

FINAL  
ENVIRONMENTAL IMPACT STATEMENT  
FOR  
KANEHOE - KAILUA SEWER SYSTEM  
Including  
MOKAPU OCEAN OUTFALL  
KAILUA EFFLUENT FORCE MAIN  
KAILUA EFFLUENT PUMP STATION  
KANEHOE EFFLUENT FORCE MAIN  
KANEHOE EFFLUENT PUMP STATION  
KAHALUU EFFLUENT FORCE MAIN  
KAHALUU WASTEWATER TREATMENT PLANT

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TABLE OF CONTENTS

Page

PART I

WATER QUALITY MANAGEMENT PLAN, KANEOHE-KAILUA

I. GENERAL	I-1
II. OBJECTIVE	
A. Goals	I-8
B. Achievement of Goals	I-8
III. STATEMENT OF THE PROBLEM	
A. Kailua Bay	I-11
B. Kaneohe Bay	I-11
C. Impact on Water Quality	I-13
D. Geographic Extent	I-14
IV. PHYSICAL AND HYDROLOGICAL CHARACTERISTICS OF DISTRICT	
A. Location	I-22
B. Climate	I-23
C. Caprock	I-25
D. Summary	I-26
V. POPULATION AND LAND USE	
A. Population	I-28
B. Land Use	I-32



	<u>Page</u>
VI. WASTE LOADS	
A. General	I-37
B. Estimated Wastewater Pollutant Loads	I-38
C. Estimated Storm Run-Off Pollutant Loads	I-50
D. Other Pollutant Loads Estimates	I-57
VII. WATER POLLUTION CONTROL SYSTEM	
A. General	I-60
B. Existing and Proposed Subdistrict Sewerage Facilities	I-60
C. Proposed District Sewerage Facilities	I-73
VIII. JOINT CITY-MILITARY USE OF MUNICIPAL SEWERAGE FACILITIES	I-81
IX. OCEANOGRAPHIC STUDIES	
A. Introduction	I-84
B. Ocean Survey Program	I-85
C. General Offshore Circulation	I-89
D. Currents in Kailua Bay	I-94
E. Density Stratification	I-138
F. Wave Conditions	I-143
G. Bathymetry and Bottom Configuration	I-145
H. Biological Observation	I-147
I. Distribution of Water Properties	I-148
X. DEVELOPMENT OF MARINE DISPOSAL PARAMETERS	
A. General	I-191

	<u>Page</u>
B. Toxicity	I-194
C. Benthic Communities	I-195
D. Biostimulation	I-196
E. Floatables	I-196
F. Settleables	I-197
G. Color and Turbidity	I-197
H. Odors	I-198
I. Water Quality Control Systems	I-198
XI. OCEAN OUTFALL DESIGN	
A. General	I-200
B. Ocean Currents	I-201
C. Waves	I-203
D. Density Stratification	I-205
E. Winds	I-205
F. Bacteria Decay Rate	I-207
G. Diffuser Design	I-207
XII. VIRUS HAZARD	
A. General	I-209
B. Pollution Indicator Index	I-211
C. Sampling Procedures	I-213
D. Sewage Treatment Removal	I-214
E. Virus Decay Rate	I-216
XIII. BACTERIOLOGY	
A. General	I-218

	<u>Page</u>
B. Sanitary Survey	I-219
C. Kaneohe Bay	I-221
D. Kailua Bay	I-224

## PART II

### ENVIRONMENTAL IMPACT OF THE KANEOCHE-KAILUA SEWER SYSTEM

I. GENERAL	II-1
A. State of Hawaii	II-2
B. University of Hawaii	II-2
C. Federal Government	II-2
D. Industry	II-3
E. Numerous private consultants	II-3
II. BRIEF DESCRIPTION OF PROJECT	
A. Introduction	II-4
B. Population	II-4
C. Waste Flows	II-5
D. Wastewater Characteristics	II-6
E. Recommended Wastewater System	II-6
F. Major Components (Projects) of the System	II-9
III. ENVIRONMENTAL IMPACT OF THE ACTION (PROJECT)	
A. Environmental Assessment of Wastewater Disposal off Mokapu Peninsula	II-21
B. Construction Impact	II-40

	<u>Page</u>
C. Long-Term Environmental Impact	II-86
IV. ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED	
A. Mokuapu Outfall	II-169
B. Kahaluu WWTP	II-171
V. ALTERNATIVES CONSIDERED WITH EVALUATION OF EACH	
A. General	II-172
B. Treatment and Disposal Concepts	II-172
C. Treatment and Disposal Alternatives	II-176
D. Present Worth Analysis	II-187
E. Comparative Costs of Treatment and Disposal Alternatives	II-187
F. Considerations and Evaluation of Treatment and Disposal Alternatives	II-189
G. Conclusions of Treatment and Disposal Alternatives	II-192
H. Ocean Disposal System Alternatives	II-193
I. Conclusions of Ocean Disposal System Alternatives	II-201
J. Alternative Routes for the Kaneohe Effluent Force Main	II-202
K. Comparative Costs of the Kaneohe EFM Alternatives	II-205
L. Conclusions of Alternative Routes for the Kaneohe EFM	II-206
M. Alternative Routes for the Kahaluu Effluent Force Main	II-208
N. Comparative Costs of the Kahaluu EFM Alternatives	II-213

	<u>Page</u>
O. Conclusions of Alternative Routes for the Kahaluu EFM	II-213
P. Alternative Sites for the Kahaluu WWTP	II-214
Q. Comparative Costs of the Kahaluu WWTP Alternatives	II-221
R. Conclusions on Alternative Sites for Kahaluu WWTP	II-223
VI. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND EN- HANCEMENT OF LONG-TERM PRODUCTIVITY	II-224
VII. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES	II-227
VIII. ECONOMIC AND SOCIAL COST ANALYSIS	
A. Definition of Beneficial Uses	II-230
B. Beneficial Uses	II-231
C. Communities or Areas Which Would Benefit	II-234
D. Aesthetics and Recreation	II-234
E. Demographic and Economic Forces	II-235
F. Specific Benefits	II-238
IX. SECONDARY IMPACT	
A. Public Controversy	II-241
B. Development	II-242

## LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
I-1	Location Map	I-7
I-2	Water Classification Areas for Oahu	I-9
I-3	Existing Sewered Area Kaneohe-Kailua District	I-20
I-4	Hydrogeologic Data For Oahu	I-27
I-5	Kaneohe-Kailua Wastewater System Population Projections	I-33
I-6	Kahaluu WWTP, Design Flow and Population Projections	I-45
I-7	Kaneohe WWTP, Design Flow and Population Projections	I-46
I-8	Kailua WWTP, Design Flow and Population Projections	I-47
I-9	KMCAS STP , Design Flow Projection	I-48
I-10	Mokapu Outfall Sewer, Design Flow and Population Projections	I-49
I-11	Relationship Between Storm Runoff and Sediment Load: Pearl Harbor and Kaneohe Bay Streams	I-53
I-12	Kaneohe-Kailua Sewerage District Wastewater System	I-79
I-13	Sampling and Survey Stations, Kailua Bay	I-87
I-14	General Circulation Patterns Around Oahu	I-93
I-15	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station X, Feb. 5-21, 1971	I-96
I-16	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station Q, Jan. 8-30, 1971	I-97
I-17	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station Q, Feb. 5-16, 1971	I-98

<u>Figure</u>	<u>Title</u>	<u>Page</u>
I-18	Drift Card Results, Kailua Bay Oct. 1971	I-102
I-19	Drift Card Results, Kailua Bay Nov. 1971	I-103
I-20	Drift Card Results, Kailua Bay Jan. 1972	I-104
I-21	Drift Card Results, Kailua Bay Feb. 1972	I-105
I-22	Drift Card Results, Kailua Bay Mar. 1972	I-106
I-23	Drift Card Results, Kailua Bay April 1972	I-107
I-24	Drift Card Results, Kailua Bay May 1972	I-108
I-25	Drift Card Results, Kailua Bay June 1972	I-109
I-26	Drift Card Results, Kailua Bay July 1972	I-110
I-27	Current Meter Configurations Used	I-113
I-28	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station B, Sept. 17-Oct. 11, 1971	I-114
I-29	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station D, Sept. 17-Oct. 12, 1971	I-115
I-30	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station E, Sept. 17-Oct. 17, 1971	I-116
I-31	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station C, Sept. 22-Dec. 12, 1971	I-117
I-32	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station C, Jan. 7-Feb. 6, 1972	I-118

<u>Figure</u>	<u>Title</u>	<u>Page</u>
I-33	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station C, Jan. 7-Feb. 6, 1972	I-119
I-34	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station C, Mar. 17-Jun. 9, 1972	I-120
I-35	Current Velocity and Direction Frequency Diagram for Kailua Bay, Station C, Apr. 17-Jun. 9, 1972	I-121
I-36	Summary of Current Meter Direction Histogram, Sept. 17-Oct. 11, 1972	I-122
I-37	Current Meter Direction Histograms, Station C, Jan. 7-Feb. 6, 1972	I-123
I-38	Current Meter Direction Histograms, Station C, May 17-Jun. 19, 1972	I-124
I-39	Current Meter Results, Kailua Bay, Mar. 23, 1972	I-128
I-40	Current Meter Results, Kailua Bay, Jun. 1, 1972	I-129
I-41	Drogue Results off Mokapu Peninsula, Mar. 9-10, 1972	I-132
I-42	Dye and Drogue Results off Mokapu Peninsula, Mar. 16, 1972	I-133
I-43	Dye and Drogue Results off Mokapu Peninsula, Jun. 1972	I-134
I-44	Dye, Drift Card and Drogue Results off Mokapu Peninsula, Jun. 1972	I-135
I-45	Density vs Depth Profiles, Kailua Bay, Station R, Nov. 1970, Jan. and Feb. 1971	I-140
I-46	Stratification Profiles, Station 4, Kailua Bay	I-142
I-47	Wave Height and Period Frequency Diagrams, Kailua Bay, Station Q, Nov. 16-28, 1971	I-144



<u>Figure</u>	<u>Title</u>	<u>Page</u>
I-48	Alignments of Bathymetric Profiles & TV Video Tape, Kailua Bay	I-149
I-49	Distribution of Viable Coral and Other Bottom Material Around Oahu, Hawaii, Mar. 1971	I-151
I-50	Biota Observed Around Oahu During Diving Surveys off the Coast of Oahu, Jun. 1970-Mar. 1971	I-152
I-51	Maximum and Minimum Total Coliform Count/100 ml Observed Around Oahu, Jun. 1970-Feb. 1971	I-220
II-1	Preliminary Plan, Mokapu Ocean Outfall	II-15
II-2	Location Map, Kailua Effluent Force Main	II-16
II-3	Location Map, Kailua Effluent Pump Station	II-17
II-4	Location Map, Kaneohe Effluent Force Main	II-18
II-5	Location Map, Kaneohe Effluent Pump Station	II-19
II-6	Preliminary Profile and Sections, Mokapu Ocean Outfall	II-20
II-7	Mokapu Outfall, Zone of Mixing	II-104
II-8	Layout, Kailua Treatment Plant	II-117
II-9	Layout, Kaneohe Treatment Plant	II-124
II-10	Detailed Land Use Map, Kaneohe, Heeia, Kahaluu, Waihee, Kaalaea, Hakipuu and Kualoa	II-131
II-11	Kahaluu WWTP, Plant Layout	II-134
II-12	Annual Average Wind Frequency Diagram	II-137
II-13	Monthly Wind Velocity and Direction Frequency Diagrams	II-138

<u>Figure</u>	<u>Title</u>	<u>Page</u>
II-14	Wastewater Management System For Kaneohe-Kailua Sewer District, Alternative 3	II-194
II-15	Wastewater Management System For Kaneohe-Kailua Sewer District, Alternative 4	II-195
II-16	Wastewater Management System For Kaneohe-Kailua Sewer District, Alternative 6	II-196
II-17	Alternative Routes, Kaneohe Effluent Force Main	II-207
II-18	Alternative Routes, Kahaluu Effluent Force Main	II-215
II-19	Alternative Sites For The Kahaluu WWTP	II-216
II-20	Existing Contours, Proposed Kahaluu WWTP	II-217

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
I-V-1	Windward Oahu's Population Distribution	I-28
I-V-2	Distribution of Population by Sub-Area	I-29
I-V-3	Distribution of Total Population Increase by Sub-Area	I-30
I-V-4	Projected De Facto Population by Sub-Areas	I-31
I-V-5	Land Use Statistics - Kaneohe-Kailua District	I-34
I-V-6	Land Use Within the Kaneohe-Kailua District	I-35
I-VI-1	Estimate of Present Waste Loads on Kaneohe-Kailua Bay	I-38
I-VI-2	Present Waste Discharges From Municipal and Military Facilities	I-42
I-VI-3	Estimated Pollutant Loads	I-44
I-VI-4	Estimated Nutrient Loads From Kaneohe Bay Streams	I-55
I-VI-5	Estimates of Sediment Loads on Kaneohe Bay	I-56
I-IX-1	Summary of Analysis of Long Series Current Meter Data	I-125
I-IX-2	Summary of Abundance of Dominant Benthic Organisms at Six Stations in Kailua Bay	I-158
I-IX-3	Chlorophyll a, b, c, and Dry Weight at Eight Location Around Oahu	I-162
I-IX-4	Results of the Plankton Sampling and the Examination of the Growth on Artificial Biostrata	I-166
I-IX-5	Some Phytoplankton Found Around Oahu Prior to 1970	I-169

<u>Table</u>	<u>Title</u>	<u>Page</u>
I-IX-6	Dry Weight of Benthic Algae at Station 1(12), Kailua Bay, Oahu	I-172
I-IX-7	Dry Weight of Benthic Algae at Station 2(11), Kailua Bay, Oahu	I-173
I-IX-8	Dry Weight of Benthic Algae at Station 4(9), Kailua Bay, Oahu	I-174
I-IX-9	Fish Survey in Kailua Bay	I-176
I-IX-10	Micromolluscan Assemblages Survey in Kailua Bay	I-179
I-IX-11	Water Quality Data, Kaneohe Bay 1970 - 1971	I-187
I-IX-12	Water Quality Data, Kailua Bay 1970 - 1971	I-188
I-IX-13	Annual Range of Water Quality, Kailua Bay, Oahu, Sept. 1971 - July 1972	I-189
I-IX-14	Annual Average of Water Quality, Kailua Bay, Oahu, Sept. 1971 - July 1972	I-190
I-XIII-1	Bacteriological Survey During WQPO of Kailua Bay and Kaneohe Bay	I-226
I-XIII-2	Bi-Monthly Bacteriological Data, Kaneohe and Kailua Bays	I-227
II-II-1	Estimated Wastewater Flows	II-6
II-III-1	Kaneohe and Kailua Treatment Plants, Heavy Metals Concentrations	II-26
II-III-2	Chemical Analysis of Sediment From Kailua Bay	II-38
II-III-3	Physical Analysis of Sediment From Kailua Bay	II-39
II-III-4	Selected Odor Threshold Concen- tration	II-143

<u>Table</u>	<u>Title</u>	<u>Page</u>
II-III-5	Estimated Sludge Handling Costs	II-164
II-V-1	Summary, Cost Estimate to Relocate WWTP to Waiahole	II-222
II-VIII-1	Beneficial Uses of the Marine Waters of Oahu	II-233
II-VIII-2	Hawaii's Economy - A Forecast for 1973	II-237

PART I  
WATER QUALITY MANAGEMENT PLAN  
KANEHOHE-KAILUA

I. GENERAL

The goal of the water quality management program is to enhance or maintain a high level of quality of the waters of Oahu. The two fundamental objectives are--

- (1) to minimize the quantities of deleterious substances discharged into the receiving waters and
- (2) to minimize the concentrations of those deleterious substances that cannot be prevented from entering the receiving waters.

The first objective, which consists essentially of the control of wastewaters can be accomplished by reducing the amount of wastes generated or by increasing the level of treatment of the wastes. Controls of the amount of wastes generated have included regulation or legislation (pesticides, toxicants, radionuclides), recycling (water reclamation or by-product recovery), and cost incentives (sewer service charges which include surcharges based on the quantities of pollutants discharged). These approaches have only limited effectiveness, however, and some degree of terminal treatment is almost always required.

No economically practical wastewater treatment process can

remove all pollutants from a waste stream, and the costs increase greatly with each added increment of removal. Moreover, not all wastewaters are controllable. Runoffs carrying nutrient and sediment loads from rural areas as well as significant pollutants from urban areas are common in streams and storm drains of Oahu.

In short, some pollutants will always be found in the receiving waters and reliance must be placed on the dilution capability of the receiving waters to achieve the second objective of minimizing pollutant concentrations. This dilution capability depends on the type of receiving waters and progressively increases from fresh-water streams to estuaries to bays to open coastal waters. The determination of the natural mixing and dispersion characteristics of the open coastal waters was one of the primary objectives of the Water Quality Program for Oahu with Special Emphasis on Waste Disposal (WQPO) (Reference 1).

The objective of the WQPO was to develop optimum overall wastewater management systems which will protect and enhance the water quality, on land and in the surrounding sea, on which the future life of Hawaii depends so completely. The program started in April 1970 and extended over an eighteen-month period. The work was assigned to a Consortium consisting of Engineering-Science, Inc. of Arcadia, California, and two local firms, Sunn, Low, Tom and Hara, Inc. and Dillingham Environmental Company.

The City retained a five-member Board of Advisors to guide the work through bi-monthly discussion meetings. Members of the Board were selected on the basis of their expertise in special fields such as sanitary engineering, marine biology, public health, and general engineering. The chairman of the Board was John D. Parkhurst, the Chief Engineer and General Manager of the Los Angeles County Sanitation Districts who has long been engaged with wastewater disposal problems. The vice chairman of the Board was Dr. Richard K. C. Lee, who served as Director of Public Health and later as Director of the Research Corporation at the University of Hawaii. Dr. Robert W. Hiatt, the biologist member of the Board, is presently Scientific Attache' with the U.S. Embassy, Tokyo, and former Professor of Zoology and Entomology at the University of Hawaii and Director of the Hawaii Marine Laboratory. Dr. John W. Shupe, Dean of the College of Engineering, brought to the Board a broad background in overall Civil Engineering field. The last member was Dr. Erman A. Pearson, Professor of Sanitary Engineering at the University of California, recognized worldwide as an expert in water quality control problems, particularly regarding waste disposal into marine waters.

The detailed work plan for the program provided for the collection and analysis of significant water quality data and for the determination of critical oceanographic parameters to provide a sound basis for insuring that the recommended



plan of wastewater disposal will provide proper protection for the public health, aesthetic, recreational, and marine ecological values of the near shore oceanic waters of Oahu. The studies were conducted on a drainage basin basis to insure that the systems developed provided optimum and economical long-term solutions to the total wastewater disposal problems of Oahu, minimizing piecemeal solutions of localized problems. Consideration was given to all significant wastewaters including the domestic and industrial wastewaters of the civilian population as well as wastewaters from military installations.

Emphasis was also given to the incorporation of provisions for the reclamation of wastewaters for industrial and irrigation reuse as well as for possible replenishment of ground water supplies.

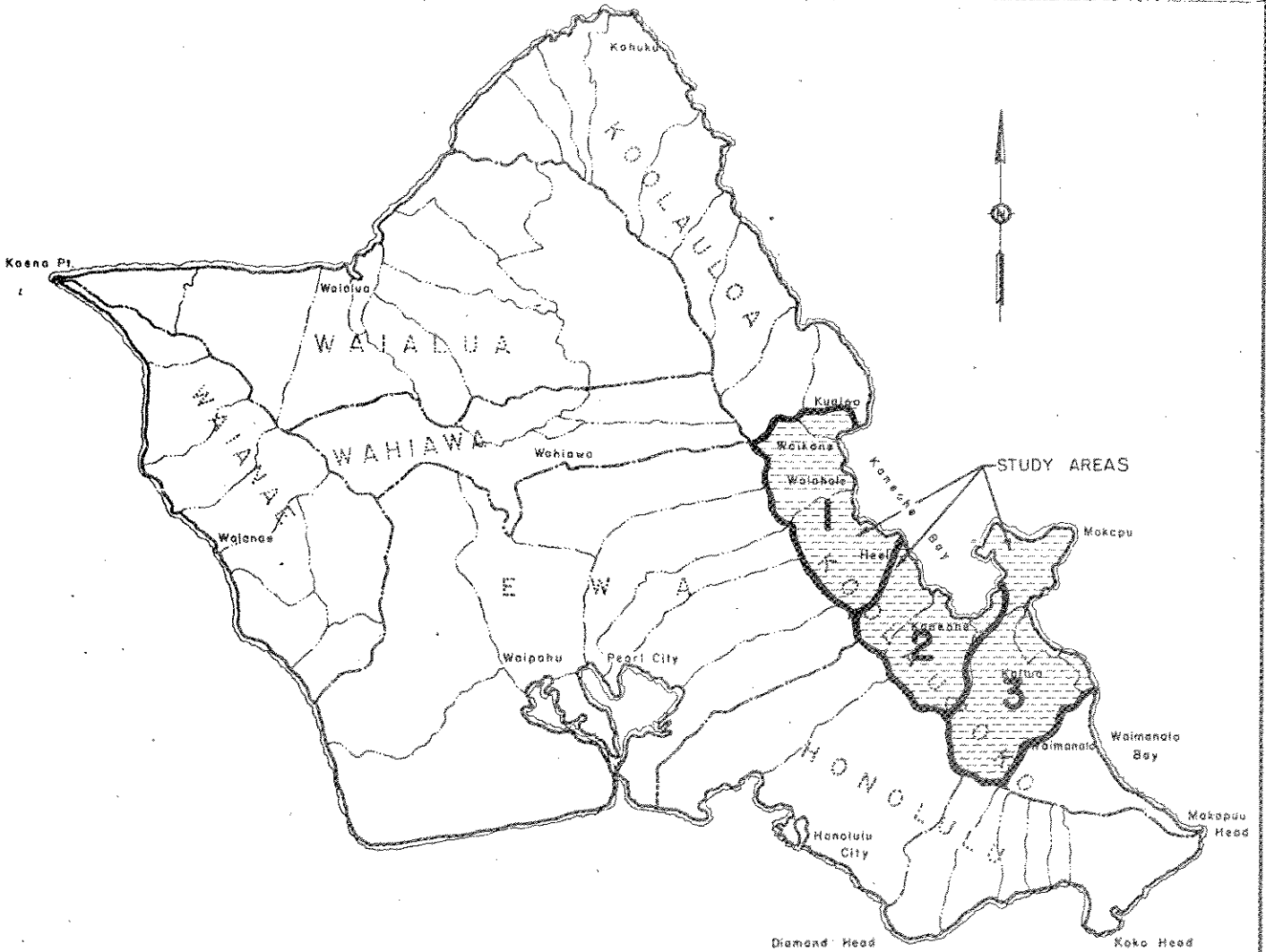
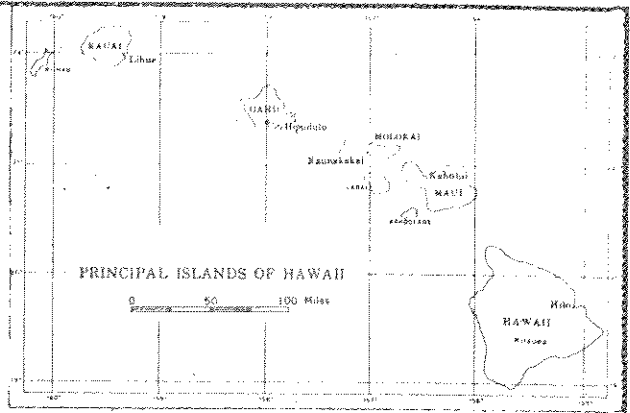
At this point it might be well to elaborate on the total process of treatment and disposal. Successful ocean disposal does not depend on a single component of the treatment system, but rather on that combination of pre-treatment on land together with properly designed dispersion in the ocean which together are necessary to accomplish the desired objective. Some people say, "we must have primary treatment before discharging effluent to the ocean"; others say, "it must be tertiary", etc. It must be recognized that basic disposal objectives can be met by utilizing a wide range of pre-treatment processes on land accompanied by varying lengths and complexities

of ocean dispersion systems. The crux of the matter is the design of that system which accomplished the objectives in the most economical manner, with due consideration to both capital investment and operation and maintenance costs, as well as the ability of the system to continue to provide reasonable protection under stressed conditions such as power outages, equipment failure or other such emergencies.

A frequently heard response is, "Let's have secondary or even tertiary treatment and a long outfall." All sanitary engineers would agree that such combinations would indeed provide excellