proposed in the Master Plan Report was 1,000 mgd. The proposed plant capacity, while large, is within reason. It amounts to 8 times the projected average dry weather flow, or three times the capacity of the existing plants, and with the help of the storage retention basins will treat combined storm flows many times larger. The plant capacity of 1,000 mgd is the maximum hydraulic capacity, whereas treatment plants are commonly rated at their design treatment capacity for average flows with the hydraulic capability of 1.5 to 3.0 times the average flow.

Proposed Treatment System

A flow diagram of the proposed Southwest treatment facility is shown on Figure V-13. Data on rainfall characteristics and treatment systems have permitted estimates of the desired treatment plant capacity and treatment processes. Additional rainfall data will be analyzed to define the desired treatment capacity and the pilot plant studies will provide information on the most efficient combination of treatment processes. The plant is presently envisioned at a maximum capacity of 1,000 mgd. Initial treatment of the entire flow is proposed to consist of gross solids and grit removal, chemical addition with low-dose ferric chloride, and sedimentation. Following initial treatment, the flow is to be split with a maximum of 250 mgd receiving further treatment and the remainder, up to 750 mgd, being chlorinated and discharged.

FIGURE V-13
PROPOSED SOUTHWEST WATER POLLUTION CONTROL PLANT CONCEPTUAL FLOW DIAGRAM



The secondary treatment level with a maximum capacity of 250 mgd will be operated continuously treating the entire dry weather flow and the portion of wet weather flow up to 250 mgd. The secondary treatment process is planned to consist of high-dose lime addition followed by flocculation, sedimentation, and recarbonation. Following treatment, the effluent will be chlorinated and discharged. From all available data, these processes appear to be preferred above others; however, they are considered tentative until the outcome of pilot plant studies.

Expected effluent qualities for various treatment levels used in the Master Plan to determine the treatment necessary to produce the desired effluent quality are shown in Table V-2. These removal efficiencies are reasonable for the treatment processes specified; however, more accurate information will be developed from the pilot plant studies currently under way.

A single treatment plant was selected because of operational advantages of having one year-round staff and a continuously operating facility. The single facility can also more economically treat runoff from the City, due to its spatial and temporal variation, than can be accomplished by individual treatment systems serving various areas in the City. Individual plants located at the three existing sites would require substantially greater total capacity than a single plant to provide the same level of control of wet weather waste discharges.

For disposal at the southwest corner of the City, wastewater must be conveyed to that area. Since transportation will be available, and operation and maintenance and capital costs are lower per volume treated for large facilities, a single plant in the southwest corner of the City is favored.

The site selected for the new plant (Southwest Water Pollution Control Plant) as shown on Figure V-14 would occupy land now under the jurisdiction of the City Park and Recreation Department, Federal Government, and a portion leased from the City to the State. Present planning for the area has been incorporated into the facility design.

The plant, as envisioned, would be designed to provide maximum multiple usage of the plant area consistent with long-range recreational planning efforts. It is anticipated that through modern design and effort, side-by-side multiple usage of treatment facility land area will be possible. The experience in this regard at the Baker Street Air Flotation Facility in the Marina area serves as a positive example of what can be accomplished. At the present time, the conceptual design for the proposed Southwest plant has incorporated planned zoo parking facilities and some other multi-uses. It was in this light that the City Park and Recreation Department approved the Master

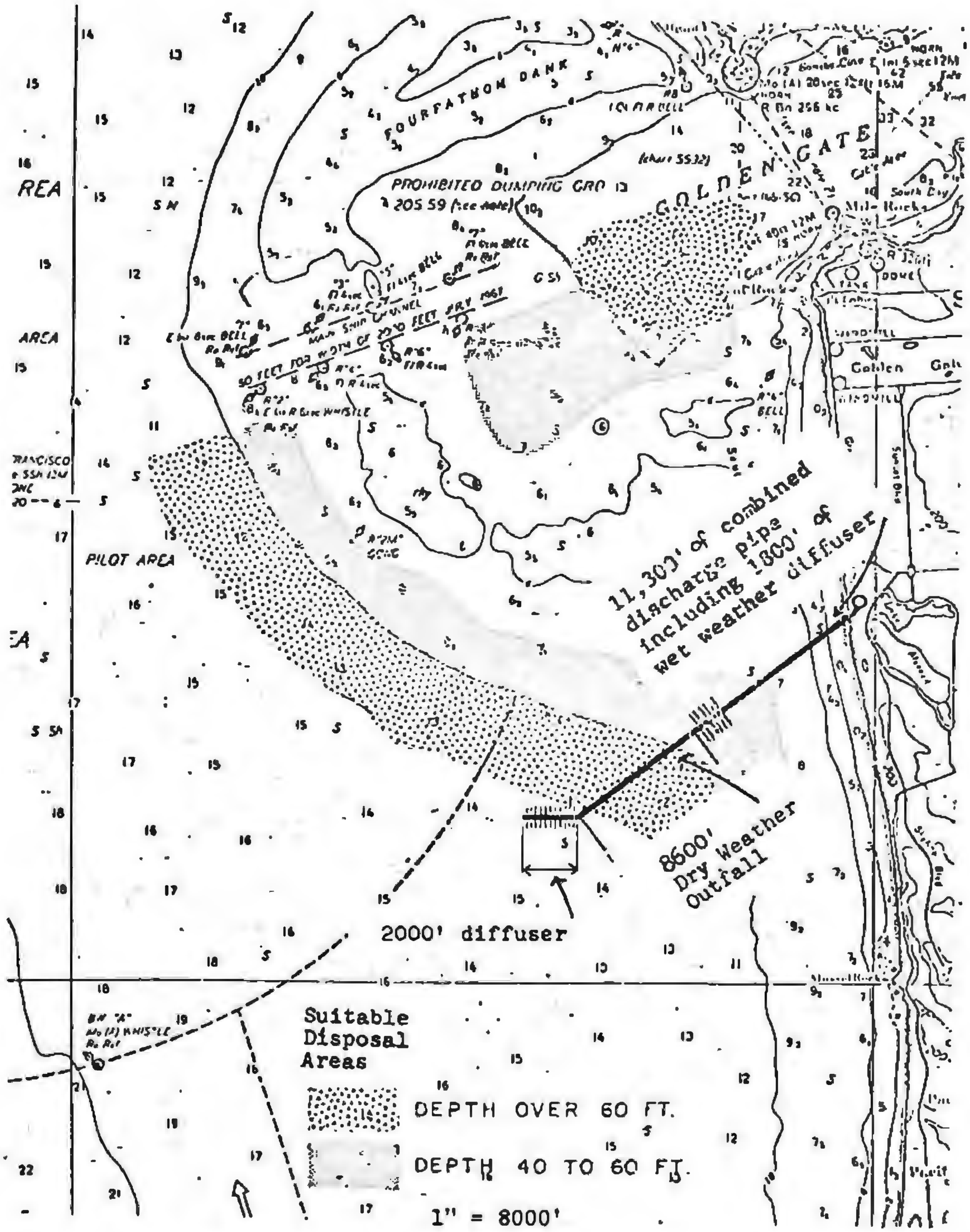
TABLE V-2

EXPECTED EFFLUENT QUALITIES
FOR
VARIOUS TREATMENT LEVELS

Parameter	Units	EXPECTED QUALITY			
		Level I	Level II	Level III	Secondary Treatment
Bioassay--96-hr TL_m	% survival	25	40	90	90
Biochemical Oxygen Demand (5-day)	mg/l	120	80	15	30
Chemical Oxygen Demand	mg/l	300	230	50	60
Oil and Grease, Total	mg/l	30	10	6	10
Aluminum	mg/l	2.2	<1.5	<1.5	<1.5
Cadmium	mg/l	0.02	<0.015	<0.015	<0.015
Copper	mg/l	0.1	<0.05	<0.05	<0.05
Iron	mg/l	1.3	<1.0	<1.0	<1.0
Lead	mg/l	0.07	<0.05	<0.05	<0.05
Mercury	mg/l	0.02	<0.005	<0.005	<0.005
Ammonia (NH_3-N)	mg/l	18	18	<0.015	18
Organic Nitrogen	mg/l	12	7	2	7
Total Nitrogen	mg/l	30	25	5	25
Total Phosphorus	mg/l	16	5	2	10
Floatables	mg/l	0.7	0.7	0.1	0.1
Settleable Matter	ml/l/hr	<0.4	<0.4	<0.1	<0.1
Total Suspended Matter	mg/l	80	40	6	30
Turbidity	JTU*	25	20	2	10

*Jackson Turbidity Units

FIGURE V-14
PROPOSED OUTFALL LOCATION



Plan in principle (see Recreation and Park Commission Resolution No. 9204 which is included in the Appendix). A perspective view of a conceptual plant cross-section and a conceptual flow diagram are presented in Figures V-15 and V-16, respectively.

The system as proposed will treat all flow conveyed to the treatment plant. No bypass at the plant is included in the plans. It is proposed to discharge all untreated wastes directly from the 15 drainage basins. It is possible for the flow to exceed 1,000 mgd at the plant assuming intensive rainfall in the Richmond-Sunset area as well as the north and east portions of the City. It is more beneficial from a water quality viewpoint to discharge untreated waste through an ocean outfall than to the shoreline area when such are the alternatives. Therefore, consideration will be given to providing a bypass around the plant and into the ocean outfall for flows exceeding 1,000 mgd. The desired capacity will be determined by an analysis of the cost of the bypass measured against the benefits of further reducing shoreline discharges.

The following statement is taken from the Master Plan:

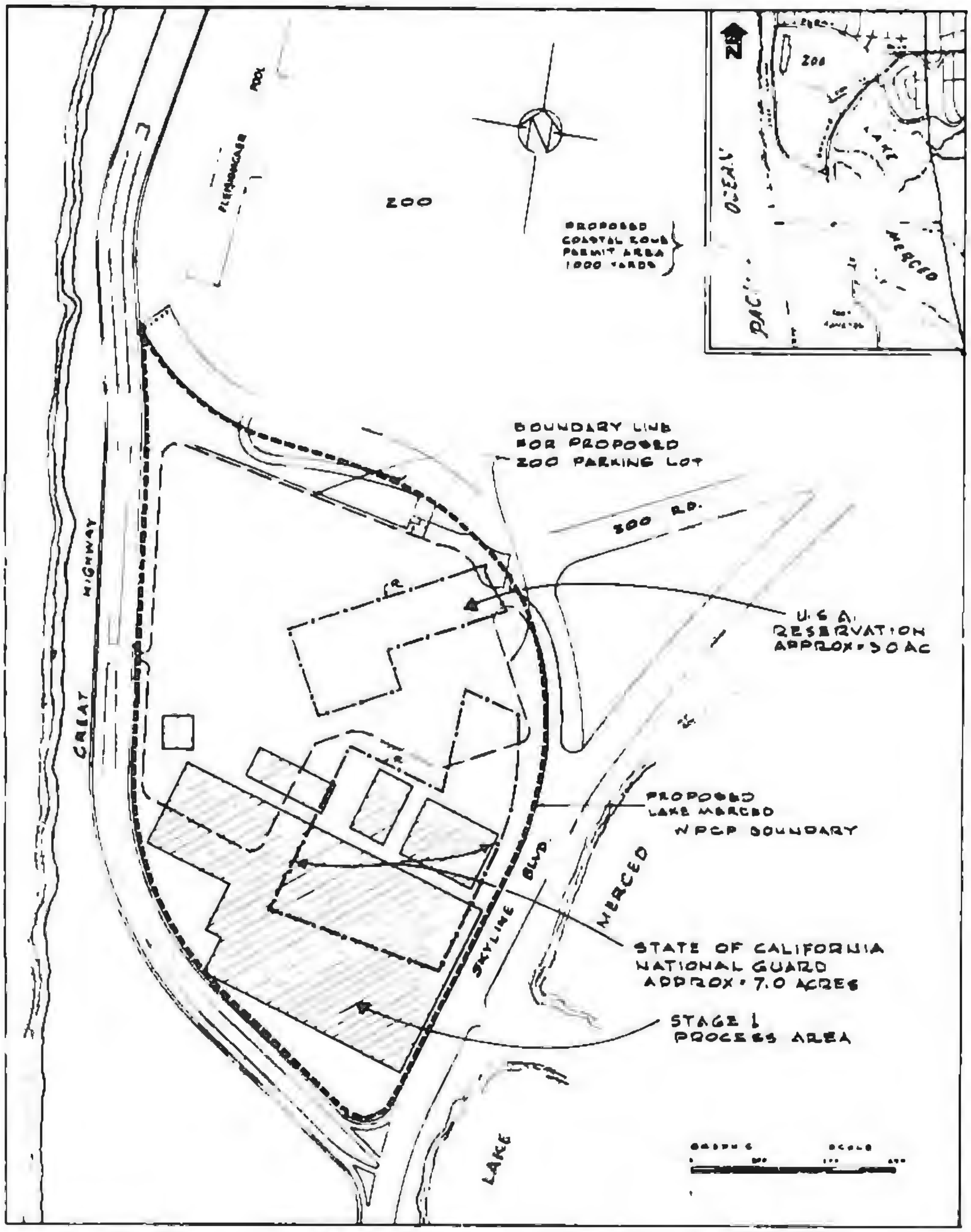
> "Page VI-2: There is an optimum treatment capacity, storage volume relationship which is dependent upon the relative costs of each. For this analysis the 0.10 inch per hour rate appears to be the breakpoint for optimum treatment for the range of withdrawal and treatment. The equivalent plant capacity for the 0.10 inch per hour rate is 1,000 mgd which is the ultimate Master Plan treatment rate."

The Master Plan Report specified a treatment rate of 1,000 mgd, as being the most cost-effective within the range of storage being considered. Relationships between effectiveness, storage capacity, and treatment rate are presented in the Report.

Proposed Lake Merced Outfall

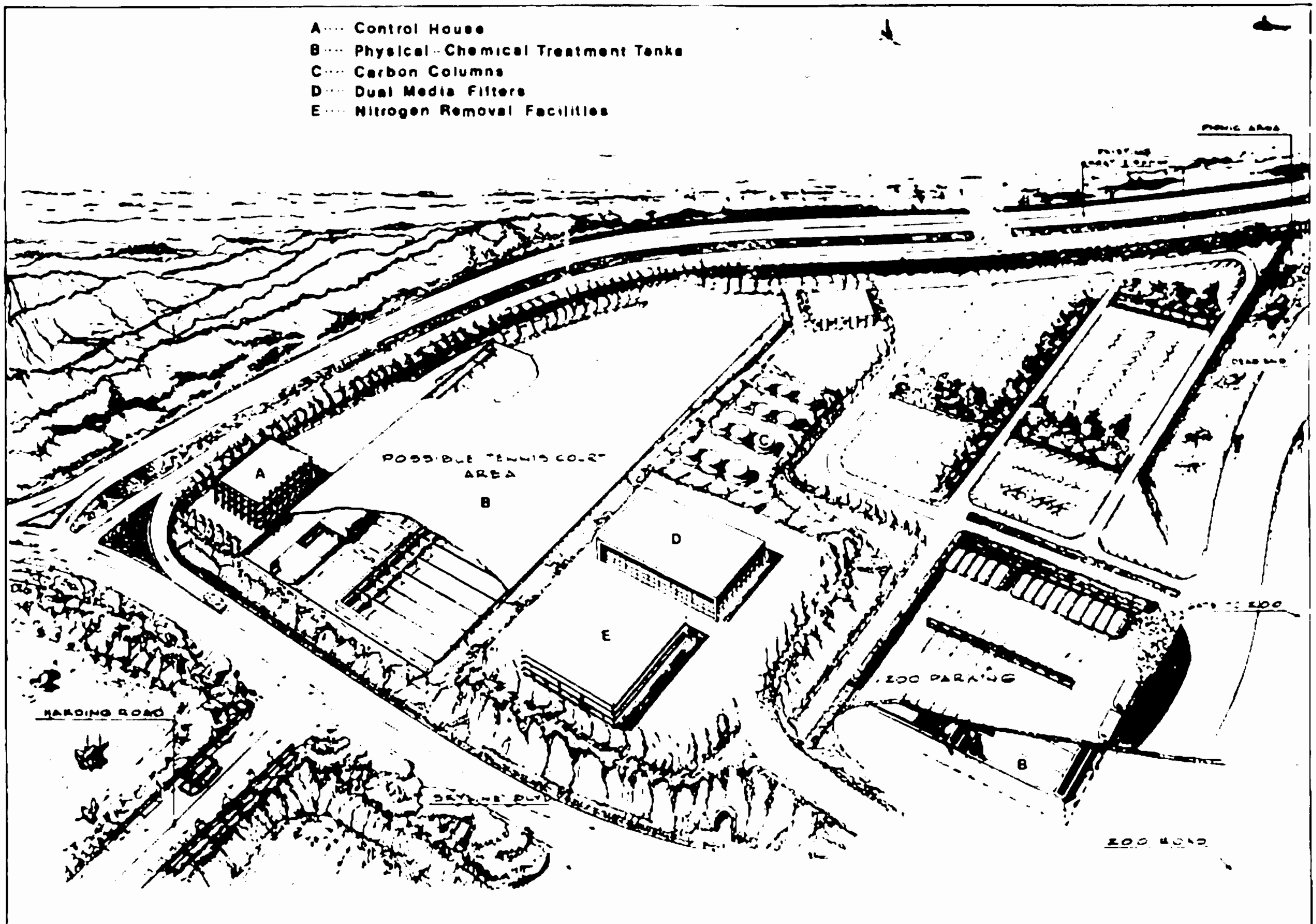
As previously discussed, the facilities proposed in the Master Plan will have the following design flows: 1) average dry weather, 125 mgd; 2) peak dry weather, 340 mgd; and 3) peak wet weather, 1,000 mgd. Because of the great variance in these design flows, the Master Plan proposed a dual-purpose ocean outfall designed to transport dry weather flows four miles and wet weather flows two miles into the ocean (see Figure V-17 for location).

FIGURE V-15
SOUTHWEST WATER POLLUTION CONTROL PLANT LOCATION



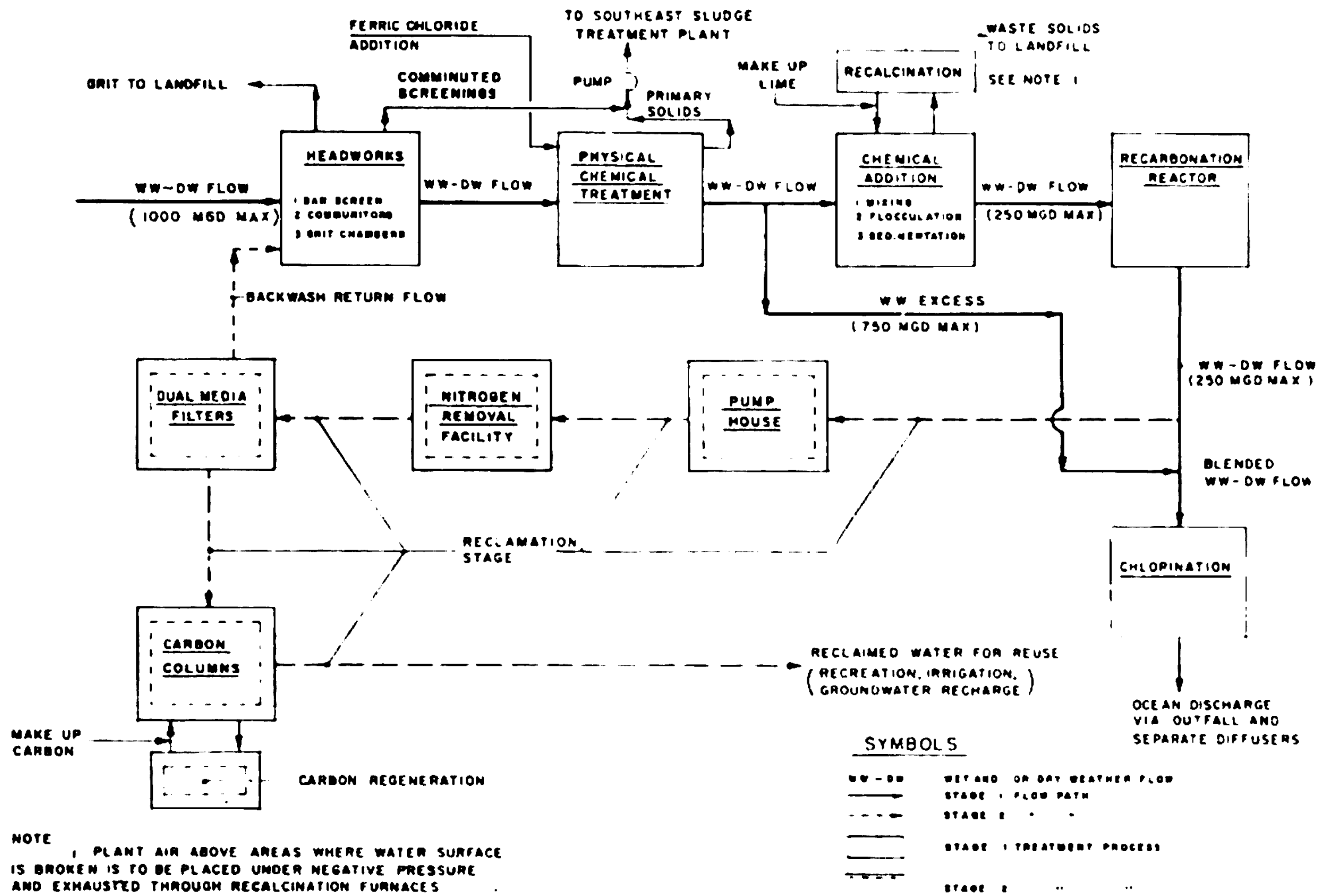
PROPOSED LAKE MERCED WATER POLLUTION CONTROL PLANT SITE
(PROPOSED ZOO PARKING LOT AND EXISTING FEDERAL AND STATE PROPERTIES)

FIGURE V-16
SOUTHWEST WATER POLLUTION CONTROL PLANT PERSPECTIVE



PERSPECTIVE OF PROPOSED COMBINED LAKE MERCED WATER POLLUTION CONTROL PLANT AND ZOO FACILITIES

FIGURE V-17
SOUTHWEST WATER POLLUTION CONTROL PLANT CONCEPTUAL FLOW DIAGRAM



Dry Weather Outfall. As proposed by the Master Plan, the dry weather outfall will contain a 2,000-foot diffuser terminating in about 80 feet of water. The diffuser will ensure that all ecological design criteria for dilution will be met. During peak dry weather flows of 340 mgd, an initial dilution of 107 to 1 will be attained by the time the rising waste plume reaches stability as a submerged field. Under the most adverse condition of low slack water, an initial dilution of 140 to 1 will be achieved for average flow. This dilution will be 2 to 3 times greater during periods of maximum current. It is anticipated that the waste field will reach initial stability at a depth of 15 to 30 feet under most conditions of waste flow and receiving water stratification.

All of the oceanographic information available on the Gulf of the Farallones outside the bar indicates that the effluent field will not contact either the shoreline or the benthos except in dilutions far greater than the recommended ecological design criteria. Near surface currents in the vicinity of the discharge site are predominately southward and westward, largely as influenced by the tidal ebb and flow through the Golden Gate. After the surface layer has been displaced westward and southward to the limit of tidal influence, it disperses and diffuses into the oceanic water mass. Within about 24 hours, its presence is no longer identifiable as a separate water mass and from that point its movement is presumed to be controlled by the prevailing ocean currents. Onshore current vectors are weak and of short duration and the effluent field will probably not reach the shoreline during any one tidal cycle of 25 hours at which time the dilution will be well in excess of 1,000 to 1.

The most critical point for bottom dilution will be the bar to the north of the discharge, because the bottom will be reached first in the shallowest area. At its shallowest point, the water depth over the bar is about 33 feet. The effluent field must travel about seven hours on flood tide at an average current speed of 0.4 knots to reach the shallow area and in that time the dilution would be 750 to 1. The depth of the effluent field would be about 16 feet at this point so that dilution due to vertical dispersion would be about 2 to 1 and the total dilution about 1,500 to 1.

At an average current velocity of 0.41 knots and taking into account horizontal dispersion only, the outfall will produce a field with a minimum dilution of 1,000 to 1 extending approximately 3.5 miles from the point of release with a maximum width of four miles during peak dry weather flows. This dilution will be reached in approximately nine hours.

Wet Weather Outfall. The wet weather outfall will include 1,800 feet of diffuser which will terminate in about 50 feet of water. Unlike the dry weather outfall, the wet weather outfall will produce a surface field. It is ecologically desirable to have a surface field for the wet weather flows because during the rainy season there is a strong surface movement away from the shoreline. (See Chapter I for detailed discussion.) The seaward movement of the effluent field would increase protection for the intertidal and benthic habitats which are the areas most sensitive to effluent impact.

During peak wet weather flows, an initial dilution of 16 to 1 will be attained by the time the rising waste plume reaches stability. However, the minimum dilution on the ocean bottom (critical benthic habitat) will be approximately 1,000 to 1.

Interim South Bay Outfall

The Master Plan calls for an enlarged interim Bay outfall at the Southeast Water Pollution Control Plant. The enlarged outfall will be designed to handle an average daily dry weather flow of 84 mgd (combined North Point and Southeast flows). The Bay outfall will not be utilized when the complete Master Plan has been implemented. At that time all wastewaters will be discharged to the Ocean via the Southwest outfall. This time period will approximate the economic life of the interim outfall.

To date, the Regional Board has not adopted waste discharge requirements for the interim discharge. However, it is anticipated that the Board will at least require "secondary treatment" as defined by EPA. Based upon the weekly average of BOD allowed under EPA's definition, the total load from the combined discharge would be about 20,800 lbs per day. Presently, the combined discharge of BOD from the two plants is about 66,800 lbs per day. Therefore, there will be a total reduction in the BOD load to the Bay of about 46,000 lbs per day due to an increased level of treatment provided at the expanded Southeast facility. However, the total BOD load at the combined Southeast discharge point will increase from its existing value of 12,700 lbs per day to 20,800 lbs per day. Although this is a substantial increase in organic loading to the South Bay it is not expected to have any adverse effects as the combined discharge will occur further offshore in deeper water. The combined discharge might cause a dissolved oxygen depression of 0.07 mg/l which is not considered significant.

It is agreed that the location of the proposed combined discharge may not be desirable from a long-term point of view; however, as an interim solution the overall improvements in water quality accompanying the action would lend favor to the concept. Specifically, the removal of the present 65 mgd primary discharge from the North Point location and conversion of that facility to a wet weather treatment facility which would eliminate most wet weather overflows in the northeast area of the City--Aquatic Park, Marina, Fisherman's Wharf area.

TRANSPORTATION

The transport system envisioned in the Master Plan includes numerous pump stations, force mains, and connecting sewers. The primary features as shown on Figure V-1 are three major force mains, two major transport lines, and a dual function ocean outfall. As presently envisioned, the transportation rate is equivalent of runoff from 0.3 inches per hour of rainfall. This rate was chosen to take advantage of rainfall variation which has been demonstrated during the first stages of the rainfall monitoring program.

The sizing of the transportation system is critical to the success of the Master Plan. For the Plan to function as envisioned, the transportation system must have the capability to convey the wastewater from heavily burdened areas in the City at a rate sufficient to relieve flooding, through storage basins, pipelines, and tunnels to the treatment facility. To provide these capabilities, the system must be sized so that all functions can occur when necessary from any individual retention basin to utilize the maximum control available with one integrated system.

The capacity of the transport system will determine the degree to which the treatment plant capacity can be utilized by any drainage area. Along with storage volume, the transport capacity also determines the necessary hydraulic capacity of the treatment plant, and the limitations on discharging through the ocean outfall rather than at the City perimeter. To date, it has not been possible to determine exactly what these relationships are and what effect they have on the transport system capacity.

The optimum sizing of the transport, storage, and treatment facilities is dependent on the variability of rainfall. The necessary information is presently being gathered to permit sizing of facilities and will soon be available. Since the usefulness of the other components of the Master Plan are limited without the transportation system, it may be necessary to proceed with design of the transportation system sized at a level reasonably assured of being adequate. A rate equivalent to runoff from 0.3 inches per hour of rainfall appears to be sufficiently large to provide such assurance.

CONTROL SYSTEM

As envisioned in the Master Plan Report, a centrally located advance information system will be utilized for planning, monitoring, and control of the Master Plan elements. That system, part of which is already in existence, is planned to operate in the following sequence:

- Rain measuring stations located throughout the City and possibly in surrounding areas such as Marin County and the Farallones Islands will transmit actual recorded rainfall data every 15 seconds to the central control station.

- Monitors located at critical control points in the sewer system will transmit data on actual flow rates to the central control station.

- The central station will record and analyze the data for three purposes:

  1. To provide information on rainfall characteristics to allow selection of probable operating mode early in the storm.

  2. To provide information for control of storage and transmission rates for each individual watershed based on actual runoff data. The system is designed to provide maximum efficiencies from available storage facilities.

  3. To provide data for future system planning and refinement of operating criteria.

Sensing Devices

The centrally located control system relies on sensing devices to measure rainfall and flow which have been developed to a reasonably high degree of reliability and accuracy by San Francisco. Signals are transmitted by telephone lines which could present reliability problems. A system of parallel lines or alternate route systems could increase reliability but is not considered necessary at this time.

Central Control

The information collected at the central receiving station is continuously fed into computers for the purposes listed above. The computers can print a visual image of the storm pattern at any time. When this information is received, the individual storage or transport facilities are instructed either manually or automatically to operate in a particular fashion. For example, when a rainfall is intense in one area of the City, local retention basins can be opened to receive wastewater, and as the storm moves across the City, these reservoirs can be emptied or remain full depending upon the need to assign treatment or transport capacity to other areas of the City.

System Operation

It is proposed that operational signals also would be transmitted on leased telephone line and the equipment that would be instructed to operate from the central control system would include large numbers and varying sizes and types of valves and pumps. The reliability of remote-control operation for 30 upstream retention basins, 15 shoreline retention basins, the crosstown tunnel storage system, and portions of the treatment plants is a complicated subject. Therefore, the proposed study of retention basin operation and centralized automatic controls will provide answers to the following questions which are essential prior to actual system design:

- The reliability of information circuits and the advantages and disadvantages of using radio signals, leased-line telephone circuitry, or a completely independent circuit.
- The reliability of circuitry and control system equipment for operation of valves and pumps from one central remote location.
- The accuracy of prediction under computer-controlled automatic operation.
- The system response rate.
- The risks at each point in the system of control-system malfunction and the need for backup safety features.
- The potential problems and liability that may result from system malfunctions in terms of flooding, unnecessary bypassing, or transportation system overloading.

- A comparison of the cost, reliability, and effectiveness of the proposed control system with a mechanically and hydraulically controlled system which responds automatically to storm conditions in localized areas without external control. The latter system would be designed based on probabilities of rainfall rates.

Operation Responsibility

To be effective it is essential that the complete control system be fully managed and operated by the department responsible for wastewater management. Operational technical functions in the use of computers, transmission equipment, etc., are secondary support functions essential to effective utilization of the system to achieve the most efficient water quality control during any storm period. Therefore, maximum benefit will be made of information provided by the monitoring system to permit the development of effective programs that reflect real system problems.

Necessity

Some form of remote automated information and control system is desirable for operation of the Master Plan. The concept is sound but the many intricacies and potential problems must be resolved and tested prior to actual system design.

The proposed system may be overly complex and result in unnecessary maintenance and operation problems. It may be adequate to provide a float-operated gate on the bypass conduit and one or more self-contained rate controllers on the basin outlets, depending on the capacity required. In the case of shoreline basins, a float-operated gate on the connection to the interceptor and programmed pump operation sensitive to interceptor and retention basin water levels may be adequate to control the discharge to the treatment facilities.

Each change in the design of storage and transmission facilities that simplifies the operational needs will add greatly to the reliability of the overall system. Every effort should be made to incorporate modifications in the system which will increase reliability without significantly sacrificing control. Reductions in numbers of upstream retention basins, increases in storage capacity in the crosstown tunnels, and simplification of tunnel and retention basin design will greatly reduce the complexity of the control system.

SUMMARY

The treatment rates, pumping rates, storage volumes and locations, and transportation system capacity are closely integrated into one overall cost-effective control plan. Unit sizes have not yet been determined and work is proceeding to analyze rainfall data to permit this analysis. A decision is necessary regarding the advantages of bypassing through an ocean outfall at the treatment plant compared to bypassing at the shoreline from the retention basins to permit sizing of the transportation system and ocean outfalls.

CHAPTER VI

SUBALTERNATIVES

LOW CONSTRAINT PROGRAM

Regulatory restrictions and time schedules presently limit control options and establish certain early high priorities. The primary regulatory restriction is that the City of San Francisco provide "secondary treatment" of all dry weather waste flows by July 1, 1977. The next priority is the control of wet weather overflows in the north shore and Ocean beach areas. Implementation of the Master Plan as presently conceived will comply with these regulatory restrictions.

If it were not necessary to comply with these regulatory restrictions, the City's implementation of a comprehensive wastewater management program would undoubtedly proceed differently. For instance, if "secondary treatment" were not required by mid-1977 improved facilities at the existing Richmond-Sunset and Southeast Water Pollution Control Plants probably would not be constructed. It is important to note, however, that the ultimate plan might be the same only the staging might be different.

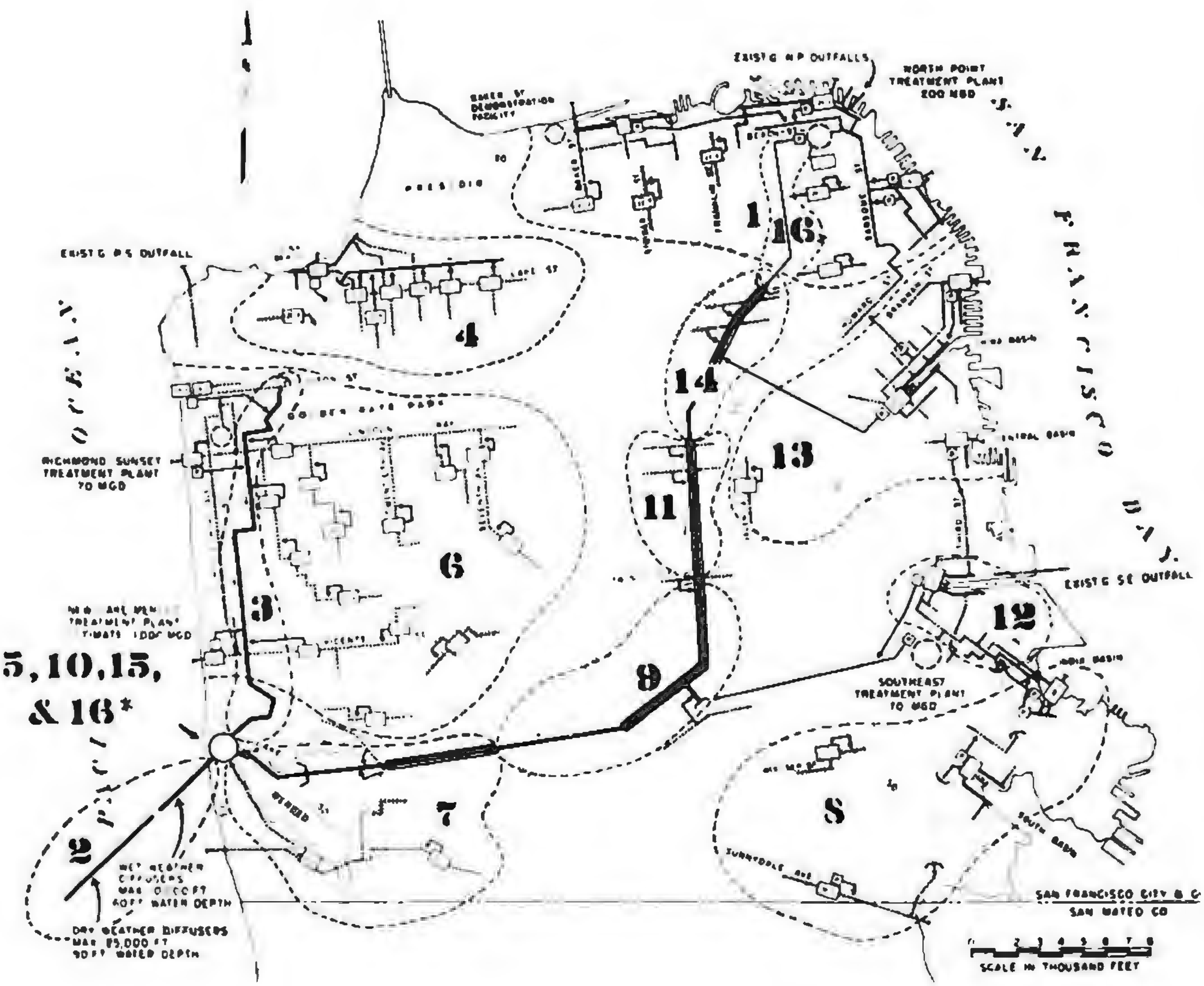
The staging of a "low constraint" program would probably follow the sequence shown on Figure VI-1. For this plan, the emphasis would first be placed on improving the north waterfront area, which includes Marina Beach, Yacht Harbor, and Aquatic Park, by controlling wet weather overflows. The next stage would place emphasis on protecting Phelan, Baker, and Ocean Beaches. The staging would then progress to the Candlestick-South Basin-India Basin areas as the next most likely waterfront areas that should be afforded protection from wet weather overflows. The Islais Creek central basin and China Basin areas constitute the last stages in construction because of the constraints imposed by the sequence in construction of the cross-town tunnel.

ALTERNATIVE LOCATIONS

In developing the Master Plan, prime consideration was given to not only alternative concepts as described in Chapter IV but also to alternative locations of outfall (Bay vs Ocean), treatment plant, and storage facilities. The rationale used in the selection of the Master Plan is summarized below.

FIGURE VI-1
NO CONSTRAINT PROGRAM STAGING

STAGE CONSTRUCTION



LEGEND

DASHED LINES DENOTE EXIST'G FACILITIES
SOLID LINES DENOTE NEW FACILITIES
RETENTION BASIN
PUMP STATION
TREATMENT PLANT
TUNNEL
TUNNEL WITH STORAGE SECTION
FORCE MAIN
SEWER
OVERFLOW SITE
50 FT CONTOUR LINE

AUGUST 24, 1971

PROJECT COST (MILLIONS OF DOLLARS)

ALTERNATE	STAGE 1	STAGE 2	STAGE 3	STAGE 4	STAGE 5	STAGE 6	STAGE 7	STAGE 8
A	20	30	15	12	33	27	18	20
B	27	30	15	17	33	38	20	26
C	39	30	15	26	33	67	26	40
D	53	30	15	38	33	96	32	58

ALTERNATE	STAGE 9	STAGE 10	STAGE 11	STAGE 12	STAGE 13	STAGE 14	STAGE 15	STAGE 16*	TOTAL
A	33	14	12	22	21	19	16	21	333
B	39	14	14	28	36	22	16	21	396
C	57	14	16	43	46	31	16	21	522
D	74	14	17	62	47	39	16	21	665

* STAGE 16 TO BE CONSTRUCTED ONLY IF NORTH POINT WPCP IS ABANDONED

Outfall

The prime consideration in the development of acceptable solutions for the disposal of treated waste from the City was the assurance that there would be no effect on the marine life or on any existing or contemplated beneficial use of the Bay and Ocean. In order to develop such assurance, the City engaged a Technical Advisory Board consisting of Dr. P. H. McGauhey, Professor Emeritus of Sanitary Engineering at the University of California, as Chairman; Dr. C. L. Newcombe, Professor of Biology at California State University at San Francisco; Dr. W. North, Professor of Environmental Health Engineering at the California Institute of Technology; and Dr. P. Wilde, Professor of Oceanography at the University of California. The function of this Board was to provide technical guidance to the firm of Brown and Caldwell which was engaged by the City to perform the field, laboratory, and evaluation work on the Bay and Ocean.

This work was required to develop the oceanographic and biological design criteria necessary for evaluation and selection of waste discharge locations.

In addition, the City established a Project Advisory Board, consisting of representatives of the State Department of Fish and Game, State Department of Public Health, State Water Resources Control Board, Regional Water Quality Control Board, U. S. Army Corps of Engineers, Environmental Protection Agency, and Marin County and San Mateo County to review the results of this study and to develop guidelines that would insure the success of the study and its acceptance by these various agencies. The study included extensive laboratory work performed by Dr. George Schuman, Marine Biologist of Marine Associates of San Diego, and work performed in the Marine Laboratory at Fort Baker under the supervision of Dr. Newcombe.

The studies of the condition of the Bay and Ocean with regard to the ultimate disposal of both treated dry weather and wet weather wastes from San Francisco were conducted over a full year cycle of oceanographic conditions. Measurements included both physical and biological parameters under field and laboratory conditions, as noted above, for the purpose of developing design criteria for effluent disposal. As a result of this effort, criteria for discharge have been developed which reflect existing oceanographic conditions and which can be extrapolated to reflect future conditions.

Briefly, the factors governing the design, location, and successful performance of submarine outfall discharges were divided into three classifications: 1) physical oceanographic factors such as currents and water density which influence the performance of an outfall; 2) conditions which the discharge must meet to avoid an adverse effect on marine environment; and 3) factors such as waste composition and flow rate, and the characteristics of the outfall system. In essence, 1 and 2 are those factors which are design constants and 3 are those factors which may be manipulated.

The field and laboratory work performed by Brown and Caldwell as well as an evaluation of that work plus the design criteria are generally described in Chapters IV and VII of this report.

Based on the Brown and Caldwell studies and recent regulatory requirements discussed in Chapter II, there are only two sites recommended for the long-term combined discharge of the massive quantities of flow under consideration: 1) the northwesterly corner of the City with an outfall extending to deep water in the channel near the entrance to the Bay, and 2) a location in the Ocean off the southwesterly corner of the City outside of the Bar. In this context, it was determined that for any combined dry and wet weather disposal plan, the best probable location is to the west and slightly south of the San Francisco Bar. Selection of this area is based upon the following advantages: 1) the area is, biologically, relatively barren; 2) the depths selected are sufficient to provide the required dilutions for discharge with properly designed diffusers to meet the design criteria presented in Chapter IV; 3) the option of provision for seasonal field variation between surface fields and submerged fields is possible through the use of dual outfall and diffuser facilities; 4) the shoreline is afforded maximum protection in terms of the dilution attained and the probability of effluent fields reaching shore; 5) if further protection is required as knowledge of the effects of disposal increases, then treatment levels may be increased on a split flow basis without the necessity of overcoming existing background levels of pollutants as are existent in the Bay or other zones of multiple discharge; 6) the possible future impairment of the waters at the Alcatraz site caused by South Bay and North Bay discharges extending into Central Bay would be averted.

Areas at the mouth of the Gate and near Alcatraz have some, but not all, of the advantages noted above. Areas south of the Bay Bridge, however, are less desirable than any of the above locations.

Treatment Plant

The location of the treatment plant is mainly predicated on the ultimate point of disposal (i.e., ocean outfall off the southwest corner of the City). Consideration of this discharge location and of the required treatment facilities together with the gravity flow possibilities inherent in the storage system leads to the alternative of consolidation of the wet weather and dry weather facilities in the southwest corner of the City.

Storage Facilities

The Master Plan includes consolidation of the 41 overflow outfalls to 15 via shoreline retention of flows by both basins and tunnels depending on the location. This consolidation, together with appropriate controls, will reduce the existing 82 annual overflows to 8.

At the inception of the study for the location of storage basins, investigation was made on the basis of placing all the storage volume at the shoreline at points of outfall consolidation in order to contain flow from the total drainage area. Two general methods of storage were examined--retention basins and storage tunnels.

A detailed analysis of the cost of tunnels in various materials and locations in the City was conducted and many different types of retention basins were analyzed. From these analyses, it was determined that tunnels at the shoreline, or in areas where water is present, are more costly than retention basins for any volume analyzed. Thus retention basins are more economical than tunnels for shoreline storage. It was also determined that upstream basins cost less per unit volume than shoreline basins. Based upon this conclusion, it was determined to minimize shoreline storage. Another reason leading to this decision was the fact that storage at the shoreline requires pumping to transport the flow to the treatment plant. Based upon this concept, the Master Plan incorporates a maximum of upstream storage for the control of flow in conjunction with peripheral-basins to intercept and contain flow from areas too low to be stored at higher elevations.

It was also determined that the unit price for tunnels in sand are greater than that for retention basins. Thus, no economic benefit would result in utilizing storage tunnels on the west side of the City as most of the area is sandy. In areas on the west side of the City where there is material other than sand, the individual required storage volumes are such that retention basins are less costly than tunnels. However, in the case of upstream areas on the easterly side of the City, the option for tunnels in cases of storage volume in excess of 600,000 cubic feet are economically beneficial.

The location of a site for a retention facility was selected, insofar as possible, to be upstream of an inadequate portion of the transport sewerage system. The flow attenuation thus generated by the basin would serve two purposes; the first being the reduction of combined sewer overflows and the second being to reduce the flow rate in downstream sewers thus relieving their inadequacy. A further benefit can be derived by placing upstream basins to relieve the problem of surface drainage pooling on the street during a high intensity storm.

Tunnels, where useable, have an advantage over retention basins because of their dual storage/transport function. The fact that the tunnel intake is to be in an upstream area allows cross-town transport of flow by gravity. This is an important feature in the evaluation of the existing treatment facilities versus the cost of construction of a new treatment facility for both dry weather and wet weather treatment and energy conservation.

The desirability of using tunnels for storage of high level flow and the locations selected enabled a master cross-town transport tunnel to be considered. Included with this transport tunnel, which is of a minimum diameter to carry a 0.1 inch per hour rainfall on the tributary area, are the necessary storage tunnels. Storage is provided in large diameter tunnels up to 34 feet in diameter with a separate transport section in the tunnel bottom.

The storm flow at the selected locations can be committed to a storage tunnel and when desired a selected discharge rate from storage to the transport tunnel can be made. Included in the control mechanism will be the capability of isolating each or any combination of storage tunnels from the transport tunnel in order that one or more other storage tunnels may be emptied at a rate faster than 0.1 inches per hour for the tributary area. It then follows that when a portion of the City is receiving more rain than another, an appropriate control mode can be exercised.

All storage will be interconnected in a system which will allow a transfer of treatment capacity to service those areas with the greatest need during periods of non-uniform rainfall over the City. This interconnection will minimize the probability of multiple overflow occurrences at different locations which cannot be prevented where zones are not interconnected.

ALTERNATIVE CONTROL FREQUENCY

In developing the Master Plan, the City considered the following four levels of wet weather overflow control:

Alternate	Overflow Occurrence
A	8 times per year
B	4 times per year
C	once per year
D	once in 5 years

Table VI-1 presents a comparison of the wet weather costs, excluding dry weather system costs and inadequate sewer replacement costs, versus the accomplishments for each of these alternatives. As shown in Table VI-1, from an existing condition of 82 overflows per year occurring over a total of 205 hours, a reduction of 92 percent is obtained under Alternate A and over 99 percent is obtained under Alternate D.

It should be pointed out that the Master Plan is the same for all alternatives and only the size of the facilities varies. Also, it is feasible, but not the most economical, to provide facilities for one alternate as a sequential building block to reach a higher alternate. Decreasing the overflow occurrence from eight times per year to even four times per year results in a substantial incremental increase in cost ($63 million).

ALTERNATIVE SIZES

The hydraulic capacity needed to treat the total existing sewer system design storm runoff, which occurs once in five years, would be at a rate of about 16 billion gallons per day. This rate is approximately 50 times greater than the combined capacity of the three existing treatment plants. However, by providing storage, the necessary treatment capacity could be reduced.

TABLE VI-1

COMPARISON OF WET WEATHER COST VS. ACCOMPLISHMENTS

Cost (Wet Weather) - $ Millions	Exist. Cond.	ALTERNATE A $333	ALTERNATE B $396	ALTERNATE C $522	ALTERNATE D $665
PER ANNUM - AVERAGE					
Number of overflow occurrences	82	8	4	1	0.2[1]
% Reduction[2]		90	95	99	99+
Duration in hours	2.5	2	2	3	4
% Reduction		-	-	-	-
Total Hours	205	16	8	3	1
% Reduction		92	96	99	99+
Vol. of untreated overflow discharge (billions of gal.)	6	.8	.4	.1	.02
% Reduction		88	96	98	99+
Vol. of treated discharge (billions of gallons)	38.8	44.1	44.4	44.7	45
Days receiving H_2O exceeds bact. standards	171	40	20	5	1
% Reduction		77	88	94	99+
Suspended solids (million lbs.)	42	14.3	13.2	12.4	12.1
% Reduction		66	68	70	71
COD (million lbs.)	126	81.2	80.9	80.6	80.5
% Reduction		35	36	36	36
Grease (millions lbs.)	10.8	3.5	3.4	3.3	3.3
% Reduction		68	69	69	69
Flotables (million lbs.)	0.5	0.3	0.3	0.3	0.3
% Reduction		30	32	33	34
Nitrogen (millions lbs.)	10.4	9.7	9.7	9.7	9.7
% Reduction		7	7	7	7
Phosphate (million lbs.)	5	1.4	1.4	1.4	1.4
% Reduction		71	71	71	71

[1] 0.2 equivalent to "once per 5 years" frequency.
[2] from "Existing Condition".

In order to develop the optimum design balance between treatment and storage capacity, the City developed a computer program to model the storage/treatment process for combined overflow control. The program was used in conjunction with 62 years of U. S. Weather Bureau hourly rainfall data and 21 years of rainfall data from the Richmond-Sunset Water Pollution Control Plant to route storms of record through the storage/treatment process.

Based on the computer program results, it was concluded that the optimum design balance is to provide a maximum of one billion gallons per day of treatment capacity and 9, 16, 34, and 55 million cubic feet of storage for Alternates A, B, C, and D, respectively.

A detailed analysis was also made to determine the capacity of the expanded Southeast Water Pollution Control Plant. Two basic alternatives were considered: 1) abandon the North Point plant and divert untreated wastewater to the Southeast plant and 2) retain the North Point primary treatment facility and divert effluent to the Southeast plant.

The capital costs of these two alternatives were essentially the same--$115 million versus $117 million. However, the City elected to abandon the North Point facility because of the following:

- Operation and maintenance costs would be reduced by more than $4 million annually.

- During the interim, the North Point facility could be used to treat storm flows and provide protection to the north shore beaches at an earlier date.

- After Stage II is completed, the North Point property could be released for other uses.

- Eliminate the need for trucking chemicals and waste materials through the North Point area.

PART III

ENVIRONMENTAL ASSESSMENT

CHAPTER VII

ENVIRONMENTAL IMPACTS OF THE MASTER PLAN

PRIMARY CONSTRUCTION IMPACTS

Implementation of the Master Plan will involve several major construction projects during the next 20 years. As previously discussed in Chapter V, the Master Plan, as presently envisioned, will be constructed in four distinct stages as follows:

Stage I - Transport System, North Point to Southeast
Southeast Plant Modification and Expansion
Richmond-Sunset Plant Modification
Southeast Interim Bay Outfall
Southwest 2-mile Ocean Outfall
Transport System, Richmond-Sunset to Southwest
North Shore Wet Weather Control System (retention basins plus transport system and North Point Plant modifications)

Stage II - West Side Tunnel Extension
Remaining Shoreline Basins
West Side Upstream Basins

Stage III - Crosstown Transport Facilities
First Phase Southwest Treatment Plant

Stage IV - Remaining Upstream Basins
Ocean Outfall Extension
Completion of Southwest Treatment Plant

The primary impacts due to construction of the Master Plan are generally discussed in the following sections. The detailed impacts will be discussed in the Master Plan Implementation Program documents which will be prepared prior to the construction of each major element. It should be pointed out, however, that all the potential impacts and the permanency of these impacts will depend to a great degree on the care taken during construction.

Biological Impacts

Construction of interceptors generally involve the loss of grasses, shrubs, trees, microflora, and associated fauna along the pipeline routes. Additional vegetation is sometimes lost as a result of the operation of construction equipment and storage of construction materials. Trenching may also destroy the root systems of trees near construction sites, which could result in the death of some specimens.

The construction zone proposed for the North Point to Southeast Transport System is generally industrial in nature and has no natural or self-maintaining plant or animal communities. There is some landscaping at the two plants, however, that could be adversely affected by the proposed construction. Plantings near the North Point and Southeast facilities were described in Chapter II.

The second element of Stage I calls for upgrading and expansion of the Southeast Water Pollution Control Plant to provide a secondary level of treatment for both the North Point and Southeast flows. The upgrading and expansion of these facilities involves a minimal loss or disruption of biota located on or adjacent to the Southeast facility. Some grasses, trees, shrubs, and associated fauna may be lost; however, due to the industrial nature of the area, biotic disruption will be minimal.

The improvement and expansion of the Southeast Bay outfall will cause some disruption to estuarine biota in the construction area, specifically the benthic community. The outfall is proposed to extend offshore from the existing outfall for a distance of about 2,600 feet. Effluent will be discharged at a depth of about 33 feet through a diffuser designed to provide an initial wastewater to estuarine water ratio of 1:100. Brown and Caldwell's studies indicate that the clam, Gemma gemma, is the most common large benthic organism in the San Francisco estuary. This organism and other benthic associated species will be directly affected during the construction phase by direct displacement, turbidity, and settleable materials. Turbidity will also effect the plankton. These effects will all be temporary, however, ending as construction is completed.

Upgrading the Richmond-Sunset plant is also planned for during Stage I. Since this plant is located in Golden Gate Park and surrounded by trees and other vegetation types, any expansion beyond present plant boundaries would result in permanent disruption of flora and fauna utilizing these habitats. However, the possibility of land acquisition beyond present plant boundaries is remote due to legal provisions attached to land use changes on park property. Consequently, the only expected biological impact due to construction at this site is the loss of grasses, shrubs, and associated fauna on the plant site.

Also included as part of Stage I, is the construction of a portion of the North Shore wet weather control system including retention basins, interceptors, and North Point Plant modifications. Construction of the retention basins will likely result in six months to a year of major disruption at each site. Construction (i.e., excavation) will undoubtedly involve the loss or disruption of grasses, shrubs, trees, and microflora which line the streets by destroying their root systems. Additional vegetation could be lost by the operation of construction equipment and storage of construction materials. Where practical, consideration will be given to offstreet sites where the retention basins could be constructed integrally with public use facilities such as parking areas, playgrounds, and parks which would provide additional benefits to localized areas.

Construction of additional interceptors would have similar effects on the biological environment. Modifications to the North Point treatment facility will be very minor and therefore it is anticipated that construction effects to the biological environment will also be very minor.

Also included as a part of Stage I will be the construction of the transport system paralleling the Great Highway from the Richmond-Sunset plant to the Lake Merced area. Any distruptions to the sand dune community and the adjacent residential-associated vegetation along the proposed transport system would be temporary. However, great care will have to be exercised to avoid the necessity of some tree removal in Golden Gate Park adjacent to the Richmond-Sunset plant.

The final element of Stage I will be the first phase construction of the ocean outfall. Initially, 11,300 feet will be constructed including 1,800 feet of diffuser which will terminate in about 60 feet of water. The major biotic effect of construction will be the disruption of the benthic community during the excavation of the outfall. Construction of this outfall will require the excavation and disposal of approximately 500,000 cubic yards of bottom material which can have a temporary adverse effect on the marine environment by causing turbidity in the water and deposition in the immediate vicinity of construction activities. The increased turbidity will have an adverse effect on phytoplankton population by decreasing light penetration, thus decreasing primary productivity. All dredged material will probably be disposed of at an approved ocean disposal site; however, the disposal operation will have an adverse effect on the benthic organisms which the material might cover.

Construction to be completed in Stages II, III, and IV is actually an extension of facilities constructed in previous stages. Therefore, the majority of the biological effects due to construction of all subsequent stages are as previously discussed for Stage I. The one exception to this generalized statement will be the removal of the flora and fauna at the proposed Southwest Treatment Plant site. Care will be exercised to protect as much of the natural habitat as possible. In addition, when completed, the site will be relandscaped to blend in with the natural surroundings which are presently open space.

Physical/Chemical Impacts

Construction associated physical/chemical impacts on the overall environment include those impacts affecting air, erosion, noise, water quality, and aesthetics. These impacts are discussed in the following paragraphs.

Air. Air quality will be affected locally by construction activities since air pollutants such as dust, smoke, and exhaust fumes (carbon monoxide, etc.) are generated by earth moving operations and engine exhausts. The control of dust will be especially important in the sand dune area during construction of the Richmond-Sunset to Lake Merced Transport System. The generation of dust in this area, coupled with the occurrence of normal breezes in the area, could have an adverse effect on residences within several hundred feet of the construction site.

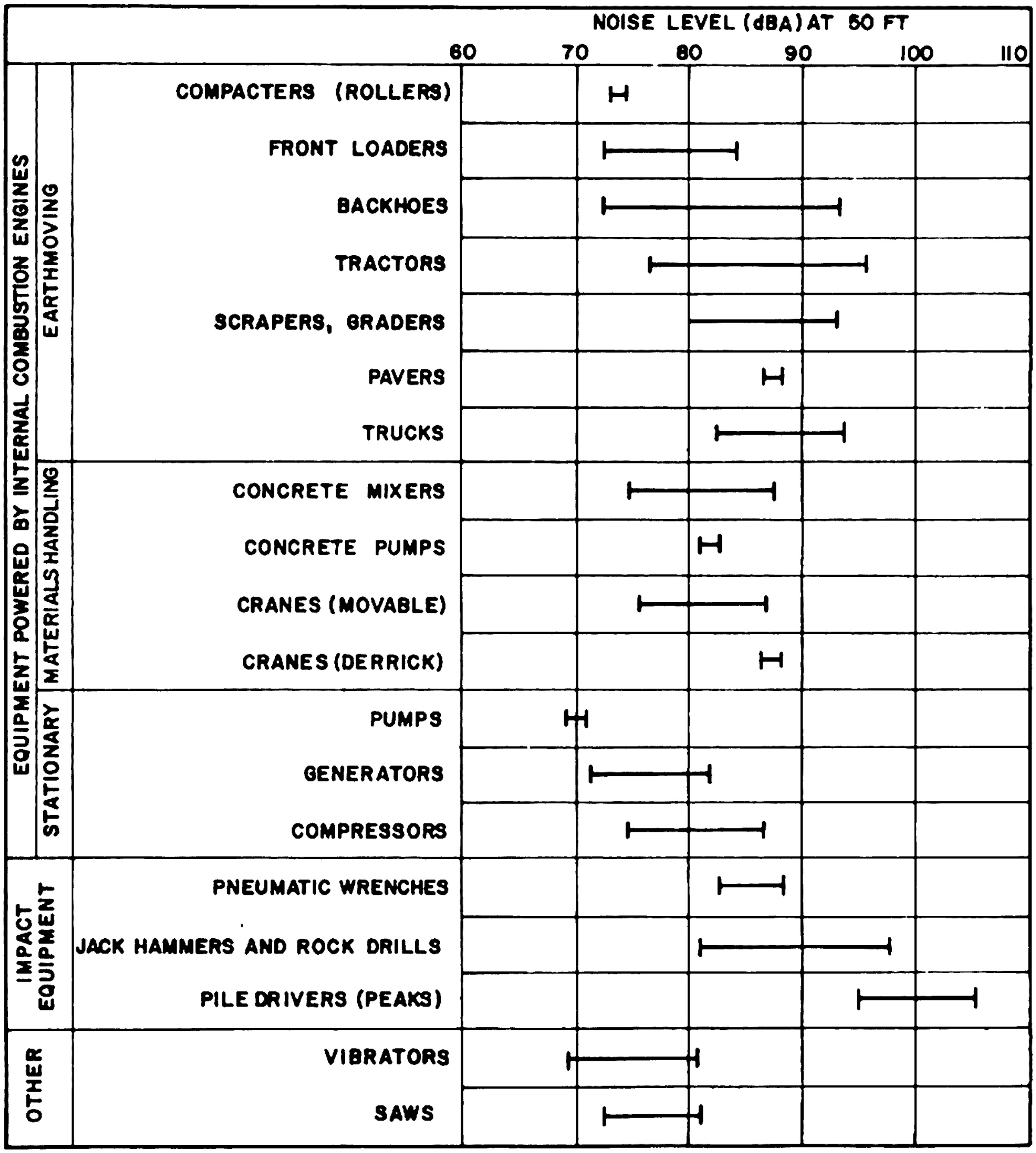
Erosion. The actual erosion hazard in the areas of construction should be only minor, providing appropriate construction practices are employed. Exceptions to this might occur in hill areas which exhibit more than gentle slopes.

Noise. The acoustical quality of the construction areas will be affected primarily by heavy equipment noises and movement of personnel and materials associated with construction activities. Despite the variety in type and size of construction equipment, similarities in the dominant noise sources and patterns of operation permit all equipment to be grouped into a very limited number of categories. These categories are indicated on Figure VII-1, together with their corresponding noise level data. For comparison, typical sources of community noise and their intensities are presented in Figure VII-2.

Most residences near the proposed wet weather retention basins are within 50 feet of the likely basin locations. Noise levels attained at times during construction may be unacceptable for those persons immediately adjacent to the construction area. Therefore, stringent noise level controls will be necessary for those areas.

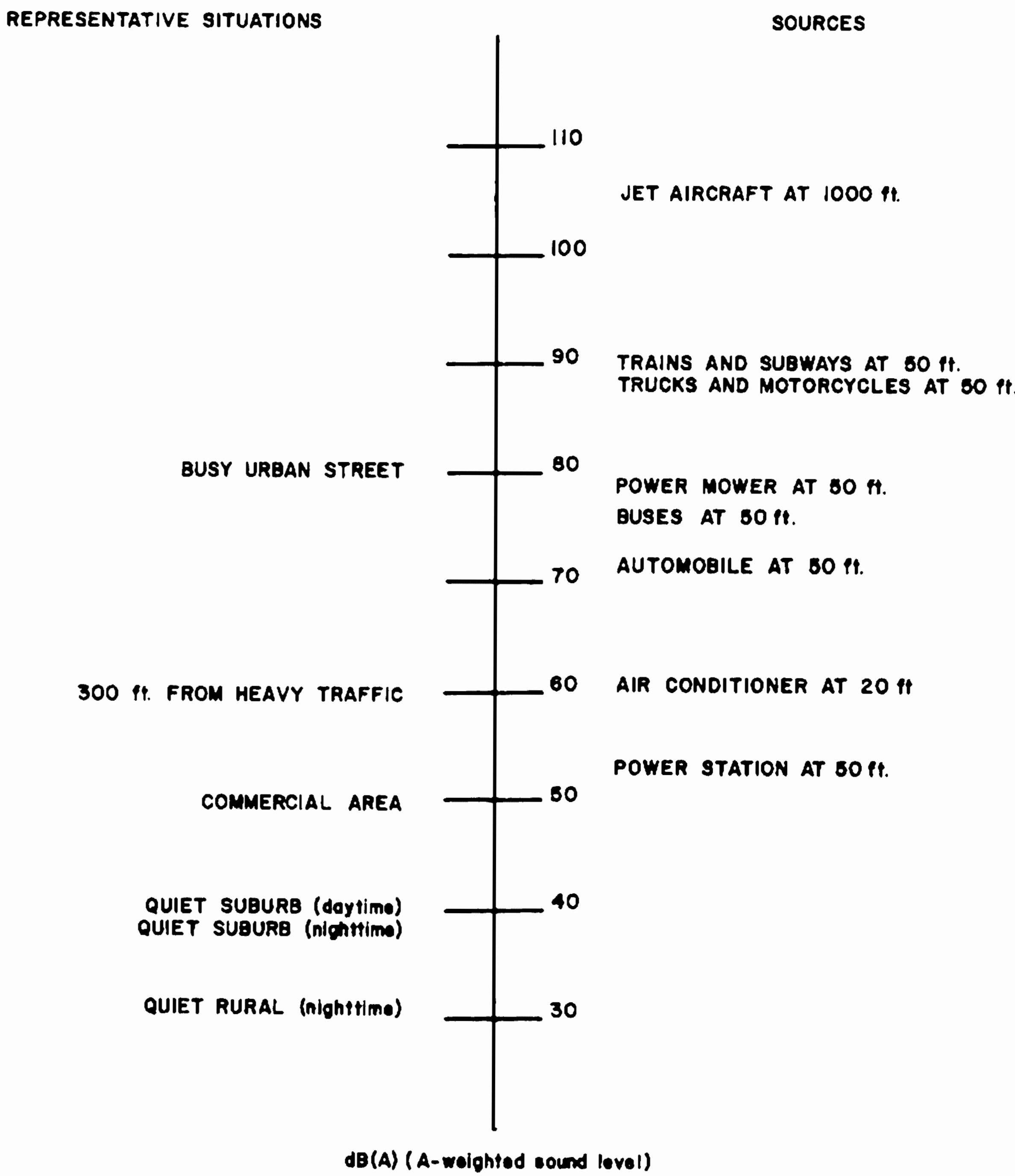
Pile driving will be required during construction of the North Point to Southeast interceptor, the ocean outfall, and the 1000 mgd Southwest treatment plant. Conventional pile drivers are either steam-powered or diesel-powered;

FIGURE VII-1
CONSTRUCTION IMPACT NOISE RANGES



NOTE: Based on limited available data samples

FIGURE VII-2
TYPICAL SOURCES OF COMMUNITY NOISE



in both types, the impact of the hammer dropping onto the pile is the dominant noise component. Noise is also generated by the power supply; steam-powered pile drivers generate noise by releasing steam at the head and diesel-powered pile drivers generate noise by the combustion explosion that actuates the hammer. Noise levels are difficult to measure or standardize because they are affected by pile type and length; however, peak noise levels tend to be about 100 dB (A) or higher at 50 feet. As shown on Figure VII-2, this noise level is about the same as a jet aircraft at 1,000 feet.

Water Quality. Construction of the two outfalls will require the excavation and disposal of large quantities of bottom material which will have a temporary adverse effect with respect to water quality by causing turbidity in the water and by causing deposition in the immediate vicinity of construction and disposal. It should be pointed out that this portion of construction will be controlled by the Environmental Protection Agency and the State and Regional Water Quality Control Boards.

Aesthetics. Bulldozing, excavation, and other earth moving practices will provide localized alterations of landforms. This will be especially critical in areas such as Golden Gate Park and the sand dunes paralleling the Great Highway. The long-term construction program proposed by the Master Plan will temporarily degrade the scenic and aesthetic qualities of the San Francisco area. Construction activities, no matter how minor, in such areas as Golden Gate Park and the shoreline lessen San Francisco's aesthetic appeal to visitors and residents alike.

Social and Economic

Social and economic impacts due to construction activities are those associated with employment, traffic and utility disruption, recreation, energy, and land use.

Employment. Increased employment opportunities will occur during the long-term construction period proposed by the Master Plan. Additional permanent employment opportunities will also be created as additional personnel will be required to operate and maintain the expanded collection, treatment, and disposal facilities. Increased employment also means increased payrolls which will add to the area's general economy.

Traffic Disruption. Construction activities in the more congested or built-up areas will probably cause significant disruptions in the vehicular and pedestrian traffic patterns. This will probably be significant in commercial areas and on the more heavily travelled streets during the peak commute hours.

Utility Disruption. Some utility lines, such as electricity, water, and gas, in the construction areas will have to be relocated. The relocation may result in a disruption of service during the relocation activities.

Recreation. Marine-oriented recreational activities could be hampered by the proposed construction activities. The ocean outfall will probably be constructed off a temporary trestle, at least through the surf zone. The trestle and other outfall construction activities will undoubtedly cause an interference to navigation. Near-shore construction activities will also interfere with recreational useage of the beach area designated as the construction site.

Energy. If the current nationwide energy crisis continues, the increased fuel and other construction-associated power requirements could cause additional shortages in the San Francisco Bay Area.

Land Use. Construction of the Southwest facility, abandonment of North Point, expansion of the Southeast plant, and possible expansion of the Richmond-Sunset facility will affect land use within San Francisco. However, the changes will be compatible with appropriate elements of the Comprehensive Plan of the Department of City Planning.

The Southwest site is presently open space with the exception of a National Guard facility occupying a portion of the property. Construction will necessitate the abandonment of the armory in addition to a land use change from open space to public facilities.

Expansion of the present Southeast facilities will necessitate a relocation of the commercial operations occupying City-owned property adjacent to the present plant site. It will also necessitate the acquisition of non-City property which is presently used for commercial and/or industrial purposes.

The planned vacating of the North Point site will also result in a land use change. This site is presently surrounded by a high density residential-commercial area. The abandoned plant site could be planned to consider the importance to the community of open space and natural areas. This site could provide valuable space within the crowded residential-commercial area for a park, grassed area, ponds, or other natural surroundings that provide needed relief from crowded urban living. To this possible end, the City recently zoned this site public use.

Unique Archaeological, Historic, Scientific, or Cultural Features

The City of San Francisco contains numerous sites listed in the National Register of Historic Places. Construction is not expected to directly affect any of these sites; however, the construction of the inland retention basins, interceptors, or tunnels may bring construction activity near some sites. Protection against land defacement will be afforded these special sites. Following construction there should be no sustained impacts in the areas which might influence the historical, cultural, or aesthetic value of the sites.

PRIMARY OPERATIONAL IMPACTS

Biological Impacts

Pacific Coast Background. Marine disposal of wastewater by means of submarine outfalls has been practiced along the Pacific Coast since the 19th century. A considerable amount of ecological data is available for these discharges since many researchers have studied their ecological effects. Professor Wheeler North, under contract to the City of San Francisco, reviewed and analyzed the biological literature relating to marine disposal of wastewater along the Pacific Coast and much of the following discussion is taken from this source.

Although most of the available literature has dealt with Southern California outfalls which discharge primary effluent into the ocean, a review of some of the prior investigations will provide the reader with a marine-discharge perspective. Therefore, the following paragraphs contain a brief summary of some of the more important investigations.

San Diego Bay received primary effluent and wet weather overflows from the City of San Diego until the Point Loma outfall was placed in operation in 1963. Dr. North inspected the area near the discharge in the late 1950's and observed very little life but large accumulations of sludge. Cessation of the discharge into the Bay caused slowed improvement in water quality and recent reports by the Environmental Protection Agency and Dr. North indicate that biota is abundant and the Bay appears to be in a healthy condition.

Additional work was conducted in 1965 by diving biologists from the California Department of Fish and Game (DFG) at San Diego's outfall site off Point Loma. Comparisons made with data collected by San Diego Marine Consultants prior to construction of the outfall indicated a diverse and abundant fauna and flora existed on the rocky shelf inshore from the outfall and no adverse effects could be attributed to the outfall.

DFG divers also conducted background (1962) and post-discharge (1967) surveys near the small (2.2 mgd) wastewater outfall off Canyon de las Encinas to note any changes caused by the operation. Principal changes involved increased abundances of sand anemonies, hermit crabs, sand stars, and white urchins. Diversities and abundances of species colonizing the outfall structure were considered normal for the age of the "reef". Overall, no adverse influences due to the outfall operation were noted.

Diving biologists from DFG surveyed biota near the Orange County Sanitation District's discharge off the Santa Ana River in early 1965. A nearby artificial reef was also inspected. Numbers and kinds of sedimentary fauna appeared normal as did communities encrusting most of the outfall structure. The last 100 feet of outfall pipe displayed reduced species diversity and there were indications of impoverishment on the artificial reef. The general biological impact of the discharge was nonetheless considered small.

Hartman in an Allan Hancock Foundation report defined several faunal zones according to estimated influence of the Hyperion discharge to Santa Monica Bay. Groups utilized for this purpose were polychetes, starfish, and crustaceans. A zone limited by pollution extended for about half a mile from the outfall terminus. Other biotic zones were labeled pollution tolerant, limited enriched, unlimited enriched, and unlimited diminished, in order of increasing distance from the discharge. Return to normality was judged to occur at a distance of six miles from the outfall. Resig in "Waste Disposal in the Marine Environment" found no barren areas in the Bay when sampling foraminifera, although she did note several unusual distribution patterns.

In a review of recent sportfishing statistics for the Santa Monica Bay, Bendix Marine Advisers noted a precipitous three year decline from 1966 to 1968 (more recent data were not available) and a decreasing long-term trend dating from 1949. The 1966-68 decline extended to all categories of fish. In summary, Santa Monica Bay has revealed signs of change and even stress.

North in reviewing the literature concerning Pacific coast ocean outfalls for the City of San Francisco concluded that no correlation has been found between sewage disposal and plankton blooms. Open sea discharges of primary effluent of less than 100 mgd over sedimentary bottoms can cause faunal enrichment; whereas, discharges of about 200 mgd or more can create adjacent zones of significant impoverishment. For large discharges over sedimentary bottoms the impoverishment may be related to sludge accumulation.

The above studies were presented to illustrate effects of ocean discharges on their own immediate environment. It should be emphasized, however, that each discharge has its own unique physical and biological environment and extreme care should be taken in any attempt to extrapolate cause-effect relationships from one marine outfall to another.

San Francisco Bay Area Background. Background conditions within San Francisco Bay are probably better documented than any other California area. Some information can be found as far back as 1870. The *Albatross* expedition of 1912-13 also provided considerable data on the Bay fauna.

A series of publications in the Wasmann Journal of Biology (1954-1959) by Filice correlated faunal distributions with proximity to waste disposal areas in the Bay. This author identified three zones around waste disposal areas - barren, marginal, and normal.

In the early 1960's a very broad survey was conducted by the Sanitary Engineering Research Laboratory (SERL) of the University of California at Berkeley. For Central San Francisco Bay, the study found the greatest biotic diversity to occur near the Golden Gate. Plant and animal diversity declined as distance from the Golden Gate increased. No correlations were made between benthic animal distributions and specific waste discharges.

The SERL survey was partially duplicated in 1968 by Engineering-Science Inc., as subcontractor to Kaiser Engineers for the San Francisco Bay-Delta Water Quality Program. A primary objective of the Biologic-Ecologic portion of that study was to compare conditions in 1968 with data collected five years previously by SERL and define changes and trends. It should be noted that perhaps the most important conclusion ("Toxicity now exerts a major influence on the Health of biological populations in the Bay", Kaiser Engineers, 1968) does not seem adequately justified. The statement appears to be based on changes found in diversity of sedimentary infauna. The diversity indices employed in the SERL study were not conventional ecological diversity indices. Recalculation of SERL data by the Kaiser Engineers led them to conclude that the effects were not statistically significant.

The City of San Francisco through its consultant, Brown & Caldwell, began a predesign report on Marine waste disposal in 1969. This study involved extensive field and ecological data necessary to establish criteria which would insure protection of the marine environment from the proposed ocean discharge. Criteria developed by the 1969-70 study have been elaborated on in Chapter I and will not be repeated here. The basic finding of the two-year study was that primary effluent from the City of San Francisco, discharged at appropriate points through properly designed submarine diffusers, would not adversely affect the marine environment of the Central Bay or the Gulf of the Farallones. However, recent Federal regulations still require a minimum of secondary treatment. Supplementary ecological investigations were continued in 1971 by Brown & Caldwell. The later study was primarily directed toward Dungeness crab populations and the effects of wastewater effluents on their various life stages. The results of the plankton studies indicate a low population of Dungeness crab zoea in the Gulf of the Farallones. Catches of adult crabs were also low with considerable fluctuation. Laboratory bioassay tests performed on adults, juveniles, larvae, and eggs of several species of crabs showed no statistically significant effect due to wastewater effluents at dilutions ranging from 1:400 to 1:20. It was further concluded, that the results of this study reinforced the conclusions with respect to ecological design criteria of the previous predesign report on marine waste disposal.

However, no samples were taken in the near vicinity of the proposed outfall off Lake Merced. Therefore, Brown & Caldwell has continued its ecological investigations with the following objectives: (1) to satisfy the recommendations of the California Department of Fish and Game, and (2) to obtain baseline ecological data in the vicinity of the proposed Bay and Ocean sites which may have some ultimate bearing on the final site selection.

Task II of this program is intended to provide the ecological baseline data for wastewater disposal in San Francisco Bay. The task is divided into several subtasks as follows:

Subtask II-A --	Preliminary Design of Wastewater Outfall
Subtask II-B-E --	Studies of Benthos near Southeast WPCP
Subtask II-F --	Dispersion of Wastewater Effluents in San Francisco Bay
Subtask II-G --	Studies of Fish and Macroinvertebrates near Southeast WPCP
Subtask II-H --	Sediment Studies
Subtask II-K --	Review of Data

All of these subtasks are currently underway and completion is expected during the Fall of 1974.

Task III-A will consider physical oceanographic conditions in the Gulf of the Farallones. Previous Brown & Caldwell studies were conducted only during the upwelling season. Therefore, this survey was designed to provide more complete data on receiving water conditions.

A dye-tracer release and tracking study was conducted in October 1973 near the proposed Lake Merced outfall. Interpretation of these results, however, must await completion of current data analysis by Brown & Caldwell.

Task III-B includes the collection of benthic biological data in the vicinity of the proposed outfall in the Gulf of the Farallones. Data is being collected in accordance with the recommendations of the California Department of Fish and Game. Three surveys have been scheduled and two have been completed. The first survey was done in July 1973, the second was done in October 1973, and the third is scheduled for February-March 1974. Each survey includes fish trawling, crab trapping, and benthic invertebrate sampling.

Effects of the Proposed Discharges. The ocean outfall in the Gulf of the Farallones will originate from the coastal area near Lake Merced and will discharge at points two and four miles offshore over a sedimentary bottom into turbulent water. Sufficient effluent mixing is expected and sludge accumulations should be negligible. Discharged wastes under these circumstances may have the following influences on surrounding biota.

1. Suspended and dissolved organics might nourish certain species, increasing their survival capabilities and causing abundance increases. Such changes probably would also affect food chains based on such favored species. Possibly less-favored species might decline due to alterations in competition for food or predator-prey relationships.

2. Discharge toxicants might affect nearby sensitive species within limited areas.

3. Concentrations of substances with slow biodegradability might increase among resident fauna and might have selective effects altering the incidence of sensitive species.

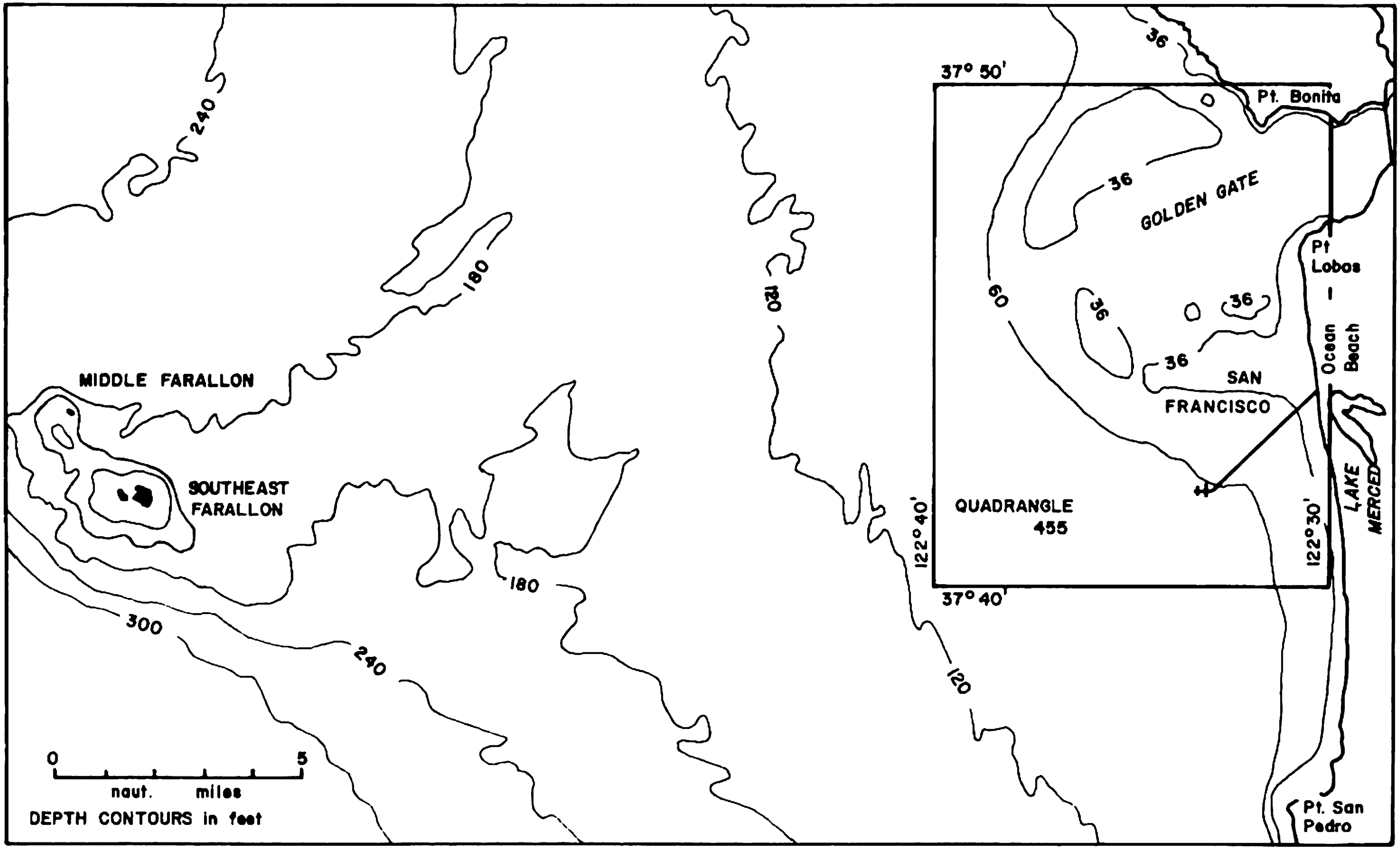
4. Abnormal tastes and odors might cause fish to shun the area.

The following discussion of biotic effects related to wastewater disposal by the proposed Master Plan system involves identification of principle marine resources within five miles of the proposed ocean outfall and within the Bay and then a discussion of how these organisms might be affected by the four mechanisms listed above.

Fin Fisheries. Statistical square 455 in the grid used by the Department of Fish and Game (Figure VII-3) encloses all ocean bottom lying within five miles of the proposed outfall.

Odemar, et al in a study for the Department of Fish and Game gave 1962-1966 averages for Square 455 for many of

FIGURE VII - 3
QUADRANGLE 455
GULF OF THE FARALLONES [a]



[a] Cross section of Gulf of the Farallones, showing location of Square 455 (actually it is a quadrangle) which is a section of an orid used by the Department of Fish and Game for subdividing the California coast.

the fisheries. This area was second only to San Francisco Bay as a source of striped bass. Square 455 also lies centrally within prime fishing areas for salmon and market crab (Dungeness crab). Considerable sportfishing effort is expended within Square 455. The area ranked 5th in partyboat average annual angler days from 1962 to 1966, considering all 129 squares lying between Point Arena and Point Lobos.

The marine resources of primary economic concern in Square 455 are thus, salmon, striped bass, market crab, and to a lesser extent, lingcod, rockfish, and English sole. Some albacore are taken in the Gulf of the Farallones but, as will be shown, any influence by a discharge on this resource would be trivial. Additionally the area contains many animals having no direct recreational or commerical values but nonetheless playing vital roles in the food chains and communities of which these fishes are a part, and thus indirectly contributing to the welfare of local fisheries. It is, therefore, pertinent to review briefly food habits and general biology of the species important in Square 455 fisheries in connection with possible influences of discharged wastes.

Salmon. King Salmon (*Oncorhynchus tshawytscha*) is the most important salmon species in the San Francisco area, being up to 2000 times as plentiful in sportfish catches as silver salmon (*Oncorhynchus kisutch*).

Salmon are anadromous fishes, moving into freshwater streams to spawn when mature. Adults die after spawning. The young migrate downstream after hatching and spend most of their three-to-seven year lifespan in the sea. Large numbers of salmon use San Francisco Bay as a pathway to and from the spawning grounds. If sewage-seawater mixtures affect salmon directly (toxicities, buildup of nonbiodegradables, adverse odors or tastes, etc.), construction of the proposed outfall into the Gulf of the Farallones should not cause any additional changes because salmon have encountered these same wastes for many years while passing through San Francisco Bay. It is more likely that any such direct effects would be reduced by the proposed outfall vs. existing Bay discharges because of design improvements and greater turbulence in the receiving waters.

Merkel, in 1957, analyzed stomach contents of 1004 king salmon captured by trolling near San Francisco. Major dietary items were: anchovy 29.1%, rockfish 22.5%, euphausiids 14.9%, Pacific herring 12.7%, squid 9.3%, other fishes 7.3%, and crab megalops 4.0%. Size of individuals did not affect food habits, but seasonal differences were noted. King salmon thus subsist on a variety of organisms that are primarily pelagic. Confirming this conclusion, Cannon in his book "How to Fish the Pacific Coast" recommended trolling depths of just subsurface to eight to twelve feet above the bottom for salmon. If any changes occurred in pelagic communities in the immediate vicinity of the proposed outfall any nearby salmon would probably substitute forage organisms that had become more plentiful. So long as the total pelagic population was not reduced there might be no effect on the salmon diet. A shift in diet is not expected to have an effect but could, in theory, change the pattern of accumulation of potentially toxic materials in the salmon. No adverse effect is expected on salmon migration as the proposed outfalls are located out of the main migration route and if anything, a beneficial effect might be expected as a result of the elimination of the existing North Point and Richmond-Sunset discharges in the main migration routes.

Striped Bass. The striped bass (*Roccus saxatilis*) like salmon, is anadromous and utilizes the San Francisco Bay-Delta system extensively for spawning. The species is not native but was introduced to San Francisco Bay from the east coast during the last century. The prime striped bass fishing areas lie within the Bay with only a relatively minor surf fishery along the ocean coastline.

Johnson and Calhoun analyzed stomach contents of 387 striped bass from San Francisco Bay. Principal dietary items in their specimens were shrimp 53%, and anchovy 39%. Skinner summarized several studies of food habits of striped bass. Apparently the striped bass is not dependent on one or two forage species; therefore, the proposed ocean outfall should have negligible adverse effects on food supplies of this fish off San Francisco.

Because the Bay fishery presently exists in waters receiving San Francisco (and many other) wastes, it is not expected that the proposed Bay outfall will exert a damaging effect (*i.e.* toxicity or taste and odors, etc.) on striped bass. In fact, if discharged wastes exert any adverse effects on striped bass within the Bay, the proposed ocean discharge in the Gulf of the Farallones would benefit the Bay fishery by reducing the volume of wastes discharged into the Bay.

Lingcod. Lingcod (*Ophiodon elongatus*) are generally associated with rocky bottom and probably most catches in Square 455 are obtained near the Golden Gate, or off Seal Rocks.

Juveniles consumed various crustacea including *Pandalus* and *Neomysis*, as well as herring. Adult stomachs contained sand lances, herring, flounder, dogfish, young lingcod, crab, shrimp, and squid. Some specimens had eaten small amounts of hydroids, ell grass, and even rocks, probably indicating adventitious ingestion while scooping up prey near the bottom. A rule of thumb for finding lingcod is "follow the herring". Quast in 1968 reported from his analysis of seventeen lingcod stomachs almost exclusive recoveries of fish and squid. He found anchovies only in individuals captured by hook and line (the lingcod possibly obtained the anchovies as a result of "chumming"). The varied diet indicated for lingcod suggests that the species would easily alter its food if changes in supply followed operation of an outfall in the Gulf of the Farallones. There is no anticipated deterioration in the Golden Gate area (probably the main source of lingcod in Square 455) as a result of the proposed ocean outfall as the Richmond-Sunset discharge that is presently released at Lands End would be discontinued. The proposed ocean outfall would accept this effluent and disperse it several miles away from the Golden Gate. In addition, the rock ballast along the exposed portion of the outfall will provide a favorable rock habitat for attached organisms and could enhance the fishery for lingcod and rockfish in the area.

English sole. Published information concerning biology of the English sole (*Parophrys vetulus*) in the Gulf of the Farallones is scarce. Even the general literature on California flatfishes is limited. Skinner in "Historical Review of the Fish Resources of San Francisco Bay" reported that "tremendous numbers of immature flounders, sole, and sanddabs are present" in San Francisco Bay. He speculated that the Bay may serve as an important nursery for flatfishes as has been demonstrated for flounders and menhaden in Atlantic coast estuaries. As a group, flatfishes feed on a variety of invertebrates and fishes characteristic of sandy bottoms. Cannon suggested ghost shrimp, fresh stripbait, clam siphons, rock worms, and small crabs as suitable bait for English sole. The available evidence thus suggests that English sole and other flatfishes should be able to adjust to changes in food types if they were to occur in either the Gulf of the Farallones or the Bay because of the proposed discharges.

Flatfishes appear to tolerate large outfalls as well as any group of fishes. Six of the ten most common fishes recovered by Carlisle in his six-year trawl survey of Santa Monica Bay were flatfishes. English sole ranked fifth in recoveries out of 103 species listed. Santa Monica Bay, which receives effluent from the City of Los Angeles, is described in the previous background section. The relatively high ranking of English sole in this survey provides some assurance that the proposed outfall in the Gulf of the Farallones should have a negligible effect on this species.

Pelagic species. Pacific albacore are large pelagic fish that occur worldwide in temperate seas. Other pelagic fish in the San Francisco Bay area include anchovy, sardine, jack mackeral, and Pacific bonito. As albacore and anchovies are the principle members of the pelagic fishery in the area, a discussion of Pacific albacore and the northern anchovy will be taken as representative of this group.

Albacore feed on a wide variety of animals. Clemens and Iselin recovered 23 categories of invertebrates and 53 categories of fishes from a seven year study of albacore stomach contents. Principal dietary components included northern anchovy, rockfishes, jack mackeral, Pacific saury, barracudines, squid, euphausiids, amphipods, and heteropods.

The diverse diet of the species indicates that the proposed discharge would not be likely to affect overall albacore food supplies. Although substantial commercial lands are made in the San Francisco area the contribution from the Gulf of the Farallones is miniscule.

The northern anchovy, *Engraulis mordax*, is a planktophagous species. It is an omnivorous animal living either on phytoplanktonic or zooplanktonic organisms, or on both at the same time. Zooplankters seem to be preferred in the anchovy diet. Among zooplankters, crustaceans such as the copepods and euphausiids are most frequently found in the stomachs, and they appear to be the most important food.

Although there is no sport fishery for northern anchovies, thousands of tons are netted each year for use as live bait by partyboat and other fishermen. A major portion of this catch originates in San Francisco Bay. Therefore, any elimination of Bay wastewater discharges should benefit this fishery simply by removal of a potential hazard.

The proposed ocean discharge would be sufficiently close to shore so that albacore, anchovy, and other pelagic species would only rarely encounter even moderately high concentrations of effluent (*i.e.* dilutions of 500 to 1). Hence toxicity effects would be quite unlikely. The only conceivable influence would be generation of a hypothetical obnoxious odor or taste, excluding albacore and anchovies from a small portion of their total habitat.

Other Fin Fisheries. No adverse effects by the ocean discharge are expected to the Walleye surf perch (*Hyperprosodon argenteum*) even though this was one of the most sensitive species in bioassays conducted by Brown & Caldwell who found 90 percent survival of Walleye surf perch as long as dilutions exceeded 1:15.

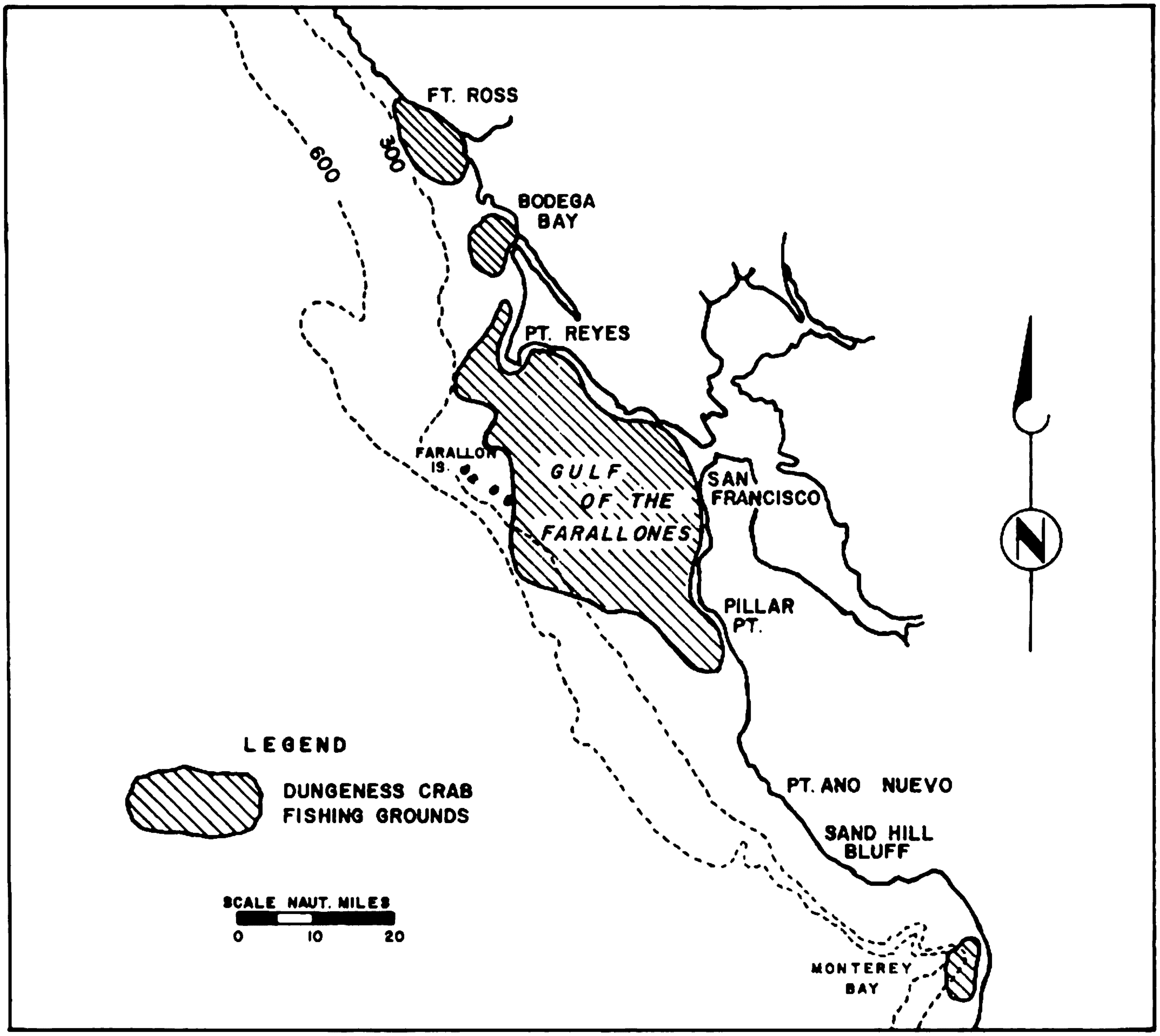
The habitat of the surf perch, however, is in the surf zone which will be protected by the 1000 to 1 dilution criteria established for shoreline and shallow water. A beneficial effect should be realized for surf perch as a result of the elimination of nearshore discharges at Lands End and North Point.

Benthic Community

The consensus of a three year study, by a committee established by the University of California Berkeley (UCB), to find a suitable location for its marine biological station (subsequently sited at Bodega Head) was stated by Dr. Cadet Hand (presently Director of the Bodega laboratory) who noted that the coast from Point Reyes to Pigeon Point (Gulf of the Farallones shoreline) showed "a faunistic and floral depression (which we blame on the pollution, silt, etc., that flows out through the Golden Gate)".

Crab fishery. Dungeness crab (*Cancer magister*), also known as the market crab, formerly occurred in San Francisco Bay in such numbers that at times they were considered a nuisance. The populations were apparently depleted by overfishing and the fishery moved outside the Golden Gate sometime after 1880. (See Figure VII-4.) Like other crustaceans, Dungeness crab have a planktonic existence as larvae lasting for months.

FIGURE VII -4
DUNGENESS CRAB FISHING GROUNDS IN
THE SAN FRANCISCO AREA



Many juveniles settling off San Francisco probably originated from parents situated far to the north. Effects of discharged wastes on reproduction by crabs off San Francisco are thus of lesser concern than effects on larvae and the adult form. Influences of San Francisco wastes on crab larvae and adults have been studied by Brown & Caldwell for the City of San Francisco. Recent investigations have provided the following conclusions:

1. The study area is a special nursery ground for the Dungeness crab.

2. Laboratory tests on adults, juveniles, larvae, and eggs of four species of crabs (Dungeness, Kelp, Hermit, and Porcelain) with primary emphasis on Dungeness crab showed no statistically significant effect due to wastewater dilutions from 1:400 to 1:20.

3. Primary effluent discharged from the City of San Francisco at appropriate points through properly designed submarine diffusers will not adversely affect the marine environment of the Central Bay or the Gulf of the Farallones.

Short-term static bioassays using crab larvae were conducted by the Department of Fish and Game in 1971. The results indicated toxicity to first-stage crab larvae at a San Francisco waste concentration between 8 (1:12.5) and 16 (1:6.25) percent, by volume. At waste concentrations around 1 (1:100) to 4 (1:25) percent, larva survival apparently was not significantly different from controls. The Department of Fish and Game emphasized, however, that these are short-term effects and should not be applied to a long-term evaluation.

Adult Dungeness crab generally prefer shallow sandy bottoms at depths ranging from 25 to 90 feet. The animals burrow until only the stalked eyes and antennules are exposed. Apparently silty water or fine sediments interfere with activities such as respiration while buried because crabs recovered from muddy bottoms may be of poor quality. Any discharge in the Gulf of the Farallones, therefore, should avoid extensive sludge deposits.

Adult crabs are primarily carnivorous. Food consists of fish, shrimp, small crabs, clams, and other animals, including corpses or portions of creatures recently dead. These broad food acceptances can be expected to aid survival of resident crabs near a proposed outfall if changes in benthic populations of infauna occur. Skinner reported that immature market crab occur abundantly in San Francisco and San Pablo Bays. Therefore, it can be surmised that the decline in the San Francisco fishery is the result of failure by crab larvae to settle in the Gulf of the Farallones, or possibly by environmental conditions affecting growth rates rather than any local change in environmental conditions adverse to the adult forms.

No adverse effect should be evidenced in the Dungeness Crab fishery provided the ecological dilution criteria are met. The dilution criteria established were largely influenced by the requirement to protect the crab from their larval stages to adulthood. These criteria will be equaled or exceeded outside the initial dilution zone. Since the level of treatment provided at the Southeast and Richmond-Sunset plants will insure removal of most particulate matter, sludge deposits will not occur. Approximately the first 8,000 feet of the ocean outfall will be buried and thus will not interfere with crab migration either inshore-offshore or laterally. The remaining portion (approximately 14,000 feet) will be laid on the bottom and protected by rock ballast on either side of the pipe which will provide an improved habitat for some benthic organisms; although some interference with crab migration may be anticipated.

Other Benthic Organisms. The proposed Southwest discharge site will be located in an area in which the Shelf community of benthic organisms exist. The Shelf community comprises those organisms which inhabit the finer grained sediments outside the bar at the mouth of the Golden Gate. The entire community is located in water depths greater than 50 feet where the effect of wave agitation and currents is minimal. This community has a low biomass, usually measuring less than one-half of one percent organic material. The major organisms are foraminifera, especially *Elphidiella hammai*, arthropods, and small molluscs.

The proposed Master Plan is designed for protection of benthic organisms by assuring adequate dilution by the time effluent reaches the bottom and by providing treatment sufficient to assure that no sludge deposits occur on the bottom. The Gulf of the Farallones supports a diverse fauna, a majority of the species occurring frequently or in high abundance do not appear to be sensitive to discharged wastes, judging from their distributions in areas near submarine outfalls and in San Francisco Bay.

Other Biota

Plankton. Much work has been done concerning the possible biostimulatory effects ocean discharges of wastewater might have. Gunnerson in the Proceedings of the American Society of Civil Engineers stated that "evidence for greater production of marine plankton in the vicinity of sewage-effluent discharges is strong", citing studies from Florida, Oslo Fjord, and the Mediterrancan as support. This conclusion has since been verified for southern California waters by Tibby *et al*.

Stevenson and Grady usually found increases in planktonic concentrations near outfall "boils". Occasionally the effect could be traced to a 12,000 foot distance. These authors did not believe that effluent mixtures caused plankton "blooms" (marked concentration increases) but they surmised that discharged nutrients might enhance bloom intensities. Gunnerson could find no convincing evidence that the subtle fertilization effects of sewage could lead to dense plankton blooms or eutrophication in open coastal waters although such effects may occur in semi-enclosed situations. Tibby *et al*. concurred in this conclusion.

The City of San Diego conducted surface to 20 foot depth plankton tows for five years near its Point Loma outfall (a discharge that rarely, if ever, extends to within 20 feet of the surface). A total of 80 groups that included 35 species were segregated during processing. Several species may have responded to the Point Loma discharge (*Ceratium dens*, *Ceratium furca*, and *Noctiluca* sp. may have increased temporarily, *Skeletonema costatum* and *Oxytoxum* sp. may have increased, particularly during a period of sludge discharge). Overall, however, it was concluded that influences on planktonic communities were negligible. This study was certainly the most detailed effort and the most carefully analyzed work of its kind ever conducted on the Pacific coast. As a result, the Regional Water Quality Control Board was convinced that the San Diego discharge was not influencing planktonic communities significantly and the City was allowed to discontinue this exceedingly costly program.

The biostimulation potential of San Francisco Bay was studied by Engineering Science, Inc. for the San Francisco

Bay-Delta Water Quality Control Program in 1968. Results of its findings for Central San Francisco Bay indicated that at the normal nitrate concentrations found within San Francisco Bay no stimulation would be expected from the addition of an activiated sludge effluent.

Brown & Caldwell attempted to determine the threshold level of biostimulatory response of San Francisco's composite sewage effluent in seawater. Results showed no difference between controls and dilutions as low as 1:20.

From the above discussion it is reasonably safe to assume there will be minimal adverse effects to the plankton populations due to the proposed discharges.

Kelp. As there are no Kelp beds in the vicinity of the proposed ocean outfall, the project will have no effect on these marine resources.

Avifauna. The project should have no adverse effect on bird life in the area. Treatment of dry weather as well as wet weather flows will insure a minimum of floating material of wastewater origin which may be ingested by birds. No substances should be present in the effluent in sufficient concentration to produce excessive magnification in the food chain to endanger bird life.

Mammals. The proposed Master Plan should have no adverse effect on marine mammals in the area. As with bird life, no substances should be present in the effluent in sufficient concentration to produce excessive magnification in the food chain to endanger marine mammals.

Rare or endangered species. The project should have no adverse effect on rare or endangered species. The only species identified in "At the Crossroads" a publication of the Department of Fish and Game dated January 1972 which might be affected are the California clapper rail, the salt marsh harvest mouse and the Guadalupe fur seal. The habitat of these species is sufficiently remote from the proposed discharge sites to insure no effect.

Physical/Chemical Impacts

Noise. Sound levels associated with wastewater treatment plant operations are generally of a low level and frequency. It has been found in past surveys that traffic generated sound levels generally exceed those from a treatment plant by 10 to 15 dB (A).

No noise complaints have been received due to the operation of the North Point, Southeast, or Richmond-Sunset Plants in the past. Since future sound generation will be no higher than now exists, no adverse impact is expected from noise generation of new equipment or new facilities.

Air. The City of San Francisco has remarkably pure air despite its size. While this is essentially accurate the emissions from the City contribute to some of the most difficult to solve air pollution problems on the west coast. The prevailing winds that disperse emissions and prevent them from accumulating over the City itself, carry these pollutants to the East Bay where they are contained by the East Bay hills and thermal inversions allowing the oxidant reaction to occur, creating some of the highest oxidant concentrations in the Bay Area.

Future air quality will depend upon population level and control measures. Changes in air quality will be a function of motor vehicle traffic and implementation of various emission control measures including regulations to control motor vehicle traffic.

The primary air emission sources contained in the Master Plan will be the waste gas burners used to dispose of excess digestion gas. Digestion gas contains about 65 to 70 percent methane by volume, 25 to 30 percent CO_2 and small amounts of N_2, H_2, and other gases. Emissions from the waste gas burners will include CO_2, water, and small amounts of SO_2.

Receiving Water Quality

Dissolved Oxygen. Depression of dissolved oxygen from wet weather and dry weather outfalls will not be a critical factor. Initial dilution capability for each outfall in combination with the fact that oxygen levels in the waters of the Gulf of the Farallones and Central Bay are near saturation should minimize problems associated with depression of oxygen levels. Mathematical model studies performed by Brown & Caldwell in 1969 indicated that the maximum depletion of oxygen in the Bay resulting from all San Francisco discharges would occur south of the Bay Bridge in the vicinity of the Southeast Plant and would be approximately 0.07 mg/l. This is not considered significant, however.

Nutrients. It was concluded in the Bay-Delta Report by Kaiser Engineers in 1969 that total nitrogen and phosphorus concentrations in Bay waters are substantially higher than the minimum concentrations necessary for biological growth. Enrichment is observed mainly along the shores and in the tidal reaches of some of the tributaries. A possible explanation for lack of excessive algal production is the low level of light availability and the presence of toxic or inhibitory components from wastewater. Projected reduced Delta outflows could significantly reduce turbid fresh water inflows to the Bay and result in increased available light. In addition, control of toxic materials in wastewater discharges will improve which could create conditions more favorable to algal production thereby resulting in increases in algal growth. The net southward movement of an increased submerged field at the Southeast Plant could result in a slight increase in South Bay nutrient concentrations from that discharge point. However, no increase in algal production is expected in this area due to the increased discharge because of the continued low level of light availability in the South Bay.

The increase in nutrient inputs to the South Bay will cease upon completion of Stage III which will divert all dry weather flows to the ocean outfall. Nutrient addition to the ocean environment will have no adverse effects due to the great dilution factor. Biostimulatory effects have been discussed in the previous section.

Turbidity. One of the effects of very fine suspended particles in wastewater discharged into the sea is reduction of local water transparency. Low transparency is typical of coastal waters in general. It affects many of the marine processes, including the depth to which phytoplankton are productive and the regions and depths to which fish and other organisms migrate. The first effect of increased turbidity is to reduce productivity, and in the case of wastewater, probably to moderate and slow the growth of phytoplankton. Low transparency may also increase the numbers of fish migrating into or residing in the region of outfalls. However, these effects do not appear to be particularly important or undesirable.

Coliforms. In densely populated areas, such as San Francisco, water pollution by sewage is an ever present hazard. Several serious diseases can be traced to polluted waters, among them typhoid fever and a group of intestinal disorders generally called "dysentery". The actual causitive microorganisms may be extremely hard to detect. Consequently, health authorities routinely check for the presence of certain bacteria that act as "indicators". The most often used "indicator organism" is the coliform bacteria.

Beaches along the San Francisco shoreline are posted by the San Francisco Department of Public Health from October to April each year due to high coliform levels from wet weather overflows. Maximum coliform levels are attained during the rainy season and can be attributed to wet weather overflows of combined sewage. Historical data collected from 1967 through 1972 shows that Public Health criteria for saltwater bathing (i.e. not more than 20 percent of the samples in any consecutive 30-day period may exceed a most probable number (MPN) of 1,000 per 100 ml.) are normally exceeded throughout the shoreline waters surrounding the City during the entire winter season. In the vicinity of the dry weather outfall, bathing standards are usually exceeded throughout the year with the exception of the Richmond-Sunset area where standards are normally met in July and August.

The proposed Southwest and the improved Southeast outfalls will provide a chlorine contact time in the pipeline itself which should be sufficient for good disinfection. The present bacteriological objective of the Regional Board is a median MPN of 240/100 ml within 1,000 feet of extreme low water. This objective can be met by achieving 99 percent coliform kill in the plant effluent which is attainable at a fairly low chlorine dosage.

Disinfection of the Southwest Treatment Plant effluent plus the long outfall will insure compliance with the above requirements. Dilutions which will be obtained by the time the effluent field reaches the shoreline will insure no bacterial contamination of marine waters and of shellfish used for human consumption.

Adequate disinfection of Bay dry and wet weather discharges, marine wet weather overflows, and sufficient dilution of marine discharged wastewater will provide a beneficial impact to the marine and Bay environments by decreasing coliform densities in critical recreational areas such as Aquatic Park and the Marina. The ocean-side beaches will further benefit from the treatment of combined flows at the Southwest site followed by Ocean disposal. The ultimate removal of all dry weather and most of the wet weather flows from Bay drainage will enhance the recreational uses of shoreline areas by greatly decreasing health hazards associated with untreated waste discharges.

Floatables. Fatty and waxy substances are not foreign to the sea surface. However, the nearshore location of wastewater-derived floatable materials, their association with sewage organisms, their probable content of pesticides and other fat-soluble chemicals, and their general visual qualities which strongly distinguish these materials from the natural ones necessitate their further control.

Variation in the density and distribution of floatable materials in the San Francisco area can be related to wet weather overflows. Distribution is also related to surface drift which for the Central Bay leads to an accumulation on the Ocean beaches outside the Golden Gate. Data collected from June 1967 through 1968 indicates a significant increase in observable floatable material on Ocean beaches during the rainy season from November through April in all areas. Floatable material was observed throughout the year near the Richmond-Sunset outfall.

The average floatable particulate concentration observed during the 1969-70 wet weather surveys was 10.5 mg/m^2 (milligrams per square meter) as compared to 1.5 mg/m^2 observed during dry weather. A similar increase in wet weather levels over those for dry weather was also observed in the surface waters of Outer Marina Beach. Wet weather levels were consistently an order of magnitude (10 times) greater for these sampling stations. There was also a difference between concentrations west of Marina Beach and those in the easterly sector. This corresponds to the lack of both combined and sanitary sewers west of Bakers Beach within the Bay.

A post-storm survey of beaches near wet weather bypass locations will impress any observer. Vast amounts of plastic debris, sanitary articles, and fecal material usually line the beach.

When implemented the Master Plan will consolidate 41 wet weather overflows into 15 shoreline retention basins. These and the other storage facilities combined with the 1,000 mgd Southwest facility will provide a minimum of primary treatment and disinfection to virtually all wet weather flows which will remove all floatable materials and consequently provide a beneficial impact not only to water quality of the marine and Bay environments but also to the aesthetic and healthful appeal of the shoreline areas.

Conservative Pollutants. Conservative pollutants such as copper, chromium, zinc, lead, and mercury will continue to be discharged into the Bay environment until such time as the ocean outfall is utilized for all wastewater disposal. The various means by which these metals accumulate in the environment can be classified as detrital and non-detrital. A conservative pollutant accumulates by detrital means if it is introduced into the sediment in the solid state, whereas it accumulates by non-detrital means if it is removed directly from sea water by means such as adsorption, sulfide precipitation, and organic reactions.

All treatment plants provided for under the Master Plan will maintain provisions for substantial removal of suspended solids which carry heavy metals such as mercury and lead. Therefore, adverse effects from the discharge of conservative pollutants to San Francisco's marine or Bay environments are expected to be minimal.

Other factors which insure minimal discharge of these heavy metals include industrial source control, chemical removal at treatment facilities, and adequate sludge disposal. San Francisco's industrial waste ordinance (City Ordinance No. 15-71) has set stringent numerical limits on toxicity of industrial waste discharged into the City's sewers. However, the development of a program for implementation of the ordinance will require a tremendous effort to identify actual or potential dischargers and to establish administrative procedures.

Pesticides. The pesticide problem was primarily due to the durable chlorinated hydrocarbons such as DDT and DDD which accumulate in food chains. Even when introduced in non-damaging levels they can eventually build up to damaging levels in shellfish and predatory species of fish and fish-eating birds. The reduction of their use has always appeared to be the only satisfactory way to avoid the problem. There has been a 90 percent reduction in the use of these pesticides in California in the last two years.

The threat of toxicity to the Bay estuary is not well understood but does not appear to be significantly increased by San Francisco's waste discharges. Marine disposal is similarly difficult to define as no information is available from which to calculate mass emission rates for storm or combined discharges of pesticides. The great dilution factor combined with an effluent containing a negligible level of pesticide should have minimal adverse effects on the marine environment. Although not pesticides, the polychlorinated byphenyls, because of their chemical similarities, behave much like conservative pesticides, such as DDT, in the environment.

Solid Waste. Presently, about 50,000 tons of wastewater sludge are disposed of annually at the City's sanitary landfill site. With the addition of secondary treatment facilities, however, this volume may increase by up to 50 percent which will present disposal problems in addition to increased transportation requirements. It should be pointed out, however, that the 50,000 tons of wastewater sludge is relatively minor compared with the 700,000 tons of other solid waste materials generated within the City.

The present landfill site in Mountain View is estimated to have a remaining life of three to nine years. Prior to the termination of disposal at this site, another suitable location will be developed. Preliminary disposal schemes include transportation to the Delta to raise the level of islands and improve flood protection, sanitary landfill at an old quarry site in Livermore, and private landfill disposal in the Fairfield area. All three of these plans are being considered in a regional context and are not limited to the City and County of San Francisco alone.

Aesthetics

Aesthetic impacts associated with the implementation of this program of wastewater treatment improvements include consideration of odor generation and control, visual effects, and maintenance of aesthetic qualities of receiving waters.

Odors. The main potential sources of odor in wastewater treatment facilities, under normal operating conditions, are the headworks, primary clarification facilities, and solids handling facilities. In addition, biological units (aeration basins) are subject to odor emissions when the biological process is upset by toxicants, temperature, or overloading. The biological units also emit a slight musty or earthy odor during normal operation which some people find offensive.

At the Southwest Treatment Plant, all facilities which have a potential of producing odors will be covered and equipped with air scrubbing equipment to assure that no offensive odors extend into adjacent areas.

Presently, the headworks, primary clarification facilities, and the majority of the solids handling facilities at the Richmond-Sunset and Southeast plants are housed. It is anticipated that this concept will be continued for all future modifications at these facilities. It may become necessary in the future, however, to scrub the air from these facilities to adequately control odors.

If untreated wastewaters remain in transmission mains, tunnels, and retention basins for long periods of time, anaerobic decomposition will most probably occur resulting in the production of hydrogen sulfide gas. It is essential that this potential source of odor be controlled and should be considered in the design of all facilities.

Visual Effects. Abandonment of the many wet weather discharges in addition to the North Point outfall will enhance the aesthetic quality of San Francisco Bay. The more stringent control on discharges of wet weather flows will also provide a beneficial impact by greatly reducing the amounts of floatables, oil, and grease released to the marine and Bay environments. In addition, enforcement of San Francisco's industrial waste ordinance will regulate discharge of petroleum products to the sewer system. No adverse visual effects will result from the discharge plume as the end of the outfall will be slightly over three miles offshore.

Landscaping. Final plant layouts of the expanded Southeast Water Pollution Control Plant and the proposed Southwest Water Pollution Control Plant have not been fully developed. However, it is anticipated that final designs for both plants will be incorporated into an overall landscaping plan that utilizes the available buffer zones.

The existing Southeast facility is in an M-1 industrial district among iron works, concrete manufacturers, building material suppliers, automobile junkyards, a trucking firm, and general contractor, and has the best kept grounds in the area. It is anticipated that the existing landscaping plan would be extended for the expansion.

It is proposed to construct the Southwest facility on a portion of the 43-acre site adjacent to the southerly portion of the San Francisco Zoological Gardens. Therefore, an adequate landscaping plan for this site is essential. In fact, the City's Recreation and Park Commission requires that a landscaping master plan be developed for the plant site, with particular emphasis on screening the structures, and presented to the Commission for review and approval. The final design of the Southwest facility will be incorporated into the Zoo master plan.

Architecture. As is the case with landscaping, final architectural plans for the expanded Southeast facility and the Southwest facility have not been fully developed. However, it is anticipated that final designs for both plants will be incorporated into an overall architectural plan that blends the facilities into their surroundings.

The existing Southeast facility does blend into its surroundings and it is anticipated that the new facilities will be harmonious with the existing plant.

The Southwest facility will be designed to incorporate multiple purpose use with the Recreation and Park Commission. Preliminary planning indicates that up to 65 percent of the treatment plant structures could be either decked or constructed underground such that the area could be compatible with zoo use. In fact, the underground structures will be strengthened to allow for zoo improvements, including animal exhibits.

Development of the site will also include parking facilities for approximately 2,200 automobiles and 100 buses which will be of great benefit to zoo visitors.

Social - Economic

The proposed Master Plan will provide the basic framework for future wastewater management for the San Francisco City-County area. The eventual form this system assumes can in turn affect the quality of life in the area. This section assesses the social impacts of this Master Plan. These impacts include economic impacts, energy consumption, water quality for future recreational activities, and public opinion.

Economic. The proposed Master Plan will result in increased employment of operating staff at all facilities. These increases will be a direct result of needs in system maintenance and monitoring programs.

Commercial trawling in the marine outfall area could be adversely affected by the minor interference caused by the discharge three miles offshore. This, however, is a small area compared to the available trawling areas in the Gulf of the Farallones.

San Francisco has a number of industrial discharges that contribute substantial quantities of waste to the system. The significance of these industries' contribution to the economy of the City is important to consider only if the additional cost of waste treatment resulting from the proposed facilities would force a closing or altering of the production of one or more of the major industries. Any conclusions in this regard must be speculative because of the lack of information concerning marginal costs, competition within the industry, and the extent to which industry itself can reduce its waste load by reducing water consumption and improving pretreatment. Actual instances of plant closure in California that have been directly attributable to waste discharge costs are extremely few. Nevertheless, the possibility of such a problem should be a matter of concern to the community and every effort should be made to assure that the wastewater rate schedule will comply with State and Federal regulations and at the same time attempt to reduce impacts to industry.

Energy Consumption. The new facilities proposed by the Master Plan will require increased energy needs. These facilities use fairly energy-intensive processes. Power requirements are a major operating expense for conventional treatment plants, and upgrading existing primary facilities or building new ones will require additional expenditures of the Bay area's energy budget. This energy demand associated with wastewater treatment depends on the degree of treatment and the unit processes involved. The major use of energy is to operate equipment such as pumps, scrapers, compressors, blower chlorinators, etc. A 1968 estimate of electrical energy by the Environmental Protection Agency for municipal waste treatment contained values from 0.018 Kilowatt-hour per day per person for minor treatment to 0.226 for tertiary treatment.

A comparison of the total energy produced, purchased, and used for the existing wastewater collection, treatment, and disposal system versus that for the system at the completion of the Stage I facilities and at the completion of the total Master Plan facilities is presented in Table VII-1. The Department of Public Works has provided quality and quantity data or digester gas production of the Southeast facility to Pacific Gas and Electric Company for study. PG&E is presently evaluating the data for economic feasibility of commercial use of the gas.

As shown in Table VII-1, the more advanced waste treatment processes being proposed are even more energy-intensive than traditional processes. Consequently, if the current energy crisis continues, operation of the Master Plan could be disrupted due to energy shortages. This could, in turn, pose severe operational problems which might be reflected in discharge quality.

Recreation. Recreation potential of the San Francisco Bay and marine environment is an important asset to the San Francisco community and California as a whole. As people's work hours decrease, recreation will increase in importance. Implementation of the Master Plan will improve and protect the water quality of the Bay and Ocean shoreline in addition to improving the general quality of life in the San Francisco area.

TABLE VII-1

ENERGY SUMMARY

CITY AND COUNTY OF SAN FRANCISCO WASTEWATER FACILITIES

	Total Energy Produced Gas 10^3 x therm[a] per year	Energy Purchased		Total Energy Available		Energy Used		Surplus Energy Gas 10^3 x therm per year
		Gas 10^3 x therm per year	Elect. 10^6 x kw-hr per year	Gas 10^3 x therm per year	Elect. 10^6 x kw-hr per year	Gas 10^3 x therm per year	Elect. 10^6 x kw-hr per year	
Present Operations	2013	137.1	20.32	2150.1	20.32	881	20.32	1269
Completion of Stage I	4000	0	102.0	4000	102.0	1900	102.0	2100
Completion of Master Plan	4360	0	97	4360	97	1960	97	2400

[a]Therm = 100,000 BTU's

San Francisco's shoreline beaches are used for water body contact recreation. Removal of virtually all discharges to the Bay and near-shore ocean areas would protect this resource by protecting public health against possible bacteriological contamination.

Public Opinion

To be written subsequent to the Public Hearing.

SECONDARY IMPACTS

The secondary impacts of the proposed Master Plan will be brought about primarily by population increases within the San Francisco service area.

Population increases in the project area will depend on factors influencing growth throughout the San Francisco region, and upon land use controls practiced.

The San Francisco City Planning Commission has adopted a comprehensive long-term general plan for the improvement and future development of the City and County of San Francisco. Facilities of the Master Plan are designed to be compatible with all elements of the general plan, particularly the Land Use Plan. In general the Land Use Plan indicates a Citywide spread of population densities, to encourage a variety of residential building types in both the Central and outlying areas, and to encourage a more even distribution of the population throughout the City on the basis of desirable space and density standards.

Population projections of the City Planning Department were used to develop effluent flow predictions and project loading factors for the Master Plan. City population for 1970 was 700,000. The City projection for 1990 is 755,000 and further extrapolated to 780,000 for 2020. Future land uses for the entire City are projected to be 40 percent residential, 22 percent industrial and commercial and 38 percent public lands and government reserves. The City's population projections are higher then those of the Department of Finance, which are being used for regional air and water quality planning in the Bay Area. However, these alternative projections do agree that the City's population can be expected to remain relatively stable.

Although design for the proposed Master Plan is still conceptual, the major sizing factor for the system will be the wet weather hydraulic loadings and not expanded capacity to accomodate population increases. The Department of Public Works agrees that the City is fully developed and any growth that might occur would be attributable to increasing densities due to various forms of urban renewal. In practical engineering terms, the project will not be affected by projected population increases. For example, the 80,000 additional persons projected for the City in 2020 would represent a flow of approximately 8.4 mgd. This is based on a 150 gallons per day per capita rate of wastewater generation. This addition becomes minor in scaling a 250 mgd treatment facility and would not change the design factors. Similarly, reduced population would not impact the Master Plan system since it is designed primarily for wet weather flows.

PROBLEMATICAL EFFECTS

Problematical effects are those impacts that cannot be fully defined but are reasonable in terms of speculation and supposition.

Biological

The discharge through the proposed ocean outfall may have a mild biostimulatory effect which is beneficial to fish and other aquatic organisms.

The question of marine discharges of wastewater influencing neoplastic (cancerous) growths on fish has been a subject of much discussion. Studies to this date have failed to implicate such discharges as being causative agents. It is therefore somewhat of a problematical effect in that such discharges may cause abnormal growths in fin fisheries. Further study is needed in this area.

The discharge of suspended and dissolved organics to the marine environment may affect the food chain. These organic substances may nourish only certain species, increasing their survival capabilities and causing abundance increases. Less favored organisms may decline due to alterations in competition for food or prey-predator relationships. Moreover, concentrations of substances with slow biodegradability may be magnified through the food chain and increased among resident fauna.

The discharge of wastes to marine waters may also cause abnormal tastes and odors causing pelagic fish to shun the area.

Physical/Chemical

Construction activities may result in temporary alterations in soil structure. The movement of heavy equipment, excavation, stockpiling of ill material, etc., may alter local characteristics such as soil permeability and compaction.

Moreover, the disposal of sludge may have a minor adverse impact on solid waste management by the contribution of additional quantities of treated solids to the landfill site.

Seismic

Woodward-Lundgren & Associates, Consulting Engineers and Geologists, recently completed a preliminary study concerning the geology, seismicity, and earthquake effects on the facilities proposed by the San Francisco Wastewater Master Plan. Woodward-Lundgren's report is included in Appendix 2 of this report. A brief summary of the problematical effects of an earthquake on the proposed facilities is presented in the following paragraphs.

Ocean Outfall. The outfall will cross the active San Andreas fault zone about two miles offshore; this zone is not yet located or mapped exactly but it is probably from 200 to 600 yards wide. It is certain that the outfall will be subjected to right-lateral earthquake displacements (sea-side moves north) where it crosses the rift zone. There will likely be breakage (probably at the rift zone) of the outfall during rupture of the San Andreas fault resulting in a major reconstruction program at the point of breakage after such an event. However, if the two-mile wet weather outfall is kept short of the fault zone, an automatic back-up discharge point would be provided while the dry weather outfall is being repaired.

Southwest Treatment Plant. It is possible that ground accelerations at the proposed Southwest Treatment Plant site could approach 0.5 g for several cycles in a 1906-like event so proper aseismic design is essential. A thorough geotechnical site investigation is needed before the specific plant design is begun. As a minimum, however, the plant should be founded on a base of stable soils to be sure that no loose potentially liquefiable dune sands underlie the plant.

Pipelines in the Vicinity of the Southwest Plant. As presently proposed, pipeline routes in the vicinity of the Southwest plant cross areas which have suffered extensive earthquake damage and liquefaction in the past

135 years. For example: the Sunset line would cross the filled area at the Zoo over much of the 1852 washout; the South line would cross the narrow filled neck between the two arms of Lake Merced where liquefaction slides destroyed the trestle in 1906 and where 1957 flow slides occurred; also, the South line crosses several filled areas east of the Lake which are potential zones of liquefaction failure. Therefore, if pipelines are not rerouted, they could be subject to severe ground motion, liquefaction, bouyant floatation, and extensive damage. A detailed geotechnical investigation will be necessary before the final location of these pipelines is determined.

However, even with precautions, major repairs can be expected after a large earthquake, especially where the pipes enter plant structures.

Tunnels. In general, well-reinforced concrete lined bedrock tunnels perform fairly well in strong earthquakes as long as they do not cross active faults. None of the proposed wastewater tunnels cross such faults; therefore, damage is expected to be minimal. A typical trouble spot is where smaller size shafts or pipes join tunnels; at such junctures cracks and pipe pullouts can occur.

North Point to Southeast Pipeline. Probably, the greatest variation of soil and rock types will occur along this proposed pipeline route. It is likely that strong earthquakes would cause damage in the filled areas along this route, especially where pipes cross from filled areas to stronger native soils or from soil to rock. Ground fissures or local liquefaction will shear pipe or remove bedding support causing pipe damage. Generally, the City should expect heavy pipe maintenance in man-made filled areas after a strong earthquake event. Damage can be moderated, however, by using strong, flexible, well-backfilled pipe laid in as few fill-over-mud areas as practicable.

The Southeast Plant. Care should be taken in designing this plant expansion to provide proper foundation support. This is necessary since the expanded plant will overlie potentially liquefiable zones of fill and because it will span from soft Bay Mud to stronger native soils in the southwest end of the site. For these reasons, a detailed geotechnical study of this site is necessary prior to any detail design work.

Reservoirs and Buried Structures. Earthquake effects on buried basins and pump stations are significant; usually the greatest effect is an increase in lateral earth pressure on the walls. For low level structures in saturated soils, dynamic groundwater pressures may also be produced by an earthquake. These structures can be designed to accommodate these increased loadings, however.

Control Facilities. Experiences in the San Fernando Earthquake of 1971 suggest that suspended telephone lines are particularly susceptible to seismic damage. Therefore, it would be very desirable to provide a back-up control system (e.g. microwave, etc.).

Summary. The previous discussion suggests a number of potential, or problematical, seismic effects on the Master Plan facilities. Hoever, earthquake effects need not be critically damaging to the on-land portion of the Master Plan facilities, if proper seismic planning and design are utilized.

Social-Economic

Cessation of wastewater discharges to San Francisco Bay may increase its desirability for fishing and other recreational uses.

Construction activities in the City area may cause temporary disruptions of cultural patterns in the immediate environs. This construction may also pose some threats to the health and safety of people utilizing the area.

CHAPTER VIII

ENVIRONMENTAL IMPACTS OF ALTERNATIVES CONSIDERED

NO PROJECT

As discussed in Chapter IV, the concept of no project is certainly not a viable solution to the City's wastewater disposal problems. It is considered for comparison and statutory purposes only. However, in general the no project concept would have the following environmental impacts.

Primary Construction Impacts

Since the no project alternative does not involve construction, there would be no impacts associated with construction activities.

Primary Operational Impacts

The City and County of San Francisco is presently served by a combined sewer system. During dry periods, all wastewater receives advanced primary treatment consisting of chemical (ferric chloride) addition to gravity sedimentation tanks for more efficient solids removal. Whenever the rainfall intensity exceeds 0.02 inches per hour, however, untreated wastewater is discharged from the collection system at 41 overflow structures located along the periphery of the City.

The biological impacts to the marine and Bay ecosystems caused by these present discharges were presented in Chapter VII. These discharges also have adverse effects on the quality of the Bay and marine waters, however, which would continue under the no project alternative. These adverse effects include the following:

- Material that is floatable or will become floatable would continue to be discharged to the Bay and Ocean shoreline.
- Organic materials that upon discharge result in the reduction of dissolved oxygen in the Bay waters would continue to pose a threat to aquatic life.
- Disease-causing organisms or indicator organisms (coliform bacteria) would continue to represent a

real or potential public health hazard resulting in the continued posting of beaches.

- Turbid wastewaters would continue to be discharged to the Bay and Ocean waters resulting in the continued discoloration problems.

It should be reemphasized that the existing level of wastewater treatment and its associated effects as described above are not in compliance with existing State and Federal regulations.

As discussed in Chapter II, the existing treatment facilities present few aesthetic impacts. The North Point and Southeast Plants are visually compatible with their surroundings. The Richmond-Sunset Plant is hardly visible from the public park roads and there is no indication that it is visually objectionable by the visitors or athletes at the soccer field. Odor generation at the Richmond-Sunset Plant would continue to be a problem, however. Odor generation at the other two existing plants is minimal other than an accidental release of unburned digester gas at the Southeast Plant. This latter problem should also be alleviated in the near future as the City is presently rehabilitating additional digesters which will triple the present capacity.

Population projections for the City of San Francisco indicate very small increases in the number of people in the foreseeable future. Presently, almost all of the land within the City is devoted to residential, industrial, commercial, public, or governmental uses. This trend is expected to continue in the future without any significant changes. Consequently, the quantity of wastewater flows is not expected to increase significantly in the future.

Since the existing treatment facilities have sufficient capacity to handle the dry weather flows and control of industrial wastes will be accomplished by enforcement of the City's industrial waste ordinance, the lack of future capacity expansions would have no direct influence on the growth or distribution of population, industry, or automobiles within the City. However, the recreational quality of areas near wastewater discharge sites would continue to be degraded by a potential hazard to the public health.

Secondary Impacts

If the no-project concept were adopted, the California Regional Water Quality Control Board, San Francisco Bay Region, would undoubtedly commence legal enforcement action against the City. Such actions might involve fines (up to

$10,000 per day), "building bans", and remedial measures. These actions could halt all development within the City and also force the City to comply with existing waste discharge requirements by constructing projects that might not necessarily be compatible with any long-range planning.

INDIVIDUAL TREATMENT PLANTS

The alternative concept of constructing separate treatment facilities at the 41 wet weather overflow structures or at some consolidation of those sites was also considered. The environmental impacts associated with this alternative concept are presented in the following paragraphs.

Primary Construction Impacts

The primary impacts to the biological and physical/chemical environments by the construction of the many treatment facilities would be dependent upon the actual sites chosen for these facilities. However, in general these impacts would include noise, dust, erosion, and traffic disruption as explained in Chapter VII.

The large number of separate treatment facilities proposed by this alternative would provide greater construction employment but would necessitate considerable land acquisition involving changes in land use.

Primary Operational Impacts

The resulting impacts of this alternative would be beneficial to the biological environment. Treatment of wet weather flows would remove many pollutants normally discharged to the Ocean and Bay. In general these effects would be similar to those impacts of wet weather treatment previously described for the Master Plan in Chapter VII.

Impacts to the physical/chemical environment are largely dependent upon the quality of treatment provided under this alternative. As discussed in Chapter IV, high-rate treatment systems for the removal of floatables, pathogens and solids have not yet been developed to provide an effluent of suitable quality for discharge to the Bay or marine environments. For purposes of comparison, however, the following impacts might be realized if adequate high-rate treatment were feasible.

- A beneficial impact would result from the removal of floatable materials now presently discharged to the nearshore waters during wet weather overflows.

- Bacteriological quality of nearshore areas would be improved to provide greater protection to public health.

- Removal of some turbidity from wet weather overflows would provide a beneficial effect to water quality.

- Solids removal by treatment of wet weather overflows would lessen the discharge of conservative pollutants to the aquatic environment.

- Operational reliability would be lessened due to the seasonal use, long periods of shutdown, and the need to "come on line" almost immediately at very high-flow rates. System failures would undoubtedly negate beneficial impacts.

- Solids handling and disposal for the many wet weather treatment facilities would pose not only economic impacts but also associated noise and odor impacts.

Aesthetic impacts associated with this alternative would involve possible noise, odor, and visual effects. The operation of the many small treatment facilities could compound problems in these areas.

Individual treatment plants would probably require increased seasonal employment as a direct result of the maintenance requirements of the wet weather treatment facilities. Power needs, however, would require increased energy over other alternatives considered.

Recreational potential of San Francisco Bay and the marine environment would increase due to the removal of all untreated waste overflows. However, the cost of this alternative has been estimated at $3 billion which far exceeds that of the Master Plan and therefore is not as cost-effective.

Secondary Impacts

The secondary impacts of this alternative would be similar to those described for the Master Plan in Chapter VII.

EXPAND THREE EXISTING PLANTS

The concept of expanding the capacity of the existing three plants to enable the treatment of all wet weather flows plus providing secondary treatment facilities and new deep water outfalls at all three plants was also considered. This concept was rejected for further analysis because of economic reasons ($1 billion for plant expansions, exclusive of collection and transport system modifications); however, the environmental impacts of this concept are presented in the following paragraphs for comparison purposes.

Primary Construction Impacts

Construction activities associated with this alternative would involve some disruption of biotic communities. Upgrading of the North Point Plant would also involve the construction of a new Bay outfall which would require the excavation and disposal of approximately 150,000 cubic yards of bottom materials. Construction of the outfall would directly affect the benthic community by direct displacement, turbidity, and settleable materials. These effects would be temporary, however, ending as construction was completed.

It would also be necessary to construct a new outfall for the Richmond-Sunset discharge. One possible site would be about two miles south of the Golden Gate centerline. Construction of this outfall would require the excavation and disposal of about 350,000 cubic yards of bottom materials causing similar effects as the North Point outfall construction.

The impacts associated with the construction of a new Southeast Bay outfall were described in Chapter VII.

Expansion at the Richmond-Sunset and North Point sites would not be possible without acquiring additional property. At Richmond-Sunset this would require taking of park property and at North Point this would require taking of commercial property.

Physical/chemical impacts of this alternative are summarized as follows:

- There would be a temporary effect on water quality as a result of the required outfall construction.

- There would be a temporary increase in noise associated with movements of personnel, materials, and vehicles.

- There would be a temporary interference with navigation and shoreline activities on nearby piers.

Aesthetic, social and economic impacts due to construction would be similar to those described for the Master Plan in Chapter VII.

Primary Operational Impacts

Biological effects of expanding and upgrading the three present facilities are summarized below.

- The impact on the sports fishery of the North Point area would be reduced.
- Shoreline biota which may have been adversely affected by the existing discharges would be benefited.
- Continued long-term discharges to the Bay environment would add nutrient that could cause biostimulation problems.
- Treatment provided to wet and dry weather flows would ensure removal of most settleable material. Little effect on the benthos would result from deposition of organic matter since sludge would not be discharged through the outfall.
- There would be a permanent minor interference with crab migration due to the new outfalls. However, the crab fishery would not be affected otherwise.

Noise and air impacts under this alternative would be similar to those of the Master Plan in Chapter VII.

The expanded facilities would all continue to discharge fresh water into the saline environment. However, this effect would be noticeable only within the dilution zone since dilutions of 20 to 1 would be achieved within 15 seconds.

Disinfection by chlorination, or some other suitable means, prior to discharge would be required to meet the bacteriological requirements for protection of public health. Toxicity attributable to chlorination, if used, would have a negligible effect largely due to the rapid dilutions of 100 to 1 within approximately one minute and the possible requirement of dechlorination. Adequate disinfection would provide a beneficial impact by protecting nearshore beneficial uses.

Other impacts to water quality would be similar to those discussed in Chapter VII.

Secondary and Problematical Impacts

The secondary and problematical impacts of this alternative would be similar to those presented in Chapter VII.

ONE REGIONAL PLANT WITHOUT STORAGE

The concept of abandoning the existing three treatment plants and constructing one regional treatment facility capable of handling all wastewater flows was also considered. Generally, the impacts of this alternative are the same as those of the Master Plan described in Chapter VII. There are some additional impacts associated with this alternative which are presented in the following paragraphs.

Because of the great costs involved ($2 billion for the plant, exclusive of collection and transportation system modifications), this alternative would provide increased benefits to the area's economy by providing additional employment in the construction trades.

The abandonment of the existing treatment plant sites would release land for other uses such as recreational, commercial or residential. This release of land, involving only a few acres, could have a beneficial impact on the local neighborhoods by providing necessary open space. However, the beneficial impact would be offset by the much larger land requirement for the 16 billion gallons per day treatment facility required for this alternative.

STORAGE/TREATMENT

The concept of providing a combination of storage and increased treatment capacity to limit uncontrolled wet weather overflows to a design frequency was also evaluated. It was concluded that the proper design balance point is to provide a maximum of 1,000 mgd of treatment capacity and nine million cubic feet of storage. This concept is the Master Plan; therefore, all impacts are discussed in detail in Chapter VII.

SEWER SEPARATION

As previously discussed, the City of San Francisco is served by a combined sewer system; therefore, the alternative of constructing a separate sewer system was considered in the development of the Master Plan. The impacts associated with this alternative are briefly described below.

Primary Construction Impacts

Construction costs of this alternative would involve about $3 billion and would result in major disruption of San Francisco for many years. This disruption would produce impacts due to noise, dust, erosion, traffic disruption, and aesthetics as explained in Chapter VII.

Primary Operational Impacts

The end result of this alternative would not necessarily provide a benefit to the environment.

Assuming that the sanitary sewage flows are adequately treated then the storm waters bearing grease, oil, silt, dirt, garbage, litter, animal feces, and all the other materials found on the streets would flow into the Bay and marine waters. It is highly probable that the City would be required to provide treatment of these flows due to the contaminants present in this highly urban runoff.

Secondary Impacts

There would be no significant secondary impacts associated with the sewer separation alternative.

RECLAMATION

Increased treatment of wastewater required prior to discharge to the environment and increased difficulty of developing new water sources are making wastewater reclamation for some uses more economically feasible. Therefore, reclamation was also considered during the development of the Master Plan.

It should be emphasized that large-scale reclamation of San Francisco wastewater does not appear practical for reasons explained in Chapter IV. However, reclamation should be considered as an extension of the Master Plan and not as an alternative to the Master Plan. Generally, the impacts of small-scale reclamation would be the same as those of the Master Plan described in Chapter VII. A large-scale reclamation project would also have the following impacts.

Primary Construction Impacts

The primary construction impacts of this alternative would be identical to those described for the Master Plan. However, since a reclamation project would entail a rather extensive transport system, these impacts would be extended in both time and space.

Primary Operational Impacts

The primary operational impacts of this alternative would also be identical to those described for the Master Plan. However, reclamation could also provide beneficial impacts related to local landscape irrigation, salinity control in the Bay-Delta, agricultural irrigation, industrial cooling, and possible municipal reuse. A detailed discussion of these beneficial impacts is included in Appendix 1.

Secondary Impacts

It is possible that this alternative could have adverse secondary impacts depending on the use of the reclaimed water. For instance, irrigation with reclaimed water could degrade the underlying groundwater by salinity buildup; the subsequent discharge of reclaimed water after use for cooling purposes could degrade the estuarine environment; and municipal reuse of reclaimed water could produce serious side effects. These potential secondary impacts would have to be resolved prior to implementation of any reclamation program.

CHAPTER IX

FUNCTIONAL, ECONOMIC AND ENVIRONMENTAL RATING OF ALTERNATIVE CONCEPTS

A comparison of the alternative concepts considered in the development of the Master Plan on the basis of functional, economic, and environmental factors is presented in Table IX-1. Each of the alternative concepts is assigned an overall environmental ranking and numbered consecutively with 1 signifying the most environmentally acceptable concept.

Criteria for evaluating functional rating factors are as follows:

<u>Regulatory Compliance</u>

1. Ability to comply with State and Federal water quality requirements.

2. Conformity with regional planning.

<u>Implementation</u>

1. Acceptability of the concept and probability of support by the general public and local government.

2. Ease of construction and permit acquisition.

<u>Reliability</u>

1. Ability of concept to consistently attain design performance standards.

2. Vulnerability to system failure or natural disaster and resulting impacts from such a failure are minimized.

<u>Flexibility</u>

1. Ability to adapt to advanced technology and future discharge requirements.

2. Ability to adapt to future land-use changes.

3. Research options are not constrained.

TABLE IX-1

FUNCTIONAL, ECONOMIC, AND ENVIRONMENTAL RATING[a] OF ALTERNATIVE CONCEPTS

	No Project	Many Indiv. Treatment Plants	Expand Exist. 3 Plants	One Reg. Plant w/o Storage	Storage/Treat. The Master Plan	Sewer Separation
FUNCTIONAL						
Regulatory Compliance	Unaccept.	Marginal	Unaccept.	Good	Good	Marginal
Implementation	Unaccept.	Unaccept.	Unaccept.	Unaccept.	Acceptable	Unaccept.
Reliability	Unaccept.	Unaccept.	Marginal	Marginal	Good	Marginal
Flexibility	Unaccept.	Unaccept.	Marginal	Marginal	Good	Unaccept.
Reclamation Potential	Marginal	Marginal	Acceptable	Marginal	Good	Marginal
ECONOMIC						
Total Capital Cost ($million)	0	3000	1000[c]	2000[c]	672	3000
ENVIRONMENTAL						
Construction Impacts	None	Signific.	Signific.	Signific.	Signific.	Signific.
Operation Impacts	Signific.	Signific.	Signific.	Moderate	Minimal	Signific.
Secondary Impacts	Signific.	Moderate	Moderate	Minimal	Minimal	Moderate
Environmental Ranking[b]	6	5	3	2	1	4

[a]Rating Scale

FUNCTIONAL - Good, Acceptable, Marginal, Unacceptable

ENVIRONMENTAL - Significant, Moderate, Minimal

[b]Environmental Ranking - 1 is most acceptable
6 is least acceptable

[c]Plant cost only exclusive of collection system modifications

4. Concept provides maximum interim protection.

Reclamation Potential

1. Concept provides no location restraints on future reclamation options.

2. Ability of concept to adapt to treatment requirements for reclamation.

CHAPTER X

STATUTORY SECTIONS

UNAVOIDABLE ADVERSE IMPACTS

Adverse environmental effects were described under appropriate topics in Chapter VII, since there is an inseparable relationship between "adverse environmental effects" and "environmental impacts". To facilitate their identification, however, the adverse impacts which cannot be avoided are summarized in the following paragraphs.

Present research indicates that the operational aspect of the proposed Master Plan will have minimal adverse environmental impacts. The most potentially adverse environmental effects are anticipated to occur as a result of the long-term construction program necessary to implement the Master Plan.

Construction Effects

1. Biological

   - Temporary disruption of flora and fauna during construction of Ocean and improved Bay outfalls.

   - Removal of vegetation near pipeline routes, plant, and retention basin sites.

2. Physical/Chemical

   - Disturbance of soils along the proposed interceptor routes and possible alteration of the soil profile.

   - Temporary increases in erosion.

   - Temporary additions of dust and other associated air pollutants.

   - Temporary increases in ambient noise levels during construction.

   - Temporary increases in turbidity of Bay and marine waters.

   - Temporary loss in aesthetic appeal in localized areas.

3. Social and Economic

- Temporary disruptions in utility service.
- Temporary disruption of pedestrian and vehicular traffic.
- Interference to navigation and recreational usage of shore areas during construction of outfall.
- Added requirements to area's current energy budget.
- Land use change from open space to public use.
- Relocation of some commercial operations.

4. Problematical

- Possible threat to health and safety of people utilizing the area.

Operational Effects

1. Biological

- The terminal 14,000 feet of Ocean outfall will be laid on the bottom and protected by rock ballast which will cause minor interference with crab migration.

2. Physical/Chemical

- There will be a continued and increased discharge of fresh water to the Ocean environment.
- Increased nutrient input to the Ocean ecosystem.
- Increased conservative pollutant input to the Ocean environment.

3. Social/Economic

- Minor interference to commercial trawling.
- Increased energy demands for system operations.

Problematical Effects

1. Biological

   - Possible influence on incidence of cancerous growths on fish.
   - Possible effect on biotic food chain.
   - May cause pelagic fish to shun discharge area.

2. Physical/Chemical

   - Possible impact on solid waste management.

3. Seismic

   - Possible breakage of the outfall during rupture of the San Andreas Fault.
   - Possible liquefaction of sands at the Southwest Water Pollution Control Plant site.
   - Pipelines could be subject to severe ground motion, liquefaction, bouyant floatation, and extensive damage.
   - Tunnels could be subject to minor cracks and pipe pullouts.
   - Possible liquefaction of fill material at the Southeast Water Pollution Control site.
   - Possible increased lateral earth pressures on the walls of buried structures.

MITIGATION MEASURES

Measures to Minimize Impacts of Construction

The degree of environmental alteration that will be caused by the project is greatly dependent upon the measures of care taken during the long-term construction period. Care should be exercised in excavation activities, equipment operation, and other construction associated enterprises to minimize all environmental disturbances. Specific measures to accomplish this objective include the following:

Vegetation. Care should be exercised during excavation activities to minimize damage to vegetation along interceptor routes and retention basin locations. Extreme precautions should be taken for all construction in the vicinity of Golden Gate Park. Replacement of destroyed vegetation should be included in post-construction planning.

Air. Impacts of dust generated during construction can be minimized by watering down bare, dry soils. Haul vehicles should be covered as necessary to prevent the blowing of dust.

Erosion. If possible, construction should be scheduled to avoid rainy weather. Erosion control measures should be employed.

Noise. Construction noise can be controlled by several methods such as work scheduling, baffling with sound barriers and the use of quieter equipment. Substitution of non-impact tools offers the best practical abatement potential. Equipment should be well muffled or restricted in size.

Requirements of San Francisco's noise control ordinance must be met. This regulation which prescribes maximum permissible noise emissions from powered construction equipment will in general restrict construction operations to normal daylight hours except under permit or emergency; and will require the tools and equipment such as pavement breakers and jackhammers to be equipped with intake exhaust mufflers and acoustically attenuating shields.

Trenches. Pipeline construction that is open cut should be scheduled to proceed as expeditiously as possible to minimize the time that a given area is disrupted. Open trenches should be barricaded or provided with bridging of adequate width, as necessary to furnish pedestrian and vehicular access to residences, piers, and commercial establishments in addition to assisting traffic movement.

Traffic. During construction of the various pipelines at least one traffic lane in each direction should be kept open for vehicular transit. In addition, trenches should be bridged as necessary to move cross traffic. Close liaison should be maintained with the City's traffic engineers and Munisystem to assure that traffic movement around and through the construction site is as smooth as possible.

Vehicles hauling materials in and out of construction sites should use designated routes as required for public convenience.

Utilities. Prior to pipe, tunnel, or retention basin construction all utility jurisdictions in the City should be contacted to resolve possible conflicts and problems.

Communication should be maintained with these authorities during construction to minimize impacts.

Measures to Minimize Impacts of Operation

Toxicity. Continuing bioassay studies should be initiated to ensure protection of receiving water ecosystems. Dechlorination facilities may be required in the future for Bay discharges which will greatly reduce the risk of toxic waste discharges to San Francisco Bay.

Upgrading current treatment processes and construction of the deep water marine outfall will incorporate an efficient diffuser to achieve improved conditions in the receiving waters.

Ultimately, there will be an elimination of three existing discharges which fail to comply with Regional Water Quality Control Board requirements and fail to achieve desired protection of marine and Bay biotic communities.

Construction of the marine outfall will include rock ballast providing a favorable habitat for certain organisms which should enhance rock fisheries in the area.

Noise. Installation of noise generating equipment will require adequate covers and any other controls to reduce noise to non-objectionable levels.

Odor Control. Improvements to existing treatment plants, as well as proposed treatment, storage, and pumping facilities must include enclosures and air-scrubbing equipment in sufficient stages to fully control operational and accidental releases of damaging or odorous gases.

Conservative Pollutants. Industrial source control, chemical removal at treatment facilities, and adequate sludge disposal are mitigation measures that the City can use to protect receiving waters from the adverse effects of conservative pollutants.

Aesthetic. The architectural features and landscaping of new facilities should be designed to blend harmoniously with existing improvements and the immediate neighborhood. Structures generally should be of low profile. Landscaping should consist of, at least, lawns, shrubs, trees, and ground cover.

Energy. The maximum use of digester gas for in-plant energy needs will lessen expenditures from the area's energy budget.

Seismic. A number of potential, or problematical, seismic effects on the Master Plan facilities were discussed previously. However, earthquake effects need not be critically damaging to the on-land portion of the Master Plan facilities, if proper seismic planning and design are utilized.

There will likely be breakage of the Ocean outfall during rupture of the San Andreas Fault, resulting in a major reconstruction program at the point of breakage, probably in the rift zone. To minimize the effects to the marine environment during the reconstruction period, the two-mile wet weather outfall should be kept short of the fault zone which would provide an automatic back-up discharge point. However, minor fault movements need not be critically damaging, if proper seismic planning and design are utilized.

LOCAL SHORT-TERM USES VS LONG-TERM PRODUCTIVITY

Implementation of the Master Plan is a long-term solution to the problem of adequate wastewater management for the City of San Francisco. There will be a protracted construction period of about twenty years with Stage I requiring approximately nine years for completion. In this context, the short-term use becomes a dedication of local environments to construction that will ultimately achieve the long-range goals now prescribed as necessary to protect the beneficial uses and long-term productivity of the San Francisco aquatic environment.

The short-term discharge of the wastewater from the combined North Point-Southeast service areas near the existing Southeast Plant site should not impair water quality. The level of treatment will be at least secondary with the possibility of advanced processes being required. This solution provides early compliance with Regional Board discharge requirements in addition to providing an option of a final Bay or Ocean dry weather discharge. This choice will enable the City to reassess long-term requirements for Bay discharge before a commitment to Ocean disposal is made. The completed Master Plan would commit marine receiving waters to acceptance of the 125 mgd of secondary treated wastes. It is not anticipated that any reduction in the long-term productivity of these waters will be affected due to the discharge of this effluent.

The benefits of improved near-shore water quality will ensure the preservation of beneficial uses and aesthetic ammenities.

The improved dispersal of the marine effluent, the reduced potential for accumulation of pollutants, plus a high dilution factor, all combine to favor an Ocean discharge as a long-term solution to wastewater disposal as opposed to Bay disposal or the present system.

The consequences of the long-term disposal of wastewater to the marine environment cannot be accurately predicted. However, in analyzing the available data, no adverse problems have been observed which would materially reduce the long-term productivity of the marine environment.

IRREVERSIBLE ENVIRONMENTAL CHANGES

The lost resources associated with any major public works project are the raw materials and energy, both in terms of labor and natural energy that are applied to the project. Other essential permanent commitments of resources resulting from implementation of the Master Plan include:

- The proposed outfalls, interceptors, tunnels, and retention basins are long-term permanent structures. The systems are designed for drainage area capacity and consequently a long useful life.
- The construction of the Southwest Plant will result in a change of land usage which will be a commitment of open space that will be difficult to reverse.
- The Master Plan will change the current wastewater drainage patterns from diffuse distribution in peripheral areas to a centralized collection point for treatment and disposal to the Ocean.
- Chemicals such as chlorine, ferric chloride, and polymers used in the treatment process are essentially irretrievable.

GROWTH INDUCING IMPACTS

There will be no significant growth inducing effect resulting from the implementation of the Master Plan. The City is substantially developed and any growth that might occur would be attributable to increasing densities due to various forms of urban renewal. The effects of these localized density changes should be evaluated as final plans are developed for specific Master Plan facilities.

COST-EFFECTIVENESS

Cost-effectiveness analysis is necessary in evaluating engineering projects to assure that major problems are resolved expeditiously, avoid unnecessary expenditure, and optimize the benefits of the project per dollar expended as implementation proceeds. A formal cost-effectiveness analysis also provides assurance to governmental agencies and the public that funds are being invested in projects that will provide the maximum benefit.

The San Francisco Master Plan for Wastewater Management was developed, in part, in response to a requirement of the California Regional Water Quality Control Board, San Francisco Bay Region, specifying that the City must submit a plan to eliminate the bypassing of untreated wastewater. This requirement raises numerous questions related to project cost-effectiveness which must be analyzed as part of the Facilities Plan required for State and Federal grants. Cost-effectiveness will affect the degree of reduction of overflows and ultimate treatment levels. The basic Master Plan is the most cost-effective concept, but individual units may be expanded, relocated, or redesigned to achieve maximum effectiveness for future investments in wastewater facilities.

Therefore, a detailed cost-effectiveness analysis is not presented in this report. Instead, the estimated costs of the Master Plan are presented in Table X-1 and a brief description of the expected results after the Master Plan is operational is presented in the following paragraphs.

TABLE X-1

ESTIMATED COSTS OF THE MASTER PLAN (1974 Dollars)

Stage[1]	Estimated Cost
I	$231,000,000
II	149,000,000
III	161,000,000
IV	131,000,000
Total	$672,000,000

[1] Staged facilities are described in Chapter V.

Completion of Stage I facilities will result in compliance with secondary treatment requirements for dry weather flows and reduction of overflows to important North Shore beaches to an average of less than five overflows per year. It is expected that operation of Stage I facilities in conjunction with improvements made to other wastewater discharges to the Bay will result in substantial improvement of the aquatic environment of the Bay, particularly in nearshore waters adjacent to San Francisco during the winter and spring months. Another benefit will be a reduction of average annual days in which bacteriological swimming standards are exceeded. At North Shore beaches violations on less than 20 days per year are expected and normally these days will occur during the least desirable periods for swimming and beach recreation. Also, the aesthetic quality of waters and beaches in the Marina, Aquatic Park, and Fisherman's Wharf areas should be substantially improved except during the worst storm conditions.

With the completion of Stage II facilities, all of the City's shoreline will be afforded some measure of protection which will greatly improve the bacteriological and aesthetic quality of the nearshore waters and the aesthetic quality of the beaches.

Subsequently, with the completion of Stage III facilities there will be further reductions of overflows and a treated wet weather discharge to the Ocean.

Stage IV represents the final phase of construction presently contemplated. Upon completion of this phase all dry weather flows to the Bay will be eliminated. During the major portion of the year, wastes will receive secondary treatment at the Southeast and/or Southwest Treatment Plants and will be discharged into the Ocean approximately four miles offshore. During storm conditions, flows exceeding the capacity of the secondary treatment facilities will be diverted to the 1,000 mgd capacity Level I treatment facilities at the Southwest site and discharged into the Ocean approximately two miles offshore. At this time, wet weather overflows will be virtually (90%) eliminated.

By the addition of storage capacity, higher levels of control can be accomplished. The additional costs over the base case of 8 overflows per year (90% control) for higher levels of control are presented below:

Number of Overflows	Level of Control	Additional Capital Cost $ million	$/capita/yr a/
8 per year	90%	0	0
4 per year	95%	63	6.50
1 per year	99%	189	19.50
1 per 5 years	99+%	332	34.50

a/ Assuming 6% interest over a 30-year period.

ORGANIZATIONS AND PERSONS CONTACTED

Personal contacts were made by the staff of J. B. Gilbert & Associates or other special consultants with the following agencies and officials:

Federal Agencies

Environmental Protection Agency

State Agencies

Department of Fish and Game
Department of Water Resources
State Water Resources Control Board
California Regional Water Quality Control Board, San Francisco Bay Region
Air Resources Board

Local Agencies

City Planning Department
City Public Works Department

Environmental Groups

Environmental Defense Fund
Friends of the Earth

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APPENDIX A

STUDY OF THE POTENTIAL FOR RECLAMATION OF WASTEWATER

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CONCLUSIONS AND RECOMMENDATIONS

An analysis of the need and potential for wastewater reclamation in the City and County of San Francisco has resulted in the following conclusions and recommendations:

1. There does not appear to be a water supply shortage, quality problem, or economic factors that would justify a wastewater reclamation project within the City and County of San Francisco at the present time.

2. The only wastewater generated within the City and County of San Francisco that could be considered suitable for reclamation without specialized treatment (i.e., demineralization) is generated within the Richmond-Sunset service area. Therefore, the City should continue its infiltration/inflow analysis to evaluate possible methods of reducing the unfiltration of highly saline waters into the sewer system.

3. There are many potential markets for reclaimed water within the San Francisco Bay Area; however, the most promising potential market for reclaimed San Francisco wastewater is for landscape irrigation within Golden Gate Park (4.0 mgd) and the three golf courses near Lake Merced - The Olympic Club, Harding Park, and Lake Merced (1.0 mgd).

4. Since it appears that reclaimed water can be produced for landscape irrigation at very competitive rates, the City should conduct an in-depth feasibility study to determine the exact costs of advanced waste treatment and distribution for landscape irrigation within Golden Gate Park and the three golf courses near Lake Merced.

5. Wastewater reclamation has no effect on the Master Plan with respect to size, location, or type of facilities proposed; therefore, the City should continue its actions to assure early completion of Phase I and to finalize plans for the remaining facilities.

SUMMARY

RECLAMATION NEED IN THE SAN FRANCISCO BAY AREA

San Francisco Bay Area communities are currently dependent on imported water supplies as much of the area's water is derived from development of water supplies in the high Sierra-Nevada Mountains. The waters imported from those sources are passed through the water distribution system, used, collected, and discharged to saline waters. This type of once-through water used is equivalent to total consumption of the water supply as opposed to upstream users which discharge back to fresh water streams or to groundwater where the wastewater can be reused or, in the case of stream discharge, serve as a fresh water source for the estuary.

The Bay Area's need for fresh water will continue to increase in the future. Provision of needed water for the future can be accomplished by development of new sources of fresh water (construction of reservoirs), reclamation of existing wastewater sources, desalination of ocean water, or conservation of existing supplies.

Development of additional supplies by construction of reservoirs is limited by the lack of economical sites, the need to retain some streams in their natural state, and a fuller understanding of the impact of dams and diversions on the environment. Desalination will not become economically attractive until a cheap source of energy is found.

POTENTIAL USES OF RECLAIMED SAN FRANCISCO WASTEWATER

There are numerous potential uses of reclaimed San Francisco wastewater. However, some of the more likely uses are for local landscape irrigation, salinity control, and agricultural irrigation. The potential market for using reclaimed water for these purposes is presented in the following paragraphs.

Local Landscape Irrigation

It appears feasible to produce a limited amount of reclaimed water at the proposed Southwest treatment plant site for use at The Olympic Club, Harding Park, and Lake Merced golf courses and at the Richmond-Sunset Plant for use in Golden

Gate Park. Reclaimed water can be produced at these two sites at very competive rates assuming that secondary effluent from the Richmond-Sunset Plant would be the source of supply for the reclamation facilities.

After the Phase I Master Plan facilities are completed, it appears feasible to construct a 4.0 mgd advanced waste treatment facility (rapid sand filtration and disinfection) at the Richmond-Sunset plant. The reclaimed water could be used for irrigation purposes within Golden Gate Park. The unit cost of reclaimed water for this alternative would be about $30 per acre-foot plus transportation costs of approximately $24 per acre-foot.

It also appears feasible to construct a 1.0 mgd advanced waste treatment facility (rapid sand filtration and disinfection) at the proposed Southwest treatment plant site. The source of water for this facility would be the effluent line from the Richmond-Sunset plant. The reclaimed water produced by this facility could be used for irrigation of The Olympic Club, Harding Park, and Lake Merced golf courses. The unit cost of the reclaimed water would be about $50 per acre-foot plus transportation costs of about $23 per acre-foot.

Salinity Control

The Department of Water Resources and State Water Resources Control Board have initiated a San Francisco Bay Area Wastewater Reclamation Study to determine the feasibility of intercepting and reclaiming treated Bay Area wastewater for transport and reuse to augment Delta outflows, either directly or indirectly by substituting reclaimed water for irrigation and groundwater recharge demands in the Bay Area or adjacent areas.

In its September 19, 1973 progress report, the Interagency Study group made the following comments:

> "The additional water required by the Central Valley Project and the State Water Project to meet contracts and future water demands can be expressed as an outflow deficiency expected at the Delta under projected conditions.

> "Water with a salinity of 4,000 to 6,000 ppm of total dissolved solids could be used to meet this water deficiency by direct augmentation of Delta outflow at about Chipps Island, with provision for treatment to avert toxicity and biostimulation effects in the estuary."

Preliminary results of this study indicate that reclaimed water could be made available for about $90 per acre-foot for this purpose. However, if extended treatment (nutrient and toxicity removal) were required to produce water which would not create biostimulation and toxicity problems in the estuary, this unit cost would escalate to approximately $130 per acre-foot. Therefore, before a conclusion regarding the feasibility of this proposal can be made a detailed environmental assessment of the proposal is required to determine the actual treatment requirements and therefore the actual cost of the reclaimed water.

It should be pointed out, however, that these studies were based on average daily dry weather flow with respect to sizing of facilities. Therefore, if this proposal were found to be feasible, it would still be necessary for the City of San Francisco to construct storage, treatment, and disposal facilities to solve its wet weather wastewater problems.

Agricultural Irrigation

Irrigated agriculture is by far the largest user of fresh water in California. Therefore, when considering large-scale reclamation projects, irrigated agriculture must be considered as a potential market for the reclaimed water. However, the use of reclaimed water for crop irrigation is not without problems which include seasonal water use, quality considerations, and public acceptance.

Two large agricultural areas in relatively close proximity to the Bay Area are the Delta-Mendota and San Luis service areas within the San Joaquin Valley. The projected import water requirements under the 2015 level of development for these areas are as follows:

Service Area	Quantity, acre-feet
Delta-Mendota	1,675,000
San Luis	1,279,000
Total	2,954,000

As a part of its study, the Interagency group investigated the possibility of using reclaimed Bay Area wastewaters to supplement the imported supplies for these two areas. Three of the alternatives studied by this group included utilization of San Francisco wastewaters. The unit costs of these three alternatives range from $108 to $143 per acre-foot.

To date the Interagency group has not made any conclusions regarding the feasibility of implementing any of its alternatives. However, it would appear that the costs of delivering reclaimed water to the point of use are very high and not competitive with State-Federal project water.

EFFECT OF RECLAMATION ON THE MASTER PLAN

The most promising potential use of reclaimed water within the City and County of San Francisco appears to be landscape irrigation within Golden Gate Park and the three golf courses in the Lake Merced area. It also appears that the most economical method of producing reclaimed water for this purpose would be to provide advanced waste treatment facilities (rapid sand filtration and disinfection) at the Richmond-Sunset and Southwest plant sites that would utilize secondary effluent as their source of supply. However, the total seasonal demand for these uses is only 5.0 million gallons per day compared to the total average daily dry weather flow of 125 mgd. Therefore, reclamation for local uses would not have any effect on the size, location, or type of facilities as envisioned in the Master Plan.

The San Francisco Bay Area Interagency Wastewater Reclamation Study investigated the feasibility of aggregating wastewaters within the Bay Area, providing some form of extended treatment, and producing relaimed water that would be direct input into the Delta channels at Chipps Island to repel salinity, into the Delta Mendota Canal to serve irrigation demands in the Delta Mendota service area, and into a proposed canal to serve irrigation needs in the San Luis service area.

The basic assumption in all the Interagency Study alternatives was that the San Francisco Wastewater Master Plan had already been implemented and that the effluents of the Richmond-Sunset and Southeast plants were combined at the Southwest plant site. It should be pointed out, however, that all these alternatives were based on average daily dry weather flow conditions and therefore the need of the 1,000 mgd wet weather treatment facility would still exist even if one of the Interagency alternatives were implemented. This is due to the fact that the average daily dry weather flow is only 125 mgd compared to the necessary wet weather treatment capacity of 1,000 mgd. In fact, all the facilities envisioned in the Master Plan would be required whether or not large-scale reclamation projects were implemented.

In summary, it appears that reclamation, either through large scale export of wastes or small scale local use, has no effect on the Master Plan with respect to the size, location, or type of facilities proposed.

SUMMARY OF THE POTENTIAL FOR USING RECLAIMED SAN FRANCISCO WASTEWATER

Reclamation Program	Quantity (mgd)	Possible Year of Implementation	Other Responsible Agencies	Cost ¢/1,000 gal	Current Cost Cheapest Alternative ¢/1,000 gal	Regulatory Constraints
Golden Gate Park Irrigation	1.0 4.0	existing 1980	none none	30 17	25[1] 25[1]	Restrictive bacteriological requirements
Golf Course Irrigation	1.0	1980	Owners of individual golf courses	22	25[1]	Restrictive bacteriological requirements
Delta Salinity Control	Total dry weather	2000	USBR[5] DWR[6]	28-40	3[2]	Restrictive toxicity and biostimulation requirements
Agricultural Use Delta-Mendota Service Area	Total dry weather	2000	USBR DWR	33	3[2]	Possible health restrictions due to intermittent cross-connection
San Luis Service Area	Total dry weather	2000	USBR	44	3[2]	Restrictive bacteriological requirements
Groundwater Recharge Santa Clara Valley	90	Prohibited	Santa Clara CFC&WD,[7] DWR	Not calculated due to regulatory constraints	10[3]	Presently prohibited by State Department of Health
Industrial Use	Total dry weather	Not feasible	Industrial users	Same as above	1.5[4]	Subsequent toxicity and biostimulation requirements
Direct Reuse		Prohibited			25[1]	Prohibited by State Department of Health

[1]Cost of San Francisco water to large users.
[2]Existing cost of Delta Mendota Canal water; if new supplies were developed, this cost could double or triple.
[3]Cost of South Bay Aqueduct water (Reference 2).
[4]Cost for pumping brackish water.
[5]United States Bureau of Reclamation.
[6]Department of Water Resources.
[7]Santa Clara County Flood Control and Water District.

BACKGROUND

RECLAMATION NEED IN THE SAN FRANCISCO BAY AREA

San Francisco Bay area communitities are currently dependent on imported water supplies. Much of the area's water is derived from development of water supplies in the high Sierra-Nevada Mountains. The waters imported from these sources are passed through the water distribution system, collected, and discharged to saline waters. This type of once-through water use is equivalent to total consumption of the water supply as opposed to upstream users which discharge back to fresh water streams or to groundwater where the wastewater can be reused or, in the case of stream discharge, serve as a fresh water source for the estuary. Consideration is currently being given to numerous projects to utilize once-through wastewaters prior to disposal. These range from small local landscape irrigation projects to large projects designed to transport most of the wastewater from the area to a place of reuse for agricultural irrigation or supplementing fresh water flows to the estuary.

Provision of needed water for the future can be accomplished by development of new sources of fresh water (construction of dams), reclamation of existing wastewater sources, desalination of ocean water, or conservation of existing supplies.

The San Francisco Bay system is the estuarine outlet for all drainage from the great Central Valley of California. As such, it supports a highly complex ecological system of major importance. Predominant features in the past have been sustenance of large fish and shellfish populations and the annual migration of anadromous fish. Since man began developing the Central Valley for agriculture, the character of the estuary has been changing. Water diversion and consumptive use changed fresh water outflow patterns. Land use changes and mining practices influenced sediment loads in the river and Bay systems. More recently, construction of dams has altered outflow patterns and sediment loadings. These activities of man have altered the character of the estuary, primarily by changing fresh water inflow patterns by diversion of water for beneficial use.

Current and planned water diversion and use could potentially result in unacceptable changes in the estuarine character. Because of this potential, public concern has resulted in legislative action to protect the estuary. Such action essentially requires that some fresh water flow be allowed to pass without diversion to the ocean, thereby maintaining the estuary. This legislative action led to Decision 1379 of the State Water Resources Control Board which requires the California Department of Water Resources and the U. S. Bureau of Reclamation to release water to maintain quality requirements in the estuary. Compliance with the decision without further water development in the northern Coastal Range of California will result in a water shortage in the near future. This situation has necessitated a re-evaluation of present water supply practices in the affected area.

Increased treatment of wastewater required prior to discharge to the environment and the increased difficulty of developing new water sources are making wastewater reclamation more economically feasible. However, a dramatic energy shortage could favor development of new water (and energy) sources over energy-consuming reclamation methods. Development of a cheap energy source would favor desalination as a water source.

Responsibility for maintaining an adequate flow of fresh water to the estuary resides with all water users who consumptively use or degrade the quality of waters tributary to the San Francisco Bay estuary.

Since the City and County of San Francisco diverts fresh water which would otherwise be tributary to the estuary and the City is in the process of finalizing its Master Plan for Wastewater Management, it thoroughly investigated the use of reclaimed wastewater to determine if it would be possible to use reclaimed water in lieu of Hetch Hetchy water and to determine what effects a major reclamation project would have on implementation of the Master Plan.

METHODS OF WASTEWATER RECLAMATION

Numerous methods of reclaiming municipal wastewaters are being discussed and utilized at the present time. For a detailed discussion of these methods, see References 1 through 17 of this text. A brief listing and description of these methods follows:

1. Direct Recycle

   This method involves extensive treatment and renovation of the wastewater with subsequent discharge to the municipal water supply system.

2. Groundwater Recharge

   This method involves extensive treatment and renovation of the wastewater with subsequent discharge to the groundwater by direct injection or by percolation through a soil layer. All types of water uses can be accommodated by this method provided water quality is acceptable for the particular use.

3. Surface Water Discharge

   This method involves treatment of the wastewater followed by discharge to a fresh water body where the water can later be further used. This method is currently practiced primarily as a means of disposal. However, it must be considered a valid reclamation method because it does allow further use by downstream users both human and non-human.

4. Agricultural Irrigation

   This method involves application of properly treated wastewater to agricultural lands for production of plants.

5. Landscape Irrigation

   This method involves application of treated wastewater to areas covered by vegetation for landscaping purposes. Such areas include parks, golf courses, cemeteries, freeway median strips, greenery in commercial areas, and residential lawns and greenery.

6. Open Space Irrigation

   This method involves application of treated wastewater to open space area not serving any beneficial purpose. This normally involves watering unused hillsides. Open space irrigation is considered an artificial or created water demand and as such is much less desirable than other methods which will supply existing water demands.

7. Industrial Use

This method involves treatment and renovation of wastewater with subsequent use by industry. Within this very general classification are many different types of uses each of which exhibits individual needs. Utilization of the industrial market for reclaimed wastewater requires considerably more pre-study than other uses because of the complex nature of industrial processes.

8. Cooling Water

This is an industrial use which requires special consideration. It involves the use of reclaimed water to remove and transport heat from industrial processing or energy production facilities. This use normally degrades the water only with respect to temperature and possibly the mineral quality. Such a change will not interfere with other reuse such as irrigation, surface water discharge, and some industrial uses and is therefore not a use cycle that decreases the reclamation potential of the wastewater significantly. It should be used whenever possible but not as the only reclamation method. Where brackish water is used for cooling, changing to reclaimed wastewater for cooling serves no purpose.

9. Impoundment

This method involves storing treated and renovated wastewater in large open reservoirs. The impounded water can serve as a recreation site, as a source of water for seasonal uses, or both. The two basic uses are somewhat in conflict since most seasonal demand occurs in the summer when recreation is at its peak. Changes in pool level required to supply seasonal use would interfere with recreational use.

10. Fire Protection

This method involves the use of wastewater for fighting or prevention of urban and rural fires. Where industrial use of wastewater occurs, reclaimed water could be used in fire sprinkler systems. In areas with high fire potential, green belting with wastewater could prevent the spread of grass fires.

OBSTACLES TO RECLAMATION OF MUNICIPAL WASTEWATER

Public Health Restrictions

Because of uncertainty about the effect of pathogenic viral agents and potentially toxic substances which may be contained in reclaimed wastewater, direct reuse involving human ingestion is not currently acceptable to the State and local health authorities. This eliminates the possibility of direct recycle or groundwater injection for municipal use. Percolation of wastewater for municipal use may be acceptable if the wastewater represents only a small portion of the recharged waters. This restriction also eliminates the potential for use of wastewater to irrigate crops which come in direct contact with the water and may be directly ingested by humans.

Any use where the public may come in direct contact with the wastewater will require proper disinfection. Affected reclamation methods include landscape irrigation and recreational impoundment. The disinfection required depends on the extent of contact anticipated.

Quality Requirements and Treatment Costs

Treatment levels required prior to discharge to surface waters or land have advanced to the point that many materials which would limit the reclaimability of wastewater are being removed. These substances are the gross solids, suspended matter, and dissolved organics. With these materials removed from the wastewater, the content of dissolved material becomes the determining factor in the wastewater's reclaimability.

Dissolved Solids. Buildup of dissolved solids restricts reuse for irrigation, groundwater recharge, many industrial uses, and reduces the water's usefulness for maintaining fresh water or estuarine habitats. Most water uses result in an incremental addition of salt content. Multiple use often results in complete loss of usefulness unless treatment for removal of dissolved solids is employed. Treatment of this type would cost from 0.30 to 1.50 $/1,000 gallons depending on the quantity being treated and the process used (Reference 17).

Boron is a concern for use of wastewater for irrigation. Many plants are sensitive to the boron content. Desalination is the only available process by which boron can be removed.

Nutrients such as nitrogen and phosphorous are beneficial in water used for irrigation but may hamper industrial use by supporting undesirable biological growth in piping systems. Phosphorous removal costs 0.04 to 0.06 $/1,000 gallons while nitrogen reduction costs 0.01 to 0.05 $/1,000 gallons (Reference 17).

Hardness is beneficial in irrigation water with high sodium content but can cause problems in some industrial processes.

Conveyance Requirements

Normal Wastewater Flows. Transportating wastewater to the location of need is a major cost to any substantial reclamation project. Reclamation in urban areas requires a second water distribution system which would involve a mass repiping program if every potential urban user is to be supplied with both a domestic drinking water supply and a reclaimed water supply for other uses because of the potential public health risks.

In rural areas, the problem is the distance from the major urban wastewater sources to water users. In some cases this problem can be solved by discharging to an irrigation canal.

Wet Weather Flows. Urban wastewater flows increase dramatically during rainfall, particularly where combined sewers are used. Reclamation of wastewater from areas with separated sewers is normally accommodated by the system without problem. Where combined sewers are used, peak flows are often several times normal flow. Such flows occur during only a small part of the year so total volume does not approach that of normal flow. Reclamation of these storm flows would require two things beyond that required to reclaim normal flow: storage and an oversized transport system. Storage is required because no water use coincides with rainfall so the water must be held until it is needed.

An oversized transport system is needed to carry the large peak flows to the storage facility. The added cost of these two factors makes reclamation of wet weather waste flows from combined systems far less attractive than reclamation of normal flows.

Existing Water Supplies. An obstacle to reclamation of wastewater in the San Francisco Bay Area is the past and present availability of large quantities of very high quality water. Actual water shortages are not immanent. Despite this many Bay Area communities have proceeded to evaluate possibilities of reclaiming their wastewater.

CHARACTERIZATION OF SAN FRANCISCO WASTEWATER

QUANTITY

Normal (Dry Weather) Flows

The City and County of San Francisco currently operates three wastewater treatment facilities. The Richmond-Sunset Water Pollution Control Plant is located in Golden Gate Park and treats an average of 21 million gallons per day (mgd) of sanitary sewage. The North Point Water Pollution Control Plant is located in the northeast corner of the City, just below Coit Tower. This facility treats an average of 65 mgd of sanitary sewage. The Southeast Water Pollution Control Plant is located in the southeastern area of the City near Islais Creek. It treats an average of 19 mgd of sanitary sewage. The total dry weather flow from the City is 105 mgd or 9,810 acre-feet per month (AF/mo).

Current plans call for consolidation of the North Point and Southeast facilities with an expanded and improved treatment plant at the Southeast site. This would result in a flow of 84 mgd from this new facility.

Wet Weather Flows

The City in developing its Master Plan for Wastewater Management (Reference 18) analyzed 62 years of rainfall data from the Federal Building raingage. From this analysis and appropriate runoff coefficients for various areas of the City, the average annual runoff of stormwaters from the City was estimated to be 8.8 billion gallons per year. Table 1 shows the distribution of this quantity by month and drainage basin. The dry weather flow for each drainage basin is shown for comparison. Distribution of runoff among the drainage basins is based on preliminary results of San Francisco's runoff monitoring program. The estimated distribution is 40 percent from the Richmond-Sunset basin, 27 percent from the North Point basin, and 33 percent from the Southeast basin.

TABLE 1
AVERAGE ANNUAL DRY AND WET WEATHER FLOWS
CITY AND COUNTY OF SAN FRANCISCO

	DRY WEATHER FLOW		WET WEATHER FLOW (AF/MO)												ANNUAL
	AF/MO	AF/YR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	AF/YR
Percent of Annual Rainfall (%)	—	--	22.5	16.5	13.8	7.0	2.9	0.7	0.1	0.1	1.2	4.4	11.0	19.8	100.0
Total City	9810	117,700	6080	4450	3730	1890	780	190	28	28	330	1190	2970	5340	27010
Richmond-Sunset Basin	1960	23,500	2430	1780	1490	760	310	80	11	11	130	480	1190	2140	10810
North Point Basin	6070	72,800	1640	1200	1010	510	210	50	8	8	90	320	800	1440	7290
Southeast Basin	1780	21,400	2010	1470	1230	620	260	60	9	9	110	390	980	1760	8910
Combined North Point and Southeast Basins	7850	94,200	3650	2670	2240	1130	470	110	17	17	200	710	1780	3200	16200

QUALITY

Undesirable characteristics of a municipal wastewater other than those related to the mineral quality can generally be reduced or eliminated by conventional treatment methods. Effluent from a well operated secondary treatment plant should be well oxidized and clear, with no odor or other objectionable property. Combinations of treatment processes, such as filtration and disinfection, can insure removal or destruction of disease agents; but, these conventional treatment methods do little to change the mineral quality of wastewater. Such change requires advanced processes which, while technically proven, would increase the cost of reclamation by a substantial amount. From a practical standpoint with the present state of technical knowledge, the mineral quality can be considered to be the most important limiting factor in defining the "reclaimability" of a wastewater.

Mineral quality in municipal wastewater if largely influenced by three factors: The mineral quality of the original water supply, the mineral pickup resulting from use, and the mineral change due to water infiltrating into the sewer system. In San Francisco, water infiltrating into the sewer system is largely responsible for the high mineral content of the wastewater. The City is presently conducting an infiltration/inflow study of its sewer system to determine methods of alleviating the infiltration problem.

In addition, the City has retained a consultant (CH_2M-Hill) to conduct a pilot treatment plant study. That study included a wastewater characterization program for the three existing treatment plants. The sampling program involved the collection of 24-hour flow proportioned composite and peak flow grab samples on alternate days over a two week period (April 16, 1973). In all 42 samples were obtained, each of which was analyzed for 110 constituents. A selected summary of the results of this sampling program is presented in Table 2 through 5.

SAN FRANCISCO WASTEWATER QUALITY

HEAVY METALS

Constituent	North Point Plant High (mg/l)	North Point Plant Low (mg/l)	North Point Plant Ave. (mg/l)	Southeast Plant High (mg/l)	Southeast Plant Low (mg/l)	Southeast Plant Ave. (mg/l)	Richmond-Sunset Plant High (mg/l)	Richmond-Sunset Plant Low (mg/l)	Richmond-Sunset Plant Ave. (mg/l)
Boron	1.26	0.16	0.61	1.47	0.12	0.83	0.39	0.10	0.25
Cadmium	0.068	0.001	0.0077	0.006	<0.001	0.003	0.006	<0.001	0.002
Chromium (Total)	1.100	0.018	0.149	6.6	1.6	3.2	0.025	0.004	0.012
(hexavalent)	0.180	<0.005	0.010	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cobalt	0.14	<0.0001	0.006	0.026	<0.0001	0.012	0.018	<0.0001	0.002
Copper	0.80	0.13	0.26	0.51	0.12	0.25	0.880	0.076	0.207
Cyanide	0.148	<0.005	0.053	0.225	<0.005	0.085	0.055	<0.005	0.019
Iron	4.10	1.12	2.12	8.29	1.04	4.33	2.07	0.54	1.26
Vanadium	<0.05	<0.01	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.01
Zinc	0.45	0.24	0.35	4.00	0.24	1.15	0.45	0.16	0.23
Lithium	0.100	0.005	0.034	0.023	0.010	0.015	0.10	0.004	0.007
Lead	0.520	0.030	0.077	0.76	0.050	0.212	0.18	0.032	0.079
Magnesium	59.02	17.75	49.6	153.1	40.63	128.9	16.79	5.36	16.42
Manganese	0.10	0.061	0.078	0.22	0.16	0.18	0.099	0.034	0.054
Mercury	0.00146	0.00048	0.00079	0.00124	0.00018	0.00057	0.00152	0.00024	0.00084
Molybdenum	<0.008	<0.003	<0.007	<0.02	<0.01	<0.018	0.002	<0.001	0.0015
Nickel	0.170	0.008	0.042	0.35	<0.02	0.130	0.180	0.003	0.018
Selenium	0.050	<0.01	<0.017	0.041	<0.01	0.011	0.05	<0.01	0.014
Silver	0.130	0.029	0.048	0.048	0.014	0.030	0.064	0.013	0.023
Sodium	510	100	372	970	370	746	350	50	142
Aluminum	5.96	1.14	2.50	26.28	1.78	6.15	3.24	0.57	1.40
Arsenic	0.0115	0.0007	0.0045	0.0074	0.0022	0.0050	0.0070	0.0016	0.0038
Barium	0.40	0.01	0.10	0.50	<0.02	0.07	0.20	0.02	0.09
Beryllium	0.0073	<0.001	0.0021	0.0037	<0.001	0.0014	0.0040	<0.001	0.0011

SAN FRANCISCO WASTEWATER QUALITY

PHYSICAL PARAMETERS

Constituent	Units	North Point Plant High	North Point Plant Low	North Point Plant Ave.	Southeast Plant High	Southeast Plant Low	Southeast Plant Ave.	Richmond-Sunset Plant High	Richmond-Sunset Plant Low	Richmond-Sunset Plant Ave.
Color	units	138	60	71	210	75	120	192	80	109.4
Conductivity	µmhos	2,001	789	1,800	5,220	2,160	4,653	1,360	625	752
Floatables	mg/l	10.0	2.4	4.2	33.0	2.7	10.3	45.0	2.8	17.5
Odor (room temperature)	Threshold Number	24,915	537.5	7,780	112,500	532	23,885	38,230	320.5	8,531
Settleable Matter	ml/l	18.0	2.0	5.0	13.0	2.0	4.6	22.0	5.5	10.2
Total Dissolved Solids	mg/l	1,010	386	881	2,940	1,114	2,092	449	183	345
Total Solids	mg/l	1,160	269	1,043	3,400	1,490	2,383	1,373	504	579
Total Suspended Matter	mg/l	480	135	163	462	150	290	1,047	155	208
Total Volatile Solids	mg/l	533	230	303	826	441	567	1,049	243	300.8
Turbidity	JTU	240	70	125	270	100	196	200	105	152
Volume Suspended Matter	mg/l	422	100.5	146	380	136	235	1,017	94	192.9
Temperature	^{o}C	22.0	18.0	20.0	20.5	16.8	18.5	21.9	17.0	19.5

SAN FRANCISCO WASTEWATER QUALITY

CHEMICAL AND BIOCHEMICAL

Constituent	Units	North Point Plant High	North Point Plant Low	North Point Plant Ave.	Southeast Plant High	Southeast Plant Low	Southeast Plant Ave.	Richmond-Sunset Plant High	Richmond-Sunset Plant Low	Richmond-Sunset Plant Ave.
BOD (5-day)	mg/l	282	130	176	412	126	235	210	142	162
Chloride	mg/l	403	80	366	1,250	344	985	244	49	94
COD	mg/l	696	363	472	1,550	471	782	2,480	420	576
Dissolved Oxygen	mg/l	4.3	0.4	2.0	4.3	0.0	2.1	3.95	0.10	2.0
Fluoride	mg/l	1.52	0.82	1.03	1.55	0.60	0.85	1.38	0.70	0.93
Oil-Grease (Total)	mg/l	220.4	20.0	95.5	116.9	37	70.4	119	17	63
pH	units	9.6	5.7	7.7	9.0	5.6	7.3	8.5	6.1	7.3
Phenols	mg/l	0.205	0.020	0.043	1.975	0.054	0.346	0.410	0.038	0.082
Sulfate	mg/l	84	22	78	396	156	242	41	16	31
Sulfide	mg/l	6.80	0.27	0.44	3.8	0.35	0.70	1.3	0.26	0.49
Surfactants	mg/l	9.6	4.3	6.7	9.3	6.0	7.4	11.5	4.6	9.7
Total Hardness	mg/l	220	100	198	560	210	459	120	70	91
Total Organic Carbon	mg/l	140	67	107.3	353	78	178	146	84	101

SAN FRANCISCO WASTEWATER QUALITY

NUTRIENTS

	North Point Plant			Southeast Plant			Richmond-Sunset Plant		
	High (mg/l)	Low (mg/l)	Ave. (mg/l)	High (mg/l)	Low (mg/l)	Ave. (mg/l)	High (mg/l)	Low (mg/l)	Ave. (mg/l)
Ammonia—N	30.0	8.8	12.3	40.0	11.2	15.6	39	15	18.5
Nitrate—N	0.59	0.04	0.193	1.20	<0.01	0.35	0.98	0.05	0.299
Nitrite—N	0.84	0.01	0.50	0.61	<0.01	0.17	0.04	0.01	0.017
Organic Nitrogen	39	7.0	20.2	48	8	22	71	6.4	22.9
Total Nitrogen	49	16	33	70	25	37	105	21	41
Orthophosphate	6.3	3.2	3.61	6.0	0.5	3.2	9.9	4.7	5.44
Total Phosphate	8.5	5.3	6.17	15.0	5.6	7.9	12.5	6.3	8.20

In November 1967 the California State Department of Public Health's Bureau of Sanitary Engineering published its Waste Water Reclamation report (Task VII-le of the San Francisco Bay-Delta Water Quality Control Program). The following classification of domestic waste discharges for reclamation was included as Table VI-II in that report:

Quality Characteristic		Classification Suitable (S)	Marginal (M)	Unsuitable (U)
A. Dissolved Solids	mg/l	<1,000	1,000-2,000	>2,000
B. Percent Sodium	%	<60	60-75	>75
C. Boron	mg/l	<1.5	1.5-2.5	>2.5
D. Chloride	mg/l	<200	200-350	>350
E. Chloride and Sulfate	mg/l	<500	500-1,000	>1,000

Discharger	Quality Characteristics* A	B	C	D	E	Overall
Richmond-Sunset Plant	S	S	S	S	S	S
North Point Plant	U	U	U	U	M	U
Southeast Plant	M	U	S	U	U	U

*Based on 1962-65 analyses.

The same quality characteristics based on the April 1973 analyses are as follows:

Discharger	Quality Characteristics A	B	C	D	E	Overall
Richmond-Sunset Plant	S	S	S	M	M	M
North Point Plant	M	S	S	U	S	U
Southeast Plant	U	S	S	U	U	U

As can be seen from the above, the only wastewater generated within San Francisco that could be considered for reclamation without specialized treatment is generated within the Richmond-Sunset service area. Wastewaters generated within the North Point and Southeast service areas are generally too mineralized to be considered for reclamation without specialized treatment or blending with a higher quality water.

POTENTIAL FOR USING RECLAIMED SAN FRANCISCO WASTEWATER WITHIN THE BASIN (EXCLUDING SAN FRANCISCO)

WATER DEMAND

The San Francisco Bay Area is largely dependent upon imported water supplies. The complex system of water supply can logically be treated in two parts: The areas North and South of San Francisco Bay.

Irrigated agriculture accounts for about 60 percent of the present water demand in the North Bay Area. However, this area is experiencing rapid urbanization particularly in Marin and southern Sonoma Counties. Although irrigated agriculture is expected to increase in the future, urban demands are anticipated to account for about 70 percent of the total water demand by 2020.

Some areas in Napa and Sonoma Counties are already experiencing groundwater overdraft problems which will continue to occur unless additional facilities are constructed to meet the projected increased demands. In fact, the North Bay Area will have an aggregate annual supplemental water demand of about 50,000 acre-feet within the 20 years, increasing to about 350,000 acre-feet by 2020. Urban development is the primary cause of this supplemental demand.

An analysis of proposed projects by the California Department of Water Resources indicates that most of the additional water needs in the North Bay Area can be met by further development of local supplies, including wastewater.

The highly urbanized South Bay Area has almost fully developed its local ground and surface water supplies and depends heavily upon four major water import projects: the Hetch Hetchy Water System of the City of San Francisco, the Mokelumne Aqueduct of the East Bay Municipal Utility District, the Contra Costa Canal of the Central Valley Project, and the South Bay Aqueduct of the State Water Project. The total amount of water imported by these four systems in 1972 was about 500,000 acre-feet. However, planned expansions would increase the total capacity of these systems to 1,150,000 acre-feet per year.

These planned expansions, which will have the capability of importing greater quantities of Sierra Water, are opposed by environmental groups because of the need to retain some streams in their natural state and the limited knowledge of the impact of dams and diversions on the environment. If reclaimed water were used for some of the less restrictive uses (e.g., landscape irrigation, industrial cooling water, etc.), it might not be necessary to expand these four systems.

There have been many recent studies with respect to the potential of wastewater reclamation in the San Francisco Bay Area. The study areas of some of the more significant studies are shown on Figure 1 and the results with respect to wastewater reclamation are summarized in Tables 1 through 13.

FIGURE III-1
SUBREGIONAL STUDY AREA BOUNDARIES

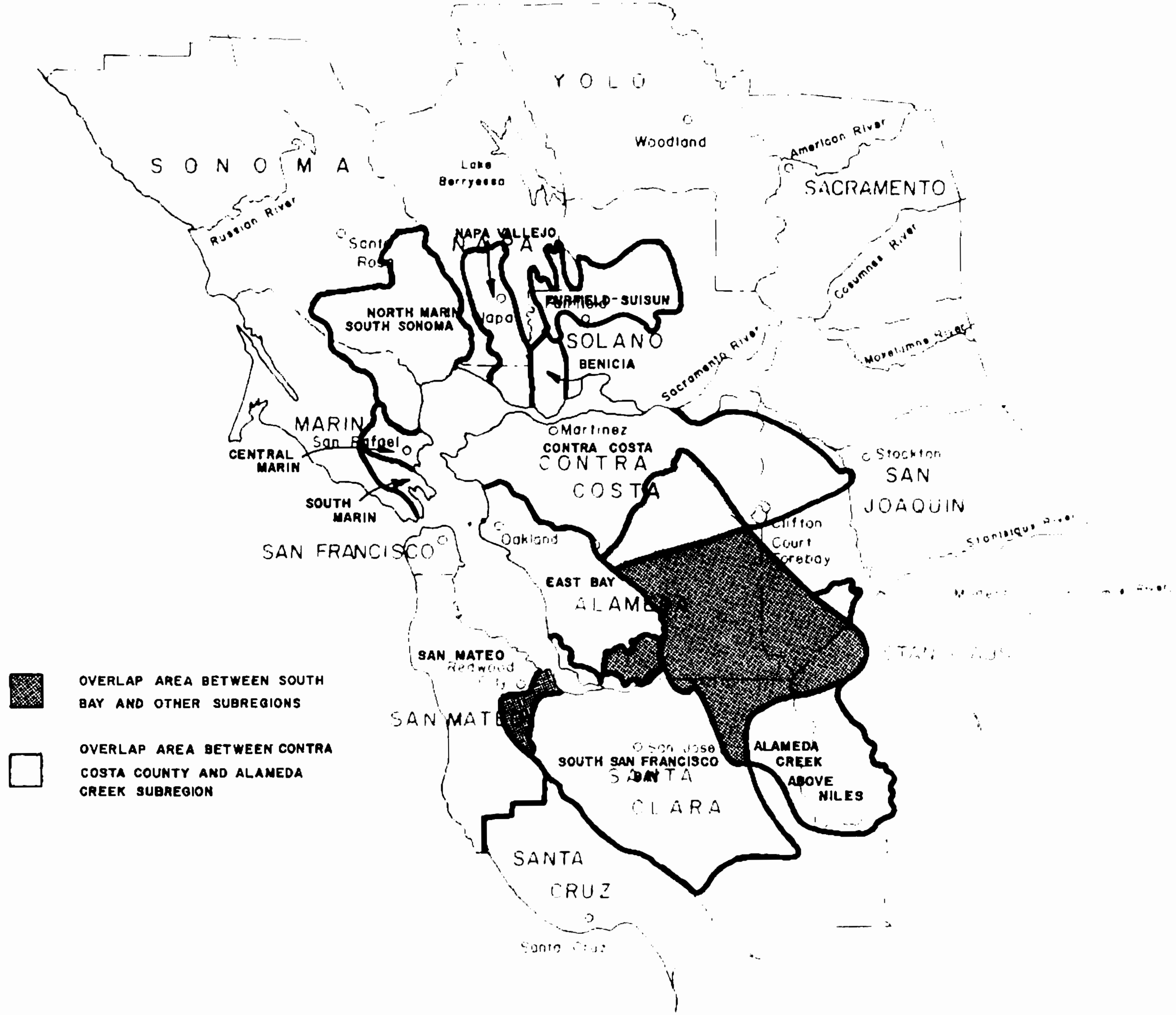


TABLE 1

RECLAMATION INFORMATION SUMMARY

Report Title: NORTH MARIN-SOUTH SONOMA REGIONAL WATER QUALITY MANAGEMENT PROGRAM - 1972 (Reference 1)

Author: J. Warren Nute, Inc./Jenks & Adamson/Yoder-Trotter-Orlob & Associates

	Present Quantity AF/year	Present Cost[1] $/AF	Future Year	Future Quantity AF/year	Future Cost[1] $/AF
Identified Markets for reclaimed wastewater					
Direct Reuse (Domestic)			1985	undefined	150[2]
Groundwater Recharge			1985	undefined	150[2]
Local					
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural	3,653[3]	15[2]	1980	6,730	15[2]
			2000	20,175	15[2]
Landscape	5,045[3]	15[2]	1980	>5,045	15[2]
			2000	>5,045	15[2]
Open Space[4]	All wastewater		1980	All wastewater	
			2000	All wastewater	
Outside Area			1980	All wastewater	
			2000	All wastewater	
Industrial					
Cooling	240				
	160				
Process					

TABLE 1
(Continued)

	Present Quantity AF/year	Present Cost[1] $/AF	Future Year	Future Quantity AF/year	Future Cost[1] $/AF
Boiler Feed					
Other					
Combined			1980	1,120	50[2]
SIC Nos	36,32,29				
Impoundment					
Recreational					
For Seasonal Use					
Combined			2000	All wastewater 41,110	114-131[5]
Total Local Market and demand					
Total Identified Local Market[9]	8,814		1980	12,900	
Demand in Excess of Supply (deficiency)[8]	0			0	
			2000	0	
Available Local Wastewater	13,400[6]		1980	16,600	
			2000	61,600[7]	
Excess Local Market and Demand					
Identified Market Excess[9]					
Demand over Supply/ wastewater total					
Excess Local Wastewater					
Excess over identified market[9]	4,590		1980	3,700	
Excess over Supply deficiency	13,400		1980	16,600	
				61,600	
Recommended Reclamation method	None		1980-1985	Recreation Lake/Outside Use	
			1985-1990	Recreation Lake Domestic Reuse/Outside Use	

TABLE 1 (Continued)	Present		Future		
	Quantity AF/year	Cost[1] $/AF	Year	Quantity AF/year	Cost[1] $/AF
Reason for not utilizing all wastewater					
Public Health Problems	X			All to be utilized All to be utilized	
Excess Costs					
Total	X				
Treatment					
Transport					
Storage					
Lack of Demand					
Scope of Report					
Considered all local markets in detail					
Emphasized local landscape irrigation	X			X X	

[1]Cost in excess of secondary treatment
[2]Wastewater treatment cost only
[3]Seasonal demand
[4]Considered a "created" market
[5]Cost of treatment, reservoir, and recreation facilities
[6]Interpolation
[7]From Table 9-23
[8]Fresh water sources are available
[9]Excludes open space irrigation and reservoir storage

TABLE 2

RECLAMATION INFORMATION SUMMARY

Report Title: WATER RECLAMATION AND REUSE/A STUDY FOR THE SANTA CLARA COUNTY FLOOD CONTROL AND WATER DISTRICT/ PHASE 1 FINAL REPORT - JULY 1973 (Reference 2)

Author: Consoer-Bechtel

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for reclaimed wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local					
Surface Spreading			1980-1990	150,000-290,000	
Injection			1980-1990	>75,000	
Outside Area	None		1990 2000	63,900 70,600	
Irrigation					
Local					
Agricultural[1]	95,000		1990 2000	72,800[2] 58,000	
Landscape	15,000				
Open Space[3]	unlimited			unlimited unlimited	
Outside Area					
Industrial					
Cooling					
Process					
Boiler Feed					

TABLE 2 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Other					
Combined	very small		1980 2000	very small very small	
SIC Nos					
Impoundment					
Recreational					
For Seasonal Use					
Combined	small		1980 2000	small small	
Total Local Market and demand					
Total identified local market	110,000		1980- 2000 2000	377,000 517,000 396,000 509,000	
Demand in excess of supply (deficiency)	6,700		1985 2000	104,000 150,000	
Available Local Wastewater[4]	115,000		1985 2000	190,000 255,000	
Excess Local Market and demand					
Identified market excess			1980- 2000 2000	187,000 327,000 141,000 254,000	
Demand over supply/ wastewater total					
Excess Local Wastewater					
Excess over identified market	5,000				
Excess over supply deficiency	108,300		1980- 2000 2000	 86,000 105,000	
Recommended Reclamation Method	None				
Reason for not utilizing all wastewater					

TABLE 2 (Continued)

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Public Health Problems					
Excess Costs					
Total					
Treatment					
Transport					
Storage					
Lack of Demand					
Scope of Report					
Considered all local markets	X		1980	X	
			2000	X	
Emphasized small scale landscape irrigation					

[1] Also a groundwater recharge market
[2] Interpolation
[3] Considered a "created" market
[4] From Ref. 5 (Sunnyvale, Milpitas, San Jose/Santa Clara, Union Sanitary District)

TABLE 3

RECLAMATION INFORMATION SUMMARY

Report Title: CITY OF FAIRFIELD/SUBREGIONAL WASTEWATER MANAGEMENT STUDY - SEPTEMBER 1972 (Reference 3)

Author: Montgomery Engineers

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for reclaimed wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local	None				
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural	15,000	0			
Landscape					
Open Space					
Outside Area					
Industrial	None				
Cooling					
Process					
Boiler Feed					
Other					
Combined					
SIC Nos					

TABLE 3
(Continued)

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Impoundment					
Recreational					
For Seasonal Use					
Combined	All waste flow			All waste flow	
Flushing Suisun Marsh	120,000	0[3]		120,000	
Total Local Market and demand					
Total Identified Local Market	135,000		1995	≈135,000	
Demand in Excess of Supply (deficiency)					
Available Local Wastewater	6,600		1995	30,600	
Excess Local Market and Demand					
Identified Market Excess	128,400		1995	104,400	
Demand over Supply/ wastewater total					
Excess Local Wastewater					
Excess over Identified Market					
Excess over Supply deficiency					
Recommended Reclamation Method	Agricultural irrigation[1]		1985	Marsh Enhancement[2]	
Reason for not utilizing all wastewater					
Public Health Problems				All utilized	
Excess Costs					
Total					
Treatment					
Transport					
Storage	X				
Lack of Demand	X				

TABLE 3 (Continued)	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Scope of Report					
Considered all local Markets in detail	X			X	
Emphasized local landscape irrigation					

[1]All summer flows
[2]Quality dependent on results of USBR study
[3]Cost in excess of disposal cost

TABLE 4

RECLAMATION INFORMATION SUMMARY

Report Title: CONTRA COSTA COUNTY WATER QUALITY STUDY - 1972
(Reference 4)

Author: Brown and Caldwell

	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)	None				
Groundwater Recharge	None				
Local					
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural	Little				
Landscape					
Open Space	>29,500	59-80			
Outside Area					
Industrial					
Cooling	103,000		1980 2000	155,000 314,000	
Process[1]	24,000		1980 2000	45,000 96,000	
Boiler Feed	18,000		1980 2000	30,000 56,000	
Other					
Combined					
SIC Nos	281,29,33, 20,26		1980 2000	281,29,33, 20,26 281,29,33, 20,26	

TABLE 4
(Continued)

	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Impoundment					
Recreational	Small				
For Seasonal Use					
Combined					
Total Local Market and Demand					
Total Identified Local Market	>174,500		1980	>259,500	
			2000	>496,500	
Demand in Excess of Supply (Deficiency)	0			0	
Available Local Wastewater	396,000		1980	447,000	
			2000	671,000	
Excess Local Market and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	<221,500		1980	<187,500	
			2000	<174,500	
Excess Over Supply Deficiency	396,000		1980	447,000	
Recommended Reclamation Method	Reclaim 33600 AF/year industrial use			At Cost Over secondary of $40/AF[2]	
Reason for not Utilizing all Wastewater					
Public Health Problems					
Excess Costs					
Total					
Treatment	X				
Transport					
Storage					

TABLE 4 (Continued)	Present			Future	
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Lack of Demand	X				
Scope of Report					
Considered all Local Markets in Detail	X				
Emphasized Local Landscape Irrigation					

[1]Exclude food and paper industries
[2]Calculated from given data capital at 6% - 30 years

TABLE 5

RECLAMATION INFORMATION SUMMARY

Report Title: WATER QUALITY MANAGEMENT PLAN FOR SOUTH SAN FRANCISCO BAY/FINAL REPORT - MARCH 1972 (Reference 5)

Author: Consoer-Bechtel

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)	5,600-25,000[7]	156[3]	2000	5,600-33,600	163[3]
Groundwater Recharge			2000	33,600-146,000	
Local					
Surface Spreading	5,600-35,500[4]	117-156[3]			
Injection					
Outside Area					
Irrigation					
Local					
Agricultural					
Landscape	11,210(st)[7]	107			
Open Space					
Outside Area[5]	7,100		1985 2000	26,500 42,700	
Industrial					
Cooling					
Process					
Boiler Feed					
Other					
Combined					
SIC Nos					

TABLE 5 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Impoundment					
Recreational			2000	35,870	59
For Seasonal Use					
Combined					
Winter Discharge[5]	7,100		1985 2000	26,500 42,700	
Total Local Market and Demand					
Total Identified Local Market	60,500		2000	222,300	
Demand in Excess of Supply (Deficiency)	0		2000	146,000[1]	
Available Local Wastewater	121,000		1985 2000	257,000 346,000	
Excess Local Wastewater and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	60,500		2000	123,700	
Excess Over Supply Deficiency	121,000		2000	200,000[1] 346,000[2]	
Recommended Reclamation Method	Livermore Valley-Recharge	South Bay & Bayside-None		South Bay & Bayside-Recharge	
Reason for not Utilizing all Wastewater					
Public Health Problems					
Excess Costs					
Total	X				
Treatment	X				

TABLE 5 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Transport	X			X	
Storage	X				
Lack of Demand	X			X	
Scope of Report					
Considered all Local Markets in Detail	X				
Emphasized Local Landscape Irrigation					

[1] If San Felipe Project not built
[2] If San Felipe Project is built
[3] In excess of Bay Disposal cost
[4] Livermore Valley recharge (Union Sanitation District & Local Wastewater)
[5] Livermore Valley Reclamation
[6] Calculated 6% interest on capital - 30 year repayment
[7] Palo Alto wastewater - total market includes only one alternate

TABLE 6

RECLAMATION INFORMATION SUMMARY

Report Title: WATER QUALITY MANAGEMENT PLAN FOR THE ALAMEDA CREEK WATERSHED ABOVE NILES - SEPTEMBER 1972 (Reference 6)

Author: Brown and Caldwell

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local[5]	2,800				
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural[5]	9,700S		1980 1990	8,800S 8,000S	
Landscape					
Open Space					
Outside Area					
Industrial					
Cooling					
Process					
Boiler Feed					
Other					
Combined[5]	5,000				
SIC Nos	10-14				

TABLE 6 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Impoundment					
Recreational					
For Seasonal Use					
Combined[6]	8,660		1990	30,000	
			2000	44,000	
Total Local Market and Demand[3]					
Total Identified Local Market[2] [5]	19,300		1990	18,000	
			2000	17,000	
Demand in Excess of Supply (Deficiency)	0		1990	0	
			2000	18,000[1]	
Available Local Wastewater	8,660		1990	30,000	
			2000	44,000	
Excess Local Market and Demand					
Identified Market Excess	10,640				
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market			1990	12,000	
			2000	27,000	
Excess Over Supply Deficiency	8,660		1990	30,000	
			2000	26,000	
Recommended Reclamation Method[5]	Impoundment 8660			30,000	
	Irrigation 5000	570[4]		11,000	
	Recharge 0		1990	5,000	165[4]
				44,000	
				14,000	
			2000	8,000	130[4]
Reason for not utilizing all wastewater					
Public Health Problems	X			X	
Excess Costs					
Total	X			X	
Treatment					

TABLE 6 (Continued)	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Transport					
Storage					
Lack of Demand	X			X	
Scope of Report					
Considered all Local Markets in Detail	X			X	
Emphasized Local Landscape Irrigation	X			X	

[1] From Figure 4-7
[2] Excludes municipal reuse
[3] Data from report—not sum of individual listings
[4] Total project cost
[5] From Table 4-4
[6] Entire wasteflow--total flow not necessarily reclaimed other than for recreational use

TABLE 7

RECLAMATION INFORMATION SUMMARY

Report Title: REUSE OF WASTEWATER IN THE EAST BAY MUNICIPAL UTILITIES DISTRICT - JUNE 1972 (Reference 7)

Author: East Bay Municipal Utilities District

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local					
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural					
Landscape	11,200-22,400[1]	124[2]			
Open Space					
Outside Area					
Industrial					
Cooling					
Process					
Boiler Feed					
Other					
Combined	19,100[1]	382[2]			
SIC Nos					
Impoundment					

TABLE 7 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Recreational & Industrial	67,100[1]	312[2] [3]			
For Seasonal Use					
Combined					
Total Local Market and Demand					
Total Identified Local Market	110,000[1]				
Demand in Excess of Supply (deficiency)	0				
Available Local Wastewater	>150,000				
Excess Local Market and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	>40,000				
Excess Over Supply Deficiency	>150,000				
Recommended Reclamation Method	None				
Reason for not Utilizing all Wastewater					
Public Health Problems	X				
Excess Costs	X				
Total					
Treatment					
Transport					
Storage					
Lack of Demand	X				
Scope of Report					

TABLE 7 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Considered all Local Markets in Detail	X				
Emphasized Local Landscape Irrigation					

[1]Relate to specifically defined "reasonable" alternates and not total market for this reuse in study area
[2]Reclamation cost beyond secondary wastewater treatment
[3]Distribution system excluded

TABLE 8

RECLAMATION INFORMATION SUMMARY

Report Title: WASTEWATER RECLAMATION STUDY FOR NORTH SAN MATEO COUNTY SANITATION DISTRICT - 1971 (Reference 8)

Author: Kirker, Chapman, and Associates, Jenks & Adamson

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local					
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural					
Landscape	3,040	75-97	when feasible	5,600	97+
Open Space					
Outside Area					
Industrial					
Cooling					
Process					
Boiler Feed					
Other					
Combined					
SIC Nos					

TABLE 8 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Impoundment					
Recreational					
For Seasonal Use					
Combined					
Total Local Market and Demand					
Total Identified Local Market	3,040		when feasible	5,600	
Demand in Excess of Supply (Deficiency)[2]					
Available Local Wastewater[1]	4,600		1980 2000	5,270 6,500	
Excess Local Market and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	1,560				
Excess Over Supply Deficiency	4,600				
Recommended Reclamation Method	Local Landscape Irrigation				
Reason for not Utilizing all Wastewater					
Public Health Problems	X				
Excess Costs					
Total	X				
Treatment					
Transport					
Storage					
Lack of Demand					

TABLE 8 (Continued)	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Scope of Report					
Considered all Local Markets					
Emphasized Local Landscape Irrigation		X			

[1]From Reference 13
[2]Water provided by the San Francisco Water Department for the foreseeable future

TABLE 9

RECLAMATION INFORMATION SUMMARY

Report Title: WASTEWATER RECLAMATION FOR BENEFICIAL REUSE FOR CITY OF PALO ALTO (Reference 9)

Author: Jenks & Adamson

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)			long-range future	maybe	
Groundwater Recharge					
Local					
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural					
Landscape	335	27-212	intermed. future	2,020	27-212
			long-range future	>2,940	27-212
Open Space					
Outside Area					
Industrial					
Cooling					
Process					
Boiler Feed					
Other (at STP)	1,255	27-212	intermed. future	1,255	27-212
			long-range future	1,255	27-212

TABLE 9 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Combined					
SIC Nos					
Impoundment					
Recreational			maybe	long-range future	
For Seasonal Use					
Combined					
Total Local Market and Demand					
Total Identified Local Market	1,600		inter. future	3,275 >4,200	
Demand in Excess of Supply (Deficiency)	0				
Available Local Wastewater[1]	25,000		1985 2000	32,000 36,000	
Excess Local Market and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	23,400		1985 2000	28,700 <31,800	
Excess Over Supply Deficiency					
Recommended Reclamation Method	Landscape irrigation and use in treatment plant				
Reason for not Utilizing all Wastewater					
Public Health Problems	X				
Excess Costs					
Total	X				
Treatment					

TABLE 9
(Continued)

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Transport					
Storage					
Lack of Demand	X				
Scope of Report					
Considered all Local Markets					
Emphasized Local Landscape Irrigation		X			

[1]From Reference 5

TABLE 10

RECLAMATION INFORMATION SUMMARY

Report Title: WASTEWATER RECLAMATION BENEFICIAL REUSE - CITY OF SAN LEANDRO - SEPTEMBER 1972 (Reference 10)

Author: Jenks & Adamson

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local					
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural					
Landscape	500	69-210[2]	"future"	1,300	69[2]
Open Space					
Industrial					
Cooling					
Process					
Boiler Feed					
Other					
Combined					
SIC Nos					
Impoundment					
Recreational					

TABLE 10 (Continued)	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
For Seasonal Use					
Combined					
Total Local Market and Demand					
Total Identified Local Market	500	69-210	future	1,300	69
Demand in Excess of Supply (Deficiency)	0				
Available Local Wastewater	8,100		2000	11,700	
Excess Local Market and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	7,600		future	10,400	
Excess Over Supply Deficiency	8,100		2000	11,700	
Recommended Reclamation Method	Local landscape irrigation				
Reason for not Utilizing all Wastewater					
Public Health Problems	X				
Excess Costs	X				
Total					
Treatment					
Transport					
Storage					
Lack of Demand	X				
Scope of Report					

TABLE 10
(Continued)

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Considered all Local Markets in Detail					
Emphasized Local Landscape Irrigation	X				

[1]From East Bay Dischargers Study
[2]Cost in excess of secondary treatment--include distribution and storage cost
[3]Only local large landscape irrigation use considered

TABLE 11

RECLAMATION INFORMATION SUMMARY

Report Title: WATER QUALITY MANAGEMENT PROGRAM/EAST BAY DISCHARGERS/ ALAMEDA COUNTY, CALIFORNIA - 1972 (Reference 11)

Author: Jenks & Adamson/Kennedy Engineers

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local					
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural[1]	11,200				
Landscape[1]	9,000				
Open Space					
Outside Area					
Industrial					
Cooling					
Process					
Boiler Feed					
Other					
Combined[1]	16,800				
SIC Nos					

TABLE 11 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Impoundment					
Recreational					
For Seasonal Use					
Combined					
Total Local Market and Demand					
Total Identified Local Market[1]	37,000				
Demand in Excess of Supply (Deficiency)	0			0	
			2000	0	
Available Local Wastewater[2]	134,600		1990	215,000	
			2000	246,000	
Excess Local Market and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	97,600				
Excess Over Supply Deficiency	134,600		1990	215,000	
			2000	246,000	
Recommended Reclamation Method	Local Landscape Irrigation				
Reason for not Utilizing all Wastewater					
Public Health Problems	X				
Excess Costs					
Total	X				
Treatment	X				
Transport					
Storage	X				

TABLE 11 (Continued)	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Lack of Demand	X				
Scope of Report					
Considered all Local Markets in Some Detail	X				
Emphasized Local Landscape Irrigation					

[1]From Table 8-3 (Flows are assumed to be annual average maximums)
[2]From Table 5-14 Dry Weather Flows only

Use Potential Within the Basin
(Excluding San Francisco)

TABLE 12

RECLAMATION INFORMATION SUMMARY

Report Title: WASTEWATER MANAGEMENT PROGRAM/SOUTH SAN FRANCISCO-SAN BRUNO SUBREGIONAL AREA - 1971 (Reference 12)

Author: Jenks & Adamson

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local					
Surface Spreading					
Injection					
Outside Area					
Irrigation					
Local					
Agricultural					
Landscape	1,220	78[1]		1,940	
Open Space					
Outside Area					
Industrial					
Cooling					
Process					
Boiler Feed					
Other					
Combined	225	78[1]			
SIC Nos	33,311				

TABLE 12 (Continued)	Present Quantity AF/year	Present Cost $/AF	Future Year	Future Quantity AF/year	Future Cost $/AF
Impoundment					
Recreational					
For Seasonal Use					
Combined					
Total Local Market and Demand					
Total Identified Local Market	1,445				
Demand in Excess of Supply (Deficiency)[2]	0				
Available Local Wastewater	9,000		2000	14,600	
Excess Local Market and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	7,555				
Excess Over Supply Deficiency	9,000				
Recommended Reclamation Method	No large scale-possible small reclamation for landscape irrigation				
Reason for not Utilizing all Wastewater					
Public Health Problems					
Excess Costs	X				
Total					
Treatment					
Transport					
Storage					

TABLE 12 (Continued)	Present			Future	
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Lack of Demand	X				
Scope of Report					
Considered all Local Markets in Detail	X				
Emphasized Local Landscape Irrigation					

[1]Treatment beyond secondary only
[2]Water supplied by the San Francisco Water Department for the foreseeable future

Use Potential Within the Basin
(Excluding San Francisco)

TABLE 13

RECLAMATION INFORMATION SUMMARY

Report Title: SAN MATEO COUNTY WATER QUALITY MANAGEMENT PROGRAM SYNOPSIS - 1973 (Reference 13)

Author: Jenks & Adamson

	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Identified Markets for Reclaimed Wastewater					
Direct Reuse (Domestic)					
Groundwater Recharge					
Local					
Surface Spreading					
Injection					
Outside					
Irrigation					
Local					
Agricultural					
Landscape					
Open Space					
Outside Area					
Industrial					
Cooling					
Process					
Boiler Feed					
Other					
Combined					
SIC Nos					

TABLE 13 (Continued)	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Impoundment					
Recreational					
For Seasonal Use					
Combined					
Total Local Market and Demand					
Total Identified Local Market[1]	11,800		future	21,000	
Demand in Excess of Supply (Deficiency)[2]	0				
Available Local Wastewater	61,600		1980 2000	72,700 96,600	
Excess Local Market and Demand					
Identified Market Excess					
Demand Over Supply/ Wastewater Total					
Excess Local Wastewater					
Excess Over Identified Market	49,800		2000	75,600	
Excess Over Supply Deficiency	61,600				
Recommended Reclamation Method	Use wastewater when possible & feasible				
Reason for not Utilizing all Wastewater					
Public Health Problems	X				
Excess Costs					
Total	X				
Treatment	X				
Transport	X				
Storage	X				

TABLE 13 (Continued)	Present		Future		
	Quantity AF/year	Cost $/AF	Year	Quantity AF/year	Cost $/AF
Lack of Demand					
Scope of Report					
Considered all Local Markets in Detail					
Emphasized Local Landscape Irrigation					
General Discussion	X				

[1]Landscape irrigation and industrial use
[2]City of San Francisco Water Department provides water as needed

POTENTIAL MARKETS

There are many potential markets for reclaimed water in the San Francisco Bay Area. Some of the more promising potential markets are irrigation, industrial use, groundwater recharge, and salinity control. The potential of these four markets is discussed in the following paragraphs.

Irrigation

The principal areas where irrigated agriculture takes place are the Sonoma and Napa Valleys, eastern Solano County, eastern Contra Costa County, Livermore Valley, and Santa Clara Valley. Except for a few areas, irrigation water is obtained by means of individual diversions. The only large-scale irrigation systems in the Bay Area are the Putah South Canal in eastern Solano County and the South Bay Aqueduct in Livermore Valley and Santa Clara Valley. However, neither of these canals would be suitable for receiving reclaimed water in the near future as they both serve municipal water and the State Department of Health will not allow direct re-use until the possible long-term effects of stable organic compounds on health are determined. The question of these unknown long term effects will not be answered for years, and years of exposure may be involved for the occurrence of adverse effects. Therefore, direct augmentation of a municipal water supply cannot be considered in the near future.

Potential agricultural markets in the San Francisco Bay Area were identified in Task VII-le, San Francisco Bay-Delta Water Quality Control Program Study and in Task Report D, Comprehensive Water Quality Management Plan for the San Francisco Bay Basin. Both of these studies indicated that the potential for agricultural use of reclaimed water in the Bay Area is very limited.

Another potential for irrigation use of reclaimed water, especially near urban communities, consists of irrigation of turf grass areas. The types of areas to be considered include golf courses, parks, greenbelts, and cemeteries. However, of all the turf grass areas of large enough size for consideration for irrigation with reclaimed water (40 acres or more) the most abundant by far are golf courses.

There are 77 golf courses scattered throughout the San Francisco Bay Area. However, the total estimated water use of these 77 courses is only 16.46 mgd and 70 percent of them are within five miles of other suitable wastewater sources. Therefore, the potential of using reclaimed San Francisco wastewater for golf course irrigation outside the City is nil.

There are many parks and cemeteries scattered throughout the Bay Area that could use reclaimed wastewater for irrigation. Generally most of the parks and cemeteries are near local wastewater sources and therefore transporting reclaimed water from San Francisco to these areas (e.g., East Bay Regional Parks, cemeteries in northern San Mateo County) would not seem practical at this time. In fact, the North San Mateo County Sanitation District is presently planning a wastewater reclamation program which involves the cemeteries in northern San Mateo County.

In summary, the potential for using reclaimed San Francisco wastewater for irrigation within the Bay Area but outside the City is very limited at this time.

Industrial Use

The San Francisco Bay Area contains a large number of industries including a number of chemical plants, steel and metal producing mills, petroleum refineries, and other large water users such as tanneries. Therefore, the potential for industrial use of reclaimed wastewater in certain areas should be good. Many of the Bay Area industries use their own well supplies as well as making use of brackish water. This private use of groundwater has contributed to a problem in some areas where the safe yield is being exceeded.

Potential industrial markets in the Bay Area outside the City are identified in Table 14. There are a total of 73 industrial plants with a total estimated fresh water use of about 210 mgd (very conservative figure) in the Bay Area. It is apparent that the major water users are the petroleum and chemical plants in Western Contra Costa County. However, fairly large water users are also the chemical plants at Newark, South San Francisco, and Nichols; a concrete plant at Napa; five steel product plants at Emeryville; a paper box plant at Oakland; and a paper products plant at San Jose.

The total estimated water use of the three petroleum refineries in the Richmond area is about 170 mgd (based on wastewater flow). The major amount of this estimated water use is, however, for cooling purposes. At the present time, the major source of supply for this purpose is brackish Bay water. One of the assumptions of this study is that where brackish water is used for cooling, changing to reclaimed wastewater for cooling would not be beneficial. Therefore, there does not appear to be a potential for using reclaimed San Francisco wastewater for this purpose.

TABLE 14
POTENTIAL INDUSTRIAL USERS
OF RECLAIMED WATER

County	City	Product	No. of Plants	Estimated Water Use, mgd[1]
Napa	Napa	Concrete	1	0.52
Solano	Benicia	Petroleum	1	(2.96)
Contra Costa	Avon	Petroleum	1	(12.8)
	Martinez	Chemicals	1	0.05
		Petroleum	2	(>4.3)
	Richmond	Chemicals	5	(>5.2)
		Petroleum	3	(167.4)
		Iron	1	0.05
	Nichols	Chemicals	1	(4.0)
Alameda	Berkeley	Steel manufacture	2	0.05
		Iron	1	0.06
		Metals	1	0.06
		Leather	1	0.06
		Paper box	1	0.06
		Soap	1	0.32
	Emeryville	Steel manufacture	5	>0.58
		Metals	2	0.02
	Oakland	Steel fabrication	5	0.05
		Sheet metal	2	0.03
		Steel manufacture	3	>0.1
		Paper box	1	0.9
	San Leandro	Pulp & paper	1	unknown
		Steel manufacture	2	>0.03
		Iron castings	1	0.02
		Rubber	1	unknown
	Hayward	Metal castings	1	0.03
		Steel fabrication	2	0.02
	Newark	Chemicals	1	(>1.69)
	Alameda	Steel fabrication	1	0.02
		Steel products	1	0.18
San Mateo	South San Francisco	Steel manufacture	3	>0.1
		Steel wire	1	0.04
		Steel fabrication	1	0.02
		Chemicals	4	(7.3)
		Non-ferrous metals	2	0.05
	Belmont	Chemicals	1	0.15
Santa Clara	Santa Clara	Paper products	2	>0.16
		Wire products	1	0.02
		Steel and aluminum	1	unknown
		Steel fabrication	2	0.003
	San Jose	Steel manufacture	2	0.34
		Chemicals	1	0.17
		Paper Products	1	0.68
		Plastics	1	0.05

[1]Figures in brackets () are wastewater flow.

There is another cluster of heavy industrial water users in the Avon-Martinez area. However, the Central Contra Costa County Sanitation District is presently constructing reclamation facilities to serve these industrial plants. When completed, these facilities will have the capability of meeting the likely future industrial needs in this area.

The only other cluster of heavy industrial water users in the Bay Area outside the City of San Francisco is in South San Francisco. Total estimated water use in this area, however, is only about 7.5 mgd. Therefore, it would not appear feasible to construct separate reclamation and transport facilities to provide these industries with reclaimed San Francisco wastewater.

In summary, the potential for using reclaimed San Francisco wastewater for industrial purposes outside the city of San Francisco appears to be very limited.

Groundwater Recharge

The most promising potential groundwater recharge area is the groundwater basins in northern Santa Clara County and adjacent southwestern Alameda County. These basins have excellent recharge capabilities. In fact, the Santa Clara County Flood Control and Water District has operated percolation facilities, a network of off-stream ponds and natural streambeds, in this area for the past decade. During this period, the District has recharged an annual average of 150,000 acre-feet (140 mgd) of local water and untreated South Bay Aqueduct water through these facilities. The Department of Water Resources recently estimated that these facilities could be increased to recharge an additional 100,000 acre-feet of supplemental water annually.

Since these groundwater basins are a source of municipal supply, the State Department of Health would not allow the injection of significant quantities of reclaimed wastewater due to the unknown health risks associated with stable organic compounds.

Salinity Control

The Department of Water Resources and State Water Resources Control Board have initiated a San Francisco Bay Area Interagency Wastewater Reclamation Study to determine the feasibility of intercepting and reclaiming treated Bay Area wastewater for transport and reuse to augment Delta outflows, either directly or indirectly by substituting reclaimed water for irrigation and groundwater recharge demands in the Bay Area or adjacent areas. The Bay Area is of particular importance because wastewater is being discharged to saline water and lost to further beneficial use and the region is adjacent to the Delta, which is the focal point of water supplies for a large portion of the State.

In its September 19, 1973, progress report, the Interagency Study group made the following comments:

> "The additional water required by the Central Valley Project and the State Water Project to meet contracts and future water demands can be expressed as an outflow deficiency expected at the Delta under projected conditions.
>
> "Operation studies were made of the Central Valley Project-State Water Project system to determine what deficiencies would occur in the future. The analysis indicated that under a 1990 level of development, the average annual deficiency would be 370,000 acre-feet and would increase to 950,000 under a 2020 level of development. Dry period average annual deficiencies would be 720,000 and 1,960,000 acre-feet for 1990 and 2020.
>
> "Water with a salinity of 4,000 to 6,000 ppm of total dissolved solids could be used to meet this water deficiency by direct augmentation of Delta outflow at about Chipps Island, with provision for treatment to avert toxicity and biostimulation effects in the estuary."

Preliminary results of this study indicate that reclaimed water could be made available for about $90 per acre-foot for this purpose. In developing these costs, it was assumed that wastewater sources currently discharging into San Francisco Bay would be aggregated at three terminal locations from which three overland conveyance and regulatory system possibilities could make the wastewater available at five possible reuse sites. However, additional treatment facilities necessary to produce reclaimed water which would not cause toxicity or biostimulation problems in the estuary were not included in these unit costs. If found necessary, this additional treatment would escalate the unit cost to about $130 per acre-foot. Therefore, before a conclusion regarding the feasibility of this proposal can be made, a detailed environmental assessment of the proposal is required.

Another possible area for using reclaimed wastewater for salinity control is in the Suisun Marsh. Since 1965 the U. S. Bureau of Reclamation has been making controlled releases of fresh water from Lake Berryessa into the Marsh via the Putah South Canal. The primary objective of this program is to determine the degree of water quality control that can be achieved by releases of fresh water into the sloughs of the Marsh. These releases are considered to be temporary and will not be available in the future because they represent supplemental water from the Solano Project. Based on this program, very rough estimates of the total water needs of Suisun Marsh indicate an annual minimum requirement of 120,000 acre-feet, the quality of which is yet to be defined. However, the staff of the California Regional Water Quality Control Board, San Francisco Bay Region has suggested that any discharge in this area must be substantially free of all toxicants and biostimulants. If this policy were upheld by the Board, using reclaimed water to flush the Marsh would not be economically feasible.

In summary, it does not appear that utilizing reclaimed San Francisco wastewater for salinity control in the Delta or in Suisun Marsh is feasible without the results of detailed environmental studies concerning toxicity and biostimulation.

POTENTIAL FOR USING RECLAIMED SAN FRANCISCO WASTEWATER OUTSIDE THE BASIN

Irrigated agriculture is by far the largest user of fresh water in California. Therefore, when considering large scale reclamation projects, irrigated agriculture must be considered as a potential market for the reclaimed water. It is recognized that the use of reclaimed water for crop irrigation is not without problems which include seasonal water use, quality considerations, public acceptance, and the possibility of using the water for drinking. These problems, however, are not insurmountable.

Two large agricultural areas in relatively close proximity to the Bay Area are the Delta-Mendota and San Luis Service Areas within the San Joaquin Valley. The projected import water requirements under the 2015 level of development for these areas are as follows:

Service Area	Quantity, acre-feet
Delta-Mendota	1,675,000
San Luis	1,279,000
TOTAL	2,954,000

As a part of its study, the Interagency Group investigated the possibility of using reclaimed Bay Area wastewaters to supplement the imported supplies for these two areas. Three of the alternatives studied by this group included utilization of San Francisco wastewaters. Brief descriptions of these three alternatives are contained in the following paragraphs.

Alternative C would aggregate and convey wastewaters from East Bay Municipal Utility District, Union-Alvarado, San Jose-Santa Clara, San Francisco-Southeast, and San Francisco-Richmond-Sunset through Livermore Valley to a 280,000 acre-foot capacity reservoir on Brushy Creek. Regulated flows from the reservoir would be released into the Delta-Mendota Canal at Tracy to serve irrigation demands in the Delta-Mendota service area during periods when the canal would not be pumped into O'Neill Forebay. Thus, there would be no mixing of reclaimed water with export flows to Southern California.

Alternative D was designed to specifically substitute for Alternative C and eliminate the intermittent cross-connection with the San Luis Reservoir-State Water Project system. Alternative D, however, only aggregates those discharges in the span from San Leandro to San Francisco's Richmond-Sunset. The aggregated discharge would be conveyed southward. Thence over Pacheco Pass into a 400,000 acre-foot storage reservoir on Los Banos Creek. Releases would be made into the Delta-Mendota Canal downstream from O'Neill Forebay for irrigation use in the Delta-Mendota service area.

Alternative E was designed as a substitute for Alternatives C and D. It is similar to D; although, it also includes the northern East Bay discharges. However, reclaimed water would not be used in the Delta-Mendota service area but in the San Luis service area which would require the construction of a separate canal from the Los Banos Reservoir southward about 100 miles along the irrigation service area.

Statistical data regarding these three alternatives are presented in Tables 1 and 2.

To date, the Interagency Group has not made any conclusions regarding the feasibility of implementing its alternatives. However, it would appear that the costs of delivering reclaimed water to the point of use are very high at this time and not competitive with State-Federal project water.

DESCRIPTION OF ALTERNATIVE WASTEWATER PROJECTS[a]

Alter-native	Wastewater Source	Yield in AF[b]	Aggregation Point	Conveyance	Storage Location, Capacity in AF	Use, Service Area
C	EBMUD south, west and north to San Francisco	380,000	Union City	East through Livermore Valley to Altamont, north to Brushy Cr, west to DMC at Tracy	Brushy 280,000	Irrigation DMC[c]
D	San Leandro south, west and north to San Francisco	310,000	Alviso	South to Gilroy, east to Los Banos Cr, east to DMC service area	Los Banos 400,000	Irrigation DMC
E	EBMUD south, west and north to San Francisco	380,000	Alviso	South to Gilroy, east to Los Banos Cr, south to San Luis service area	Los Banos 400,000	Irrigation P.P Cooling San Luis

[a]From Table 1, Interagency September 19, 1973 Progress Report
[b]First stage yield to 1990
[c]Delta-Mendota Canal

COSTS OF ALTERNATIVE WASTEWATER PROJECTS[a]
(in dollars per acre-foot)

Alternative	Aggregation	Conveyance to Storage	Energy	Storage	Conveyance from Storage	Coagulation	Filtration Disinfection	Nutrient Removal	Drainage Salt Balance	Total
C	32	23	14	11	1	12	15	NA	[b]	108
D	29	34	16	4	1	12	15	NA	[b]	111
E	29	34	16	4	33	12	15	NA	NA	143

[a]From Table 2, Interagency September 19, 1973 Progress Report
[b]Costs variable and speculative (see Remarks)

REMARKS:

1. Assumed economic life of storage and conveyance facilities: 50 years.
   Assumed economic life of treatment facilities: 50 years.
   Interest rate for economic analysis: 6 percent.

2. Alternative C: Results in partial cross-connection of reclaimed wastewater with San Luis Reservoir and California Aqueduct. Could aggravate drainage problems in DMC service area. Project participation in drainage export facility is indicated. Additional cost undetermined.

3. Alternative D: Could aggravate drainage problems in DMC service area. Project participation in drainage export facility is indicated. Additional cost undetermined.

4. Alternative E: This alternative carries the least unresolved deterrents at this stage of planning.

POTENTIAL FOR USING RECLAIMED WASTEWATER WITHIN THE CITY AND COUNTY OF SAN FRANCISCO

Wastewater reclamation is not new to the City and County of San Francisco. In 1899, John McLaren, Superintendent of Golden Gate Park, began irrigating park lands with untreated sewage. However, because of complaints, a septic tank was installed in 1912. Effluent from the septic tank was used to fill and maintain a series of ornamental lakes and for the irrigation of about 250 acres. Then in 1932, a 1.0 mgd activated sludge plant was constructed solely for wastewater reclamation--the first in California.

Reclaimed water from the new plant was first used to fill the ornamental lakes; however, this use was later expanded to include irrigation of the polo field and other park areas. Because the limited use of reclaimed water evoked no complaints, reuse of the water was later expanded to the entire park irrigation system. Today this source supplies about 25 percent of the park's total horticultural irrigation water needs.

WATER SUPPLY

The City and County of San Francisco was served by a private water company until the early part of the Twentieth Century when the City developed a plan to utilize water from the Tuolumne River in the Sierra Nevada. The Raker Act, passed by Congress in 1913, granted to San Francisco rights-of-way and the use of Yosemite National Park lands for constructing, operating, and maintaining reservoirs, dams, conduits, and other structures necessary to use the Tuolumne River as a water supply and power source.

In 1934 the first water from Hetch Hetchy Reservoir on the Tuolumne River was delivered via the 149-mile aqueduct to San Francisco. The system was designed for an ultimate delivery of 400 mgd to the Peninsula. Besides three reservoirs now used in the Tuolumne Basin, the City has two reservoirs in the East Bay as well as three major reservoirs on the Peninsula. Water storage, distribution, and sales in the Bay Area are managed by the San Francisco Water Department. The water and power properties are under control of the San Francisco Public Utilities Commission.

The entire San Francisco water system now supplies water to two million consumers directly through its own distribution facilities or indirectly through about 40 other municipal and water distributing agencies. The water is supplied to the City and County of San Francisco, most of San Mateo County, and parts of Santa Clara and Alameda Counties.

Even though the demands for fresh water in the Bay Area are expected to increase in the future, the San Francisco Water Department expects no water supply problems for the next 50 years nor does it expect a water rate increase in the future. The present cost of fresh water within the City is approximately 25¢/1000 gallons ($82/acre-foot) for large users.

POTENTIAL USES FOR RECLAIMED WATER

The possible potential uses of reclaimed water within the City and County of San Francisco include groundwater recharge, landscape irrigation, and industrial use.

The potential market for using reclaimed water for these purposes is presented in the following paragraphs.

Groundwater Recharge

The two fundamental benefits of an artificial recharge operation are relief of overdraft and use of the groundwater basin for water storage and distribution. Overdraft of a groundwater basin can create numerous problems including increased well construction and pumping costs, sea water intrusion, and land subsidence.

However, highly urbanized San Francisco utilizes only very small quantities of local groundwater. The major use of local groundwater used to be the Sunset well field which had a yield of 6,600 acre-feet. The use of this field was abandoned, however, in the early 1930's.

Landscape Irrigation

As previously stated, the City and County of San Francisco operates a 1.0 mgd wastewater reclamation facility in Golden

Gate Park. In addition to this facility, the City also operates two small reclamation facilities--San Francisco County Jail and San Francisco Log Cabin Ranch for Boys. The total quantity of reclaimed water produced at these two facilities, however, is only about 0.1 mgd.

With respect to landscape irrigation, the most promising market for reclaimed water is within Golden Gate Park. Since the McQueen Plant is only capable of producing one-fourth of the total demand within the Park it appears logical to expand that plant to a capacity of 4.0 mgd. However, in addition to the regular activated sludge plant it would be advisable to also provide rapid sand filtration which would guarantee a consistently high quality effluent. The cost of reclaimed water produced by the expanded facility would be approximately $140/acre-foot compared to about $82/acre-foot for fresh water. Therefore, the expanded facility would not seem feasible based solely on economics.

It might be feasible, however, to construct only filtration and disinfection facilities at the upgraded Richmond-Sunset Plant and a reclaimed water line from the plant site to the areas of use. The unit cost of water for this alternative would be about $30 per acre-foot plus transportation costs of about $24 per acre-foot. Therefore, the total estimated unit cost for the reclaimed water would be approximately $54 per acre-foot compared to $82 per acre-foot for fresh water.

Other than expanded use at Golden Gate Park the most promising landscape irrigation markets for reclaimed water are the seven larger golf courses within San Francisco. Statistical data with respect to these courses are shown below:

Name of Course	Area, Acres	Water Use, mgd
McLaren Park	40	0.1
Harding Park	100	0.2
The Olympic Club	190	0.3
Lake Merced Golf & Country Club	110	0.2
San Francisco Golf Club	100	0.2
Lincoln Park	80	0.14
Presidio Army Golf Club	100	0.2
TOTALS	720	1.34

Although golf courses are usually the largest single water users in a municipal system, their total water demands are not that great as shown above. There are three large golf courses (Harding Park, The Olympic Club, and Lake Merced) in close proximity to the proposed Southwest Treatment Plant, however. While the total water demand at these three courses is only about 0.7 mgd, it might be possible to divert the necessary quantity of effluent from the Richmond-Sunset effluent line and further treat it by sand filtration and disinfection.

The cost of this excess treatment would be about $50 per acre-foot and transportation costs of about $23 per acre-foot giving a total estimated unit cost of $73 per acre-foot. Therefore, based on cost, irrigation of these three golf courses with reclaimed water would appear feasible if a major repiping project at the golf courses is not necessary. The other golf courses were not considered due to their distance from planned treatment facilities.

It appears feasible to produce a limited amount of reclaimed water at the proposed Southwest Treatment Plant site for use at the Olympic Club, Harding Park, and Lake Merced golf courses and at the Richmond-Sunset Plant for use in Golden Gate Park at very competitive rates assuming that secondary effluent from the Richmond-Sunset Plant would be the source of supply for the reclamation facilities.

Industrial Use

As part of its Basin Planning Program, the State Water Resources Control Board contracted with the State Department of Health to investigate the feasibility of wastewater reclamation in the Bay Area. As part of that study, potential industrial markets for reclaimed water were identified. Following is a Department list of potential industrial markets within San Francisco:

Product	No. of Plants	Est. Water-Use, mgd
Steel Fabrication	3	0.03
Steel Manufacturing	5	>0.14
Chemicals	5	>0.35
Tannery	1	0.04
Metals	1	0.02
TOTALS	15	>0.58

Due to the very small volumes involved and the distances between industrial facilities, it does not appear feasible to reclaim municipal wastewater for industrial use within the City of San Francisco.

EFFECT OF RECLAMATION ON THE MASTER PLAN

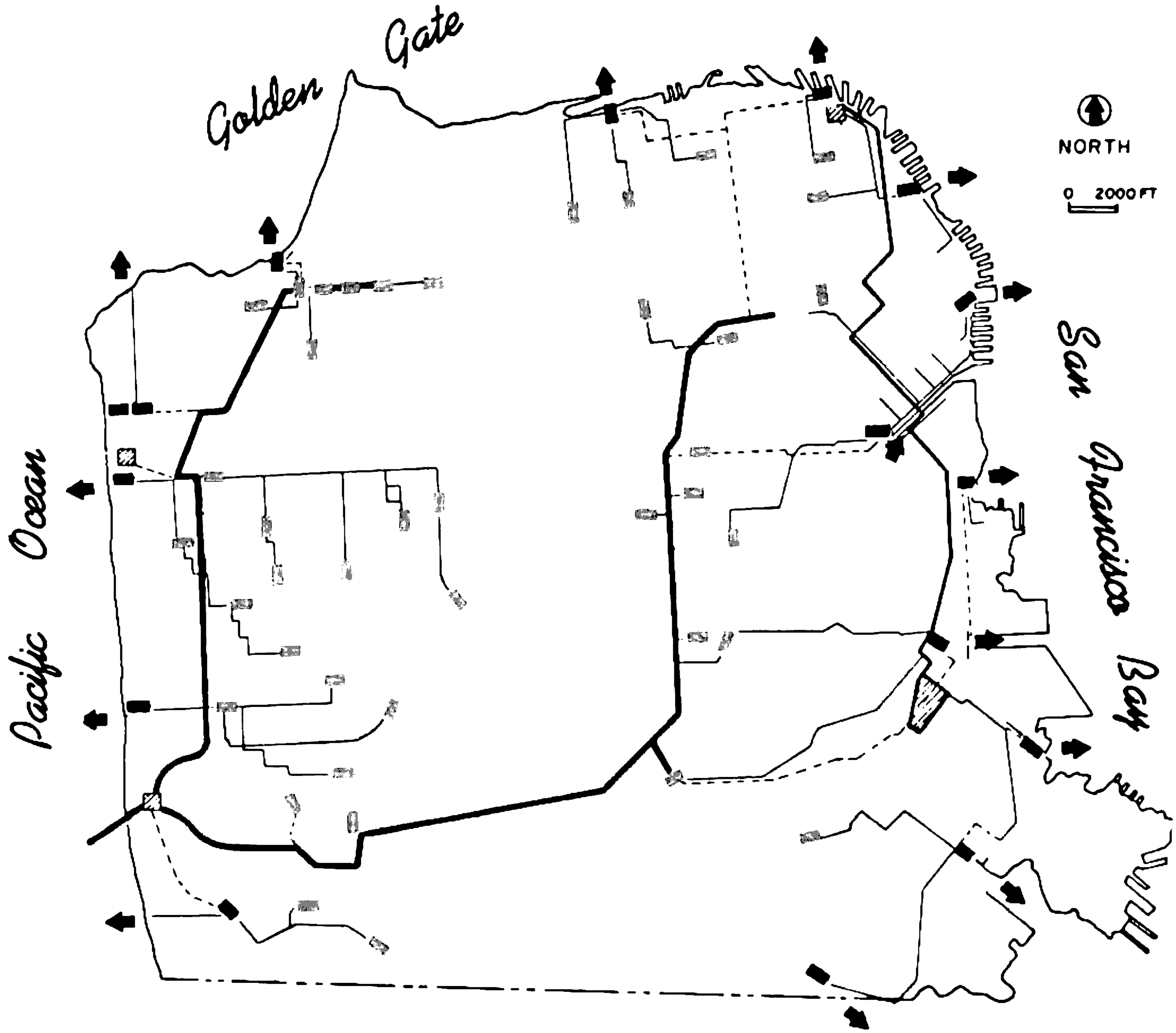
The Master Plan for wastewater management as shown on Figure 1 envisions secondary treatment of all wastes during a major part of the year, elimination of Bay discharges, and the virtual elimination of untreated waste bypasses. During the major portion of the year, wastes will receive secondary treatment at the Southeast and Richmond-Sunset plants. Effluent from these plants will be transmitted through the tunnel and pipeline systems to the Lake Merced area where they will be discharged approximately four miles offshore. The existing North Point plant will be abandoned. During storm conditions, flows exceeding the capacity of the secondary treatment plants will be transported to a 1,000 mgd capacity treatment facility at Lake Merced. Effluent from this facility will be discharged approximately two miles offshore.

The Phase I Improvement Program designed to achieve early compliance with State and Federal treatment standards and to reduce overflows in the critical north shore and ocean beach areas is shown on Figure 2. Wastewater generated in the North Point service area will be pumped to the Southeast Treatment Plant which will provide secondary treatment for the dry weather flows from both the North Point and Southeast areas. Effluent from the Southeast Plant will be discharged to the Bay through an improved outfall. Wet weather waste control facilities will be constructed to control overflows in the north shore area and the North Point Plant will be converted to a wet-weather facility to treat wastewaters from the area during storm periods. The Richmond-Sunset Plant will be substantially improved to produce an effluent quality acceptable for continued ocean disposal. Effluent from the Richmond-Sunset Plant will be transmitted to the Lake Merced area for ocean disposal.

As previously pointed out, the most promising potential use of reclaimed water within the City and County of San Francisco appears to be landscape irrigation within Golden Gate Park and the three golf courses in the Lake Merced Area--The Olympic Club, Lake Merced, and Harding Park. It also appears that the most economical method of producing reclaimed water for this use would be to provide advanced waste treatment facilities (rapid sand filtration and disinfection) at the proposed

Figure VI-1

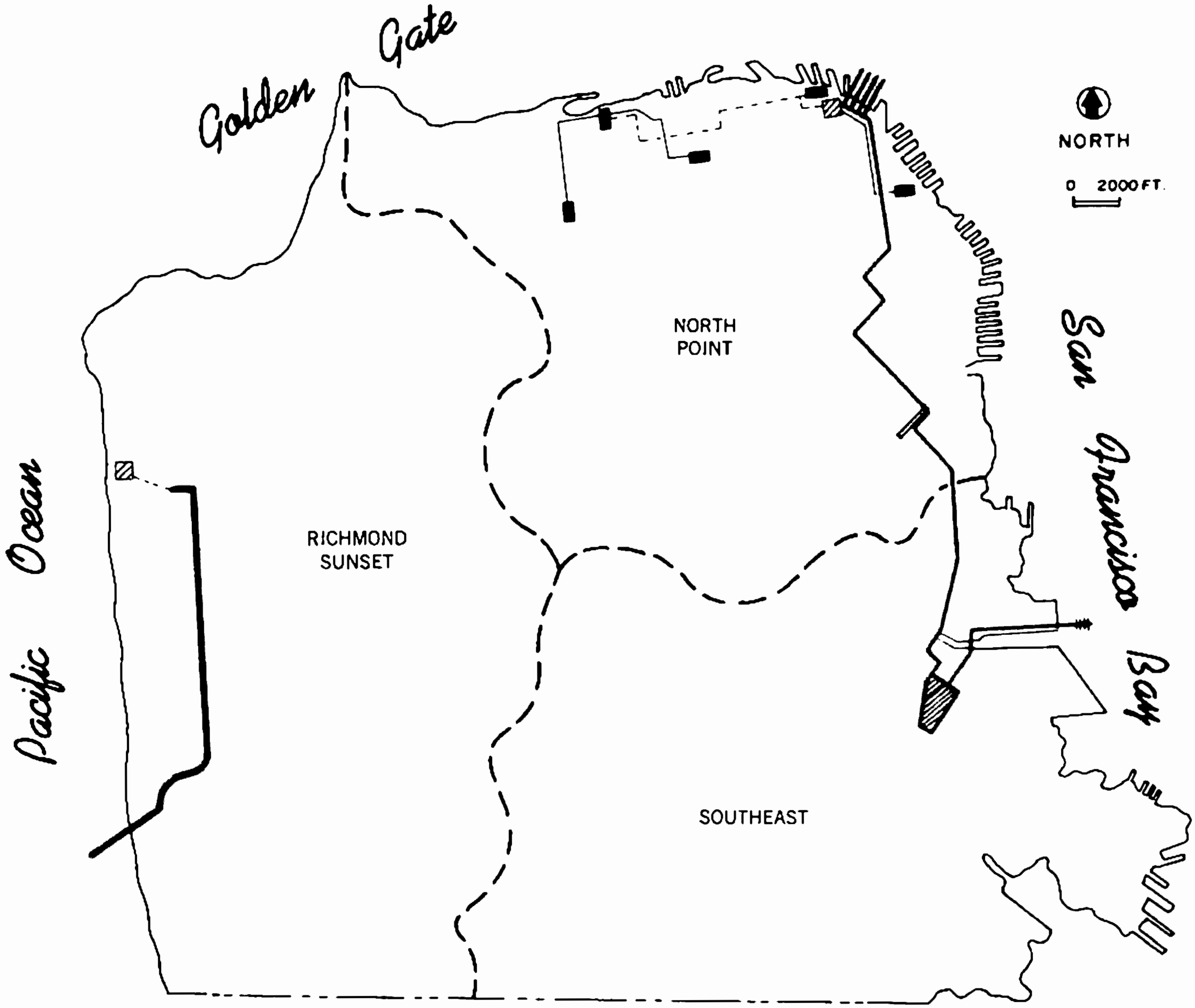
MASTER PLAN



The complete Master Plan for wastewater management is shown above. Retention basins (upstream — light blue, shoreline — dark blue) provide storage, control flooding, and allow regulation of flow to the transportation system (green). During the major portion of the year, wastes will receive secondary treatment at the Southeast and Richmond-Sunset plants. These treated effluents will be transmitted through the tunnel and pipeline systems to Lake Merced where they will be discharged approximately 4 miles offshore. The North Point Plant will be abandoned. During storm conditions, flows exceeding the capacity of the secondary treatment plants will be transported to a 1000 million-gallon-per-day capacity treatment plant at Lake Merced. The effluent will be discharged 2 miles offshore. The system will provide secondary treatment of all waste during a major part of the year and the bypassing of untreated waste will be virtually eliminated.

Figure VI-2

FIRST PHASE OF MASTER PLAN



The improvement program designed to achieve early compliance with State and Federal treatment standards and to reduce overflows in the critical north shore and ocean beach areas is shown in red. Raw waste from the North Point service area will be pumped to the Southeast Treatment Plant. The Southeast Plant will provide secondary treatment for the dry weather flows from the North Point and Southeast areas. The effluent will be discharged to the Bay through an improved outfall. Wet weather waste control facilities will be constructed to control overflows in the north shore area. The North Point Plant will be converted to a wet weather facility to treat wastewaters from the area during storm periods. The Richmond-Sunset wastwater treatment plant will be substantially improved to produce an effluent quality acceptable for continued ocean disposal. Effluent from the Richmond-Sunset Plant will be transmitted to the Lake Merced area for ocean disposal.

Southwest Treatment Plant site and the Richmond-Sunset Plant site that would utilize secondary effluent as their source of supply. However, the total demand for landscape irrigation of these four areas is only 5.0 mgd. Therefore, reclamation for local uses would not have any effect on the size, location, or type of facilities as envisioned in the Master Plan.

The San Francisco Bay Area Interagency Wastewater Reclamation Study investigated the feasibility of large-scale reclamation projects within the Bay Area. The Interagency Study investigated the feasibility of aggregating wastewaters generated within the Bay Area, including San Francisco, providing some form of extended treatment, and producing reclaimed water that would be direct input into the Delta channels at Chipps Island to repel salinity, into the Delta Mendota Canal to serve irrigation demands within the Delta Mendota service area, and into a proposed canal to serve irrigation needs in the San Luis service area.

It should be pointed out, however, that all these alternatives were based on average daily dry weather flow and therefore the need for the 1,000 mgd wet weather treatment facility would still exist even if one of these alternatives were implemented. In fact, all the facilities envisioned in the Master Plan would be required whether or not any of the alternatives investigated in the Interagency Study were implemented. The only questionable portion would be the two barrel outfall as designed for dry weather flow. However, some form of "fail-safe" system (alternate method of disposal) would be necessary and generally the most efficient type of "fail-safe" system is an ocean outfall. Therefore, all Master Plan facilities are necessary whether or not large-scale reclamation plans are implemented.

In summary, it appears that reclamation, either large scale and export of wastes or small scale and local use, has no effect on the Master Plan with respect to the size, location, or type of facilities proposed.

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APPENDIX B

GLOSSARY OF TERMS

advection: transfer by horizontal motion.

aerobic: requiring, or not destroyed by, the presence of free oxygen.

algae: primitive plants, one- or many-celled, usually aquatic, and capable of synthesizing their food stuffs by photosynthesis.

aquatic growth: the aggregate of passively floating or drifting or attached organisms in a body of water.

arthropods: invertebrate animals with jointed legs, including insects, crabs, spiders, etc.

aseismic: protection against seismic effects.

assimilative capacity: the capacity of a natural body of water to receive (a) wastewaters without deleterious effects; (b) toxic materials, without damage to aquatic life or humans who consume the water; (c) BOD, within prescribed dissolved oxygen limits.

average daily flow: the total quantity of liquid tributary to a point divided by the number of days of flow measurement.

benthic: relating to, or occurring, on or at the bottom of a body of water.

benthos: the aggregate of organisms living on or at the bottom of a body of water.

bioassay: a method of determining toxic effects by using viable organisms as test agents.

biological wastewater treatment: forms of wastewater treatment in which biochemical action is intensified to stabilize, oxidize, and nitrify the organic matter present. The activated sludge process is an example.

biota: animal and plant life, or fauna and flora, of a region.

bloom: large masses of microscopic plant life, such as green algae, occurring in bodies of water.

B.O.D.: abbreviation for biochemical oxygen demand. The quantity of oxygen used in the biological processes that degrade organic matter under specified conditions.

B.T.U.: abbreviation for British Thermal Unit. Quantity of heat required to raise one pound of water one degree Fahrenheit.

chumming: a procedure in which food is broadcast to attract fish, which are then caught.

clarification: any process, or combination of processes, the primary purpose of which is to reduce the concentration of suspended matter in a liquid.

C.O.D.: abbreviation for chemical oxygen demand. The quantity of oxygen used in biological and nonbiological oxidation of materials in water.

coliform bacteria: a heterogeneous group of bacteria normally inhabiting human and animal intestinal tracts. Used as an indicator of fecal pollution of water and hence of the probability of presence of organisms causing human disease.

combined sewer: a sewer intended to receive both wastewater and storm water.

combined wastewater: a mixture of surface runoff and other wastewater, such as domestic or industrial wastewater.

conservative pollutants: nondegradable or slowly degradable substances which tend to accumulate in organisms and sediments.

crustacea: aquatic arthropods having a body covered with a hard shell, such as lobsters, shrimp, crabs, and barnacles.

db(A): a generally accepted unit of loudness which is corrected for the variation in frequency response of the typical human ear at commonly encountered noise levels.

diatoms: unicellular, microscopic aquatic plants with a box-like cell wall containing silica.

dissolved oxygen: the oxygen dissolved in water, or other liquid, usually expressed in milligrams per liter (mg/l) or per cent of saturation. Abbreviated D.O.

effluent: wastewater, partially or completely treated, flowing out of a treatment plant, or part thereof.

elutriation: a process of sludge conditioning whereby the sludge is washed by either fresh water or effluent to reduce the demand for conditioning chemicals and to improve settling or filtering characteristics of the solids.

estuarine: of, or pertaining to, an estuary which is a passage where the tide meets a river current, especially an arm of the sea at the lower end of a river.

euphausiids: small crustacea, members of the plankton community.

fathom: a unit of lenth equal to six feet, used primarily in marine measurements.

fauna: the animals of a given region or period considered as a whole.

flora: the plants of a given region or period considered as a whole.

foraminifera: a group of marine protozoa which form shells usually of lime. Foraminiferan shells form an important part of chalk.

gravid: pregnant or in the condition of having young or eggs.

heavy metals: dense metals, such as mercury and lead, which are toxic because of their ability to react with active sites on biologically important molecules.

hydrograph: a graph showing, for a given point on a stream or conduit, the discharge, stage, velocity, available power, or other property of water with respect to time.

hydroids: members of the invertebrate group Hydrozoa; related to jelly fish.

hyetograph: a graphical representation of average rainfall, rainfall excess rates, or volumes over specified areas during successive units of time during a storm.

infauna: animals living in the sea bed.

inorganic matter: chemical substances not of basically carbon structure.

invertebrates: animals having no backbone.

liquefaction: earthquake induced transformation of a stable granular material, such as soil, into a fluidlike state, similar to quicksand.

littoral current: a current that moves along the shore in a direction parallel to the shoreline.

lower low water: the lower of the two low tides along coasts where the two daily low tides are unequal.

median tolerance limit(Tl_m): in toxicological (bioassay) studies, the concentration of pollutants at which 50 per cent of the test animals can survive for a specified period of exposure, usually 96 hours.

megalops: the last larval stage in the development of the crab.

microorganism: minute organism, either plant or animal, invisible or barely visible to the naked eye.

milligrams per liter (mg/l): a unit of concentration. In the case of water solutions, it is equivalent to one part per million by weight.

mollusc: member of an invertebrate group containing most of the animals popularly called shellfish, except the crustacea. It includes the slugs, snails, mussels, clams, oysters, and octopi.

most probable number (MPN): that number of organisms per unit volume that, in accordance with statistical theory, would be more likely than any other number to yield the observed test result with the greatest frequency. Generally expressed as density of organisms per 100 milliliters.

nitrification: the conversion of nitrogenous matter into nitrates by certain bacteria.

organic matter: substances with a basic framework of carbon atoms.

oxygen saturation: the maximum quantity of dissolved oxygen that liquid of given chemical characteristics, in equilibrium with the atmosphere, can contain at a given temperature and pressure.

pathogens: disease causing organisms.

pelagic: inhabiting the mass of water of sea or lake, in contrast to the bottom.

photosynthesis: the synthesis of complex organic materials, especially carbohydrates, from carbon dioxide, water, and inorganic salts, with sunlight as the source of energy and with the aid of a colored catalyst, such as chlorophyll.

phytoplankton: plant plankton.

plankton: the aggregate of microscopic organisms in a body of water.

planktophagous: plankton eating.

primary productivity: the rate at which energy is stored by photosynthetic (plant) producer organisms in the form of organic substances that can be used as food materials by other organisms.

primary treatment: the first major (sometimes the only) treatment in a wastewater treatment works, usually sedimentation. The removal of a substantial amount of suspended matter but little or no colloidal and dissolved matter.

protozoa: small, one-celled animals including amoebae, ciliates, and flagellates.

recarbonation: diffusion of carbon dioxide gas through liquid to replace the carbon dioxide removed by the addition of lime and thereby to lower the hydrogen ion concentration (pH).

secondary treatment: the treatment of wastewater after primary treatment by sedimentation. The United States Environmental Protection Agency has defined the minimum level of effluent quality attainable by secondary treatment as follows:

Parameter	Units of Measure	Monthly	Weekly	Monthly % Removal
Biochemical Oxygen Demand	mg/l	30	45	85
Suspended Solids	mg/l	30	45	85
Fecal Coliforms	no./100 ml.	200	400	--
Acidity	pH	6.0 to 9.0		

static bioassay: bioassay in which solution is not renewed during the test.

stripbait: pork rind bait used mainly for black bass fishing.

tidal prism: the total amount of water that flows into a tidal basin or estuary and out again with movement of the tide, excluding any fresh-water flow.

turbidity: a condition in a liquid caused by the presence of suspended matter, resulting in the scattering of light rays.

zoeae: an early crab larval form.

zooplankton: animal plankton.

APPENDIX C

GEOLOGY, SEISMICITY AND EARTHQUAKE EFFECTS
SAN FRANCISCO WASTE WATER MASTER PLAN

For

J. B. GILBERT & ASSOCIATES

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CONSULTING ENGINEERS AND GEOLOGISTS

AN AFFILIATE OF WOODWARD-CLYDE CONSULTANTS

February 6, 1974

Project: S-13037

J. B. Gilbert & Associates
Planning and Engineering Consultants
1101 "R" Street
Sacramento, California 95814

Attention: Mr. Fred McLaren
Mr. Keith Dunbar

Gentlemen:

As authorized by your letter of December 27, 1973, and in accordance with subsequent verbal discussions with Mr. Dunbar, we have completed our preliminary study concerning the geology, seismicity and earthquake effects on the San Francisco Waste Water Master Plan. It is our understanding that this information will be used as part of the Environmental Impact Report which your firm is preparing for the Master Plan. As requested, Professor H. B. Seed has reviewed our findings and preliminary conclusions on January 14, 1974.

We are pleased to submit the enclosed geology and seismicity report which includes a map and a general discussion of the effects which an earthquake would have on the planned waste water facilities. A discussion of potential liquefaction effects in the Lake Merced area and other filled areas is included along with suggested alternate routes to avoid such problem areas.

We appreciate being asked to provide the enclosed information and hope to be of further service on this most interesting project. Please direct any questions concerning the report to the undersigned Associate.

Very truly yours,

Edward Margason

Edward Margason
Associate

EM:sb

Encls.

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GEOLOGY, SEISMICITY AND EARTHQUAKE EFFECTS
SAN FRANCISCO WASTE WATER MASTER PLAN

INTRODUCTION

The purpose of this study is to provide geotechnical information from existing geologic data so that earthquake effects can be predicted in a general manner for the San Francisco Waste Water Master Plan (SFWWMP). This study is based on an extensive review of existing geologic and scismologic data and is intended to provide general geotechnical planning information in connection with an environmental impact report being prepared by J. B. Gilbert and Associates for SFWWMP.

SCOPE

This report provides a description and map of presently known active and inactive faults in San Francisco and potential problem areas due to faults and seismicity. The potential effects of sand liquefaction near Lake Merced and other areas is discussed. A description of potential earthquake effects on SFWWMP facilities such as outfalls, treatment plants, pipelines, tunnels, underground storage and pump stations is given along with special design considerations which might minimize adverse effects during larger earthquakes.

PROJECT

The Wastewater Master Plan concept is described in detail in the May 1973 San Francisco Waste Water Master Plan Evaluation report prepared by J. B. Gilbert & Associates. Essentially, as Figure 1 indicates, the plan includes three large north-south trending waste water transportation lines (North Point-Southeast, Guerrero, and Sunset) which tie together with an east-west line running south of Mount Davidson to Lake Merced. Ultimately, the North Point plant will be abandoned, the Southeast plant will be expanded and upgraded, the Richmond-Sunset plant will be upgraded, and a new 1,000 mgd wet weather treatment facility will be constructed just west of Lake Merced. The plan also includes about 30 upstream retention basins, 15 shoreline basins, and a dual-purpose ocean outfall designed to transport the continuous dry weather flows three miles into the ocean and flows above the base rate two miles into the ocean.

As the topography indicates, the 1,000 mgd system is essentially a gravity flow network draining to the lower southwest corner of the City; however, some pumping will be required in the North Point and Southeast areas to assure gravity flow in the Guerrero-Mount Davidson line. The outfall location has been selected for minimal impact on biologically important offshore areas.

When the plan is complete, wastes will receive secondary treatment at the Southeast and Richmond-Sunset plants and effluents will be transmitted through the tunnel and pipeline systems to the Southwest site where they will be discharged approximately three miles offshore. During storm conditions, flows exceeding the capacity of the secondary treatment plants will be transported to the 1,000 mgd wet weather treatment plant and discharged two miles offshore. This system will eliminate continuous waste discharges to San Francisco Bay and virtually eliminate wet weather overflows to the Bay and Ocean.

GEOLOGY OF SAN FRANCISCO

The geology of the San Francisco Peninsula consists basically of a dense Franciscan shale, sandstone and chert bedrock at least 150 million years old overlain in the lower coastal areas by Quaternary dune sands and clays generally less than 3 million years old, see References 1, 2, 3 and 4. The general distribution of these two basic formations is shown on the geology map enclosed as Figure 2.

In the Lake Merced area and along San Francisco Bay numerous man-made fills have been placed, as shown on Figure 2. The Bay fills lie over soft clayey Bay Mud which in turn overlies old drowned Franciscan bedrock valleys in the Marina, Downtown, China Basin and Islais Creek areas. The Lake Merced fills consist mainly of saturated reworked dune sands, but no mud exists in this area.

Faults

Basically one active fault and three inactive faults trend northwesterly through the San Francisco area, as shown on Figure 2. The active fault is the San Andreas fault which lies in the ocean about 2 miles west of Lake Merced; no part of the San Andreas fault lies in the land area of the City of San Francisco. The last movement of this fault nearest to the city was in 1906 when the west or ocean side moved north as much as 21 feet with respect to the city side, a movement termed right-lateral motion.

Of the three presently known inactive faults, the San Bruno fault lies in the Franciscan bedrock from 300 to 1500 feet under Lake Merced. There is no evidence that this concealed fault cuts up into the surface sand formations of the Lake Merced area, hence, it is considered to be inactive. The City College fault passes northwesterly through San Francisco City College and out near Seal Rocks. This fault is exposed at ground surface in Franciscan rocks near the campus, but is concealed beneath the Quaternary dune sands north of the campus; it is also considered inactive. The shear zone which passes from Hunters Point up through Fort Point is an ancient fault which is found only in limited outcrops of the Franciscan; its location is characterized by ancient serpentine extrusions along the fault zone which have formed Hunters Point, Potrero Hill and part of Fort Point. There is no direct evidence that this fault or shear zone has been active in the past 100 million years; however, some surface soil failure may have occurred in the vicinity of this fault in 1906.

Seismicity

The activity of the San Andreas fault is well documented in the literature, see References 5, 6 and 7. At least five significant earthquakes have affected the San Francisco City area by movements on this fault in the last 135 years. In each case major land failures occurred.

In June 1838, a large (magnitude similar to 1906 event) shock originated on the San Andreas fault south of San Francisco. The Presidio and Mission Dolores were seriously damaged. In November 1852, a large shock (Intensity VIII on the Modified Mercalli Scale) caused considerable ground fissuring in the north end of Lake Merced where it formerly was connected to the ocean, see Reference 5; as a result a channel some 300 yards wide and 1/2 mile long was washed out by the lake waters as they emptied to the ocean, Reference 9. As Figure 2 indicates, the site of the 1852 washout was most likely through the east and north side of Fleischacker Zoo and along Sloat Boulevard to the ocean, Reference 12; this area has since been filled and developed by man, and it is through this fill that a major pipeline is proposed.

In October 1865, a large shock (Intensity IX) was centered along the San Andreas fault just south of the city and caused extensive lateral spreading and fissuring of filled land on Howard Street from 7th to 9th Streets. In April 1906, the major San Francisco earthquake (Magnitude 8.2) occurred causing a continuous surface rupture on the San Andreas fault from southern Humbolt County to

San Juan Bautista. The maximum horizontal movement was 21 feet at Tomales Bay, the probable epicenter; vertical fault movement was less than 3 feet. Damage was reported in all parts of the city, but it was generally least on the Franciscan bedrock areas where rock is close to the surface, see Figure 2. Where the earth cover increased, damage generally increased especially in the artificial fill-over-mud areas shown on Figure 2. Lateral-spreading land failures occurred in the filled Downtown and China Basin areas producing lateral movements of 1 to 6 feet toward the Bay. Pavements were fissured, buckled and arched, and sewers and water mains broken. Well-ballasted street car tracks were thrown into permanent shallow wave forms 1 to 2 feet high and several blocks of filled land surface were deformed into shallow waves of irregular length and amplitude. Excellent photos of such damage exist in Reference 12.

In the dense sand areas, the effects were generally less destructive than in the fill-over-mud areas although sand boils, fissures and sand bars were reported in the vicinity of Lake Merced. A timber railroad trestle, which crossed the narrow neck between the north and south arms of Lake Merced, see Figure 2, was totally destroyed as both the west and east banks of the lake liquefied and slid into the lake, uprooting the trestle. This area has since been covered by a man-made fill dike about 25 feet high and 50 feet wide with a roadway on top; it is through this same location a major pipeline is proposed. General slope disturbance was also reported on the earth slope west of the trestle location and just east of the Armory in Fort Funston.

In March 1957, the San Andreas fault produced a moderate (Magnitude 5.5) earthquake centered in the Mussel Rock area. While this was a milder event than the prior four described (no surface rupture was found along any fault) above, it nevertheless produced extensive landslides and liquefaction in the Lake Merced-Stonestown area. Description of these effects are detailed in Reference 7.

Liquefaction landslides occurred in the artificial roadway fills around Lake Merced, see Figure 2, and filled areas east of the lake near Stonestown experienced settlements of 1 to 4 inches. A small foot-bridge on the north arm of the lake was also heavily damaged by liquefaction landslides.

Damage to pile-supported sewage treatment plant at Linda Mar was negligible; however, ground settlement around the tanks caused buried pipelines to break. The Daly City sewage plant digestor at Alemany and Lake Merced Boulevards rests on concrete spread footings 10 feet below grade; it experienced backfill settlement of 1/2 to 1-1/2 inches but the deeper tank base remained stable; no sewer line damage occurred. In general, sewage collection pipes from houses did not show damage.

At the Lake Merced pump station, a filled area settled 4 to 6 inches severing a 12-inch pipeline where it entered the station. Four steel fresh water mains were broken in the southwest area of the city as earthquake-induced water surges in pressure pipelines damaged air valves and weak joints. Line surges caused extensive pressure pipe damage in both the 1971 San Fernando and the 1952 Kern County earthquakes.

In Westlake Palisades, nearer the epicenter, several Transite water lines broke and one partially-buried square reinforced-concrete reservoir settled and cracked causing major leaks. This tank was about 20 feet high and was buried about 8 to 10 feet in the ground with its base on friable sandstone and its walls partly backfilled with sand.

In the 1971 San Fernando earthquake, extensive damage reports were filed on water and sewage facilities. The general conclusions from these reports which could apply to the SFWWMP area are that: 1) active fault crossings cause certain damage, 2) transitions between aboveground pipes and underground tunnels or tanks are potential breakage points, 3) pipelines on steep hillsides often suffer landslide damage, 4) buried pipes are damaged by soil compaction, lateral land spreading, soil liquefaction and severe ground shaking, 5) buried bell-and-spigot pipe joints are damaged when they are pushed together, pulled apart or deflected excessively by ground movement, 6) dynamic lateral soil pressures on buried tank structures often greatly exceed static design loads. Photos of similar effects in 1906 in San Francisco are given in Reference 12.

In conclusion, the levels of seismicity which the SFWWMP project could experience during its design life will be significant and must be recognized in location and design. There are, in our opinion, no presently known active faults which the on-land facilities would cross; however, a portion of the ocean outfall will cross the San Andreas fault, see Figure 2.

Maximum bedrock accelerations from San Andreas events which could occur during the project life could vary approximately as shown in Table I below:

TABLE I

Event	Distance from Epicenter	Maximum Bedrock Accelerations
Magnitude 4 (typical small event)	5 to 10 miles	0.10 g
Magnitude 5-1/2 (1957 event)	5 miles 10 miles	0.25g 0.12g
Magnitude 7 (poss. 1852 or 1865 events)	5 miles 10 miles	0.45g 0.35g
Magnitude 8.2± (1906 event)	5 miles 10 miles	0.55g 0.45g

As in any general tabulation, the above values should not be interpreted too literally; these maximum bedrock accelerations are approximate and may be attenuated or amplified at any ground surface location depending on the soil conditions over bedrock, the duration of shaking and the vibration period of the site and structure. For instance, in the 1957 event, it is our opinion that the maximum bedrock acceleration deep under Lake Merced was probably about 0.25g, yet only about 0.18g of maximum ground surface acceleration is estimated in areas of liquefaction, Reference 11.

EARTHQUAKE EFFECTS AND SPECIAL DESIGN CONSIDERATIONS

The previous factors suggest a number of potential seismic effects on the SFWWMP system, and these are discussed in turn for each of the major facilities. It is our general conclusion that earthquake effects need not be critically damaging to the on-land portions of the Master Plan SFWWMP if proper seismic planning and design is utilized as described in a preliminary manner in the following sections. Of course, detailed geotechnical studies should be made of all major structure sites before final design is done; however, such studies are beyond the scope of this report.

Ocean Outfall

The outfall is approximately a 15-foot-diameter pipe that will be laid directly on the ocean floor; storm overflows will discharge about 2 miles offshore in 55 feet of water, however a dry weather effluent pipe will continue on to ultimate ocean discharge 3 miles offshore in 80 feet of water.

The outfall will cross the active San Andreas fault zone about 2 miles offshore; this zone is not yet located or mapped exactly but it is probably from 200 to 600 yards wide. It is certain that the outfall will be subjected to right-lateral earthquake displacements (sea-side moves north) where it crosses the rift zone.

To our knowledge, few major ocean outfalls presently cross a major active fault, so the crossing design becomes somewhat unique. Certainly a strong flexible pipe system is a minimum requirement and the outfall should cross the fault at right angles to minimize extension or compression of joints and to shorten the transit distance. There will likely be breakage of the outfall pipe during rupture of the San Andreas, and major reconstruction would be required at the point of breakage after such an event. However, if the 2-mile storm outfall is kept short of the fault zone, then a back-up discharge point might be provided while the 3-mile line is being repaired.

One design approach, then, is to provide a strong flexible pipe but plan to repair it after each major earthquake. However, if economics would permit, there may be at least three alternate methods which might be considered for increased outfall survivability during a large earthquake.

1) If the pipe were designed to contain a reverse "S" configuration at the fault zone crossing, with the "S" bending to the south where it crossed the fault, then fault movement would tend to straighten the pipe to a more normal alignment. All joints across the rift zone must be capable of shortening by sliding as the pipe straightens, and the pipe cylinder must be very strong to withstand lateral passive earth pressures induced on the outfall by fault movement. Major repairs are still a likely requirement with this scheme.

2) If the 15-foot diameter pipe is placed in a 25- or 30-foot diameter corrugated culvert laid across the rift zone, then a right lateral movement of about 10 to 15 feet might be tolerated before the inner outfall suffers serious bending. By such a device, possibly the outfall could survive one event such as the 1906 offset of 21 feet before repairs are needed; however, in subsequent major events after that repairs would be certain. If this scheme is considered, the water depth over the culvert could present a hazard to navigation unless the culvert were buried.

3) If the outfall is supported on pile bents across the fault zone and kept just above the shifting sands on the ocean floor, the pipe may be able to bend safely with the fault movement by sliding laterally on beams placed across the tops of the piles. Of course, the piles themselves may be subjected to serious shearing influences during an earthquake, and local loss of pipe support could occur. This technique has been proposed for pipe-fault crossings on land in the Alaska pipeline.

Another possibilityis to run the outfall northwest 3 miles terminating it just east of the fault. However, this would place the discharge somewhere off Seal Rocks in 35 feet of water which is not biologically desirable.

A number of additional factors will influence the support of the ocean outfall. These would include, but not be limited to: a) littoral and tidal currents and attendant forces on the outfall, b) influence of wave action and forces, c) sand erosion and shifting of ocean floor, d) fluctuation of ocean bottom profile with time, and e) the depth of loose or weak deposits on ocean floor along the alignment. All of these factors need to be evaluated by a detailed offshore study before design to assure adequate pipe support and operation.

Southwest 1000 MGD Plant and Pipes

The details of this plant are not yet known; however, it will be one of the largest in the U.S. It will occupy about 45 acres and will be constructed probably below Elevation +50 (City Datum) for hydraulic reasons. The site proposed is in the north tip of the Fort Funston area near an existing Armory, see Figure 2. Probably a slightly better site would be Site 2 on Figure 2 between the Armory and the Coast highway. This area is not so close to the steep east slopes along Lake Merced which failed during the 1906 event.

The plant should be founded on a base of stable soils; this is required to be sure that no loose potentially liquefiable dune sands would underlie the plant. If a stable base is provided, foundation piles would not be necessary; in fact, piles would probably not be the best foundation choice in such an area of potentially high seismicity.

It is possible that ground accelerations could approach 0.5g for several cycles at the plant site in a 1906-like event so proper aseismic design is essential. A thorough geotechnical site investigation is needed before specific plant design is begun.

The proposed pipeline routes in the vicinity of the Southwest plant cross areas which have suffered extensive earthquake damage and liquefaction in the past 135 years. As Figure 2 indicates, the Sunset line would cross the filled area at the Zoo over much of the 1852 washout. The South line through Stonestown will cross the narrow filled neck between the two arms of Lake Merced exactly at the location where liquefaction slides destroyed the trestle in 1906 and where 1957 flow slides occurred; this pipe is certain to be washed out and broken at the dike in a large event, and untreated sewage could flow into Lake Merced. The South line also crosses several filled arms east of the lake which are also potential zones of liquefaction failure. If pipelines are left at their present locations they will be subject to severe ground motion, liquefaction, bouyant floatation and extensive damage.

A much more stable pipeline route through the Lake Merced area would be north of the Lake, as shown on Figure 2. The topography is favorable for a gravity route along this alignment as Figure 1 indicates. At the same time, the Sunset line could be turned north of Sloat and parallel lines could be laid in a more economical common trench across Sloat and through the Zoo down to Site 2. The Sloat crossing would be over the 1852 washout, although at its narrowest point. This section of pipe would have to be protected at the washout crossing by a dense compacted gravel bed and backfill, but this should provide a reasonably stable base at the Sloat crossing.

If land use permitted, an even better plant location, which would permit location of all pipes in undisturbed natural ground, would be Location 1 shown on Figure 2. This would remove the plant from the Lake Merced area and avoid a major pipe crossing of any soils which have liquefied in past earthquakes. A dense gravel foundation mat may still be required at Location 1. Another advantage of Location 1 is that the plant would be about 1/2 mile further east of the San Andreas fault and further off the San Bruno fault, and the two-mile outfall discharge point would fall well short of the San Andreas fault. Sufficient freeboard (at least 20 feet above MSL) would be required around Location 1 to avoid Tsunami effects, Reference 8.

Richmond-Sunset Pipeline

This line will be located primarily in loose to medium dense dune sands well above sea level. It will probably be constructed in braced open-cut trenches and be backfilled by sand. The major seismic problem with this line will be differential settlements of the bedding and backfill during a strong event; liquefaction should not be a problem since most of the line should be well above the groundwater level.

To minimize differential pipe settlements and cracking, the backfill and bedding should be well-compacted around the pipe. The pipe itself should be a strong-thick-walled reinforced-concrete section with well designed bell and spigot joints capable of accepting large joint deflections and movements. Joints should be neoprene gaskets,and welded or solid mortar joints should be minimized. Even with the above precautions, major repairs can be expected after a large earthquake, especially where the pipe enters plant structures.

Pipe Tunnels

The Guerrero linc from south of Mt. Davidson to north of Market will have several large storage tunnels nominally 25 feet wide and 30 feet high with a cover depth varying from 50 to 150 feet. Much of this line will be located in Franciscan bedrock, and there will be two inactive fault crossings.

In general, well-reinforced concrete-lined bedrock tunnels perform fairly well in strong earthquakes as long as they do not cross active faults, and none of the proposed SFWWMP tunnels appear to cross such faults. Cracking of linings can occur at transitions between bedrock and soil overburden, and extra strong lining is desirable at such points. At the crossing of the City College fault extra lining strength may also be desirable in case a sheared and weakened bedrock zone is encountered; however, direct fault shearing of the lining is not expected.

A typical trouble spot is where smaller size shafts or pipes join tunnels; at such junctions cracks and pipe pullouts can occur. Aboveground pipes should extend at least 1/2 the pipe diameter into the tunnel, and exterior shear rings should be used on pipes and shafts to prevent their movement when they meet the tunnel linings.

Northpoint-Third Street Line

This Phase I pipeline will probably consist of 36-inch and 66-inch diameter pipe laid in a variety of conditions. Probably the greatest variation of soil and rock types will occur along this portion of the SFWWMP, as Figure 2 shows. The line will consist of a 36-inch diameter force main within an existing sewer from the Marina past the Downtown fill and to a pump station at the China Basin. From China Basin south past the Potrero Hill bedrock and the Islais Creek fill to the Southeast plant a 66-inch diameter force main will be provided. Ultimately, one or more deep pump stations will be required to lift sewage up to the Guerrero tunnel as operation of the Southeast plant is modified.

It is likely that strong earthquakes will cause pipe damage in the filled areas along the east side of San Francisco. The pipelines which would be placed in fills will be relatively flexible elements (on a large scale) which essentially move with the soil; if the soil does not rupture, liquefy or shear then pipe damage should not be great. It is expected that pipes in fills subject to lateral spreading could be pulled gradually easterly with a maximum of as much as 6 feet in a strong event and that the vertical pipe alignment will be thrown into a series of waves of variable length and amplitude.

Where pipes transit from filled areas to stronger native soils or from soil to rock, differential deflections may occur causing damage. Likewise, ground fissures or local liquefaction will shear pipe or remove bedding support causing pipe damage. Ground motion in filled land and at cut-fill transitions can push or pull axially on pipe joints causing joint breakage and pipe separations.

Generally, the City must expect heavy pipe maintenance in man-made filled areas after a strong earthquake event. Maintenance can, however, be minimized by initially selecting a thick-walled flexible-joint pipe with strong and long gasketed sliding joints at the connections. It would be desirable to work with pipe manufacturers to develop reinforced-concrete pipe for the SFWWMP which could withstand large passive soil pressures and permit joint deflection and joint sliding without serious joint leakage. The pipes should be installed on well-compacted granular bedding courses with at least 3 feet of well-compacted granular fill at the spring line. Good backfill compaction will at least minimize the possibility of fill liquefaction around the pipe in low wet areas.

In conclusion, pipelines in filled areas, especially fills over soft muds, will move with the soil, and earthquake damage will occur which will require extensive repairs. However, damage can be moderated by using strong, flexible, well-backfilled pipe laid in as few fill-over-mud areas as is practicable.

The Southeast Plant

This plant site is located partly on fill and mud in the Islais Creek Basin. The maximum fill thickness is probably about 20 feet and from 15 to 20 feet of soft Bay Mud underlies the north-east half of the site, see Figure 2. Just as was described during 1906 in the Downtown area, some lateral spreading of this site is likely during a large earthquake. The plant will likely be founded on piles which will be subjected to bending as they follow the mud and fill. Such pile bending should be checked by rational analysis to be sure the piles are sufficiently moment-resistant to safely sustain bending.

An alternate foundation scheme for areas where the depth to the base of mud is not more than about 30 feet, is to support structural elements of the plant on mat foundations extending through the Bay Mud. This would also minimize seismic disruptions where pipelines connect to structures or tanks. Care should be taken to provide proper foundation support for the plant since it will overlie potentially liquefiable zones of fill and because it will span from soft Bay Mud to stronger native soils in the southwest end of the site. A detailed geotechnical study of this site is very important but is beyond the scope of this report.

Reservoirs and Buried Structures

The storage basins will probably be reinforced concrete structures buried well below grade. The approximately 30 basins in the higher inland sites will be placed in a variety of locations on both soil and rock as Figure 2 indicates; most of these should be well above the ground water level.

Earthquake effects on buried basins and pump stations are significant; usually the greatest effect is an increase in lateral earth pressure on the reservoir walls. Where basins are buried above ground water and all in rock or all in soil (i.e., where the basin does not extend through a horizontal soil-rock contact), the Mononobe-Okabe analysis using a safety factor of about 1.2 gives realistic predictions of earthquake loadings. A horizontal acceleration at the base of the structure of 0.2g causes approximately a 20 percent increase over static active earth pressures; an acceleration of 0.4g causes approximately a 60 percent increase over static active earth pressures. Vertical roof loads associated with horizontal accelerations are usually less, being probably about 1/3 of the horizontal loads.

If the buried structure is partly in rock and partly in soil, differential site response can create shears which may increase the Mononobe-Okabe seismic soil pressures up to 3 times greater than the pressures suggested in the prior paragraph; thus a basin in soil-over-rock may experience as much as 180 percent soil pressure increase under 0.4g base acceleration.

For low-level basins or pump stations in saturated soils, dynamic ground water pressures may also be produced by the earthquake; these could be 2 to 3 times greater than the corresponding dynamic earth pressures, but they would probably not materially affect a water-filled structure. The empty structure would be most vulnerable to dynamic ground water pressures or to floatation if the base soil liquefied. It is extremely desirable to be sure that all buried basins at or below ground water level be checked for floatation and be founded on mats of dense soils which will resist liquefaction.

Buried basins on hillsides may also be subjected to differential horizontal dynamic pressures as the basin tends to move toward the lower confinement of the slope face. It is therefore desirable to avoid locating buried basins on excessively steep slopes or on slopes which may be subject to flow landslides. This same general precaution applies to pipelines. It is very important that each buried reservoir or pump station site be subjected to detailed geotechnical studies prior to design so that the above factors may be evaluated.

Control Facilities

The filling and emptying of the retention basins in the SFWWMP will normally be controlled at a central location using telephone lines to transmit water level data from each basin. Experiences in the San Fernando Earthquake of 1971 suggest that suspended phone lines are particular susceptible to seismic damage. It would be very desirable to provide a secondary back-up control at each basin or groups of basins in an area to minimize loss of system control during an earthquake.

LIMITATIONS

This evaluation of the potential earthquake effects on the SFWWMP is preliminary in nature and is primarily intended for use in environmental assessment and system planning. This study is based on published or unpublished data and prior experience; no new field data was generated in this study. While the seismic guidelines are, in our opinion, very realistic, we recommend that a detailed geotechnical study be made of all SFWWMP sites after final locations are selected and before detailed design is commenced.

The future earthquake events are primarily assumed to occur along the San Andreas fault, which will likely produce the strongest ground motion in the SFWWMP system; however, other active faults in the San Francisco Bay area could also produce significant response in the system although the severity of these events would not likely be any greater than that of the San Andreas events.

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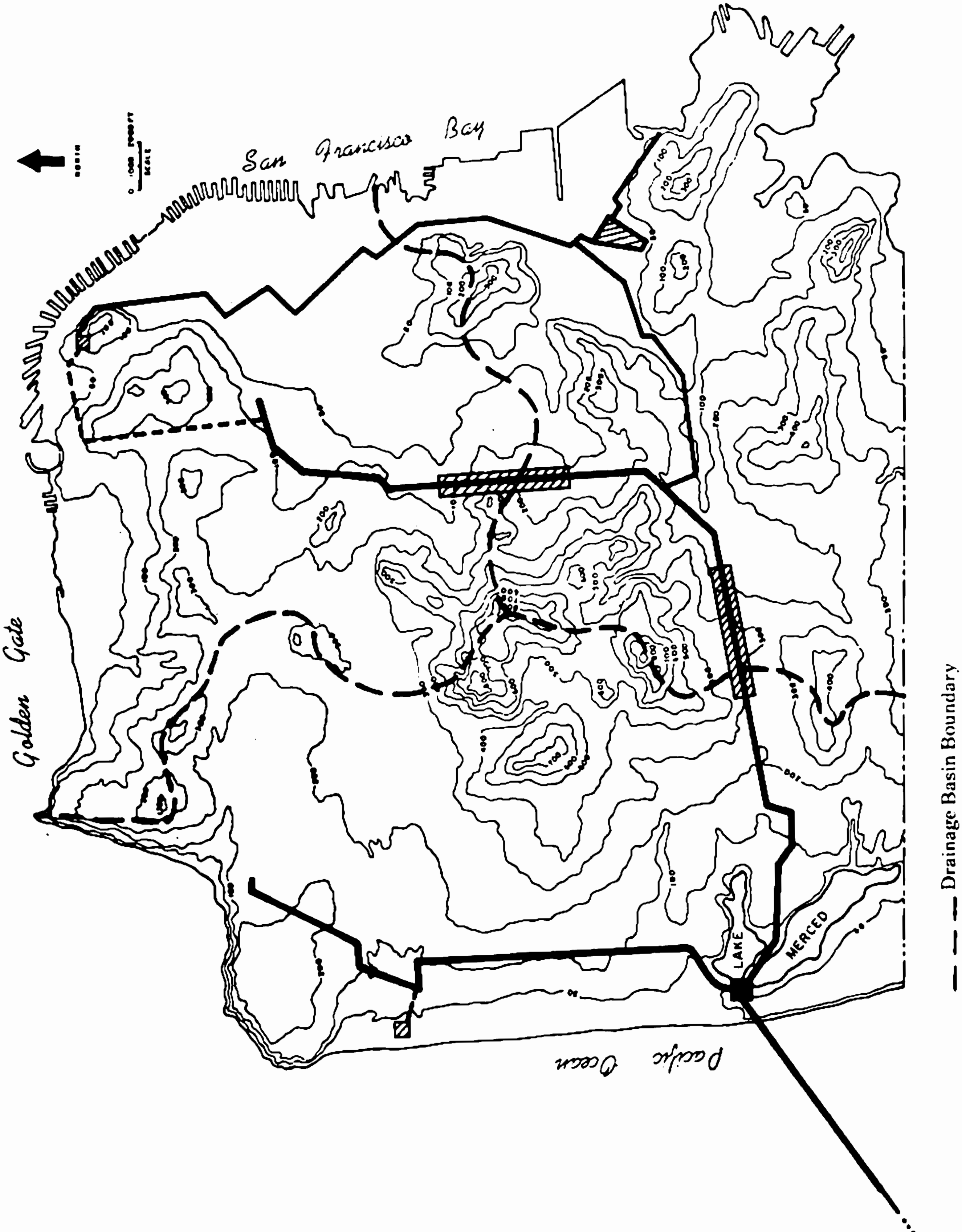
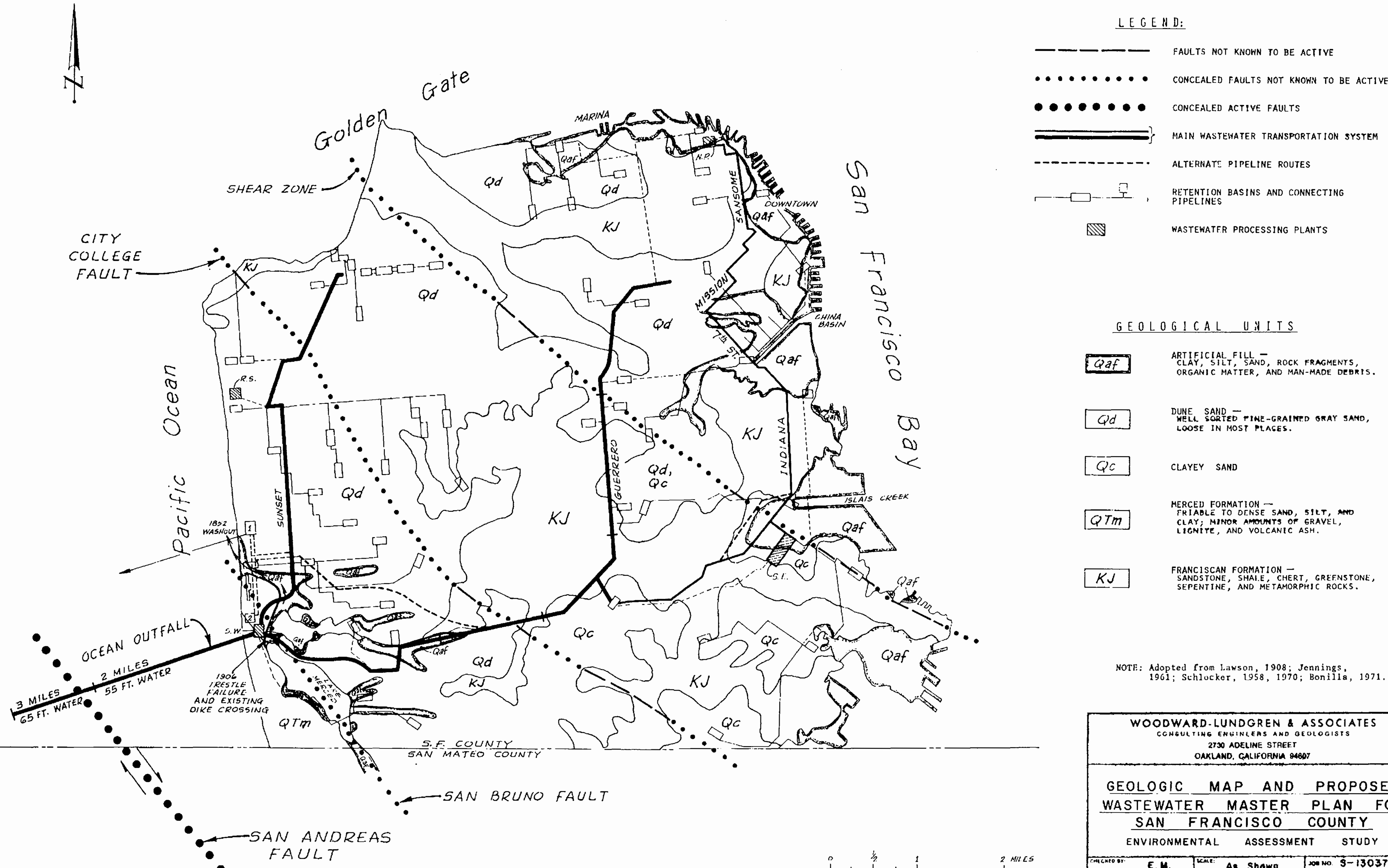
FIGURE 1 - **TOPOGRAPHY OF SAN FRANCISCO**

S.F. WASTEWATER MASTER PLAN





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GEOLOGIC MAP AND PROPOSED WASTEWATER MASTER PLAN FOR SAN FRANCISCO COUNTY

ENVIRONMENTAL ASSESSMENT STUDY

CHECKED BY:	E.M.	SCALE:	As Shown	JOB NO.	S-13037
DRAWN BY	L.H.	DATE	1-17-74	**Figure 2**	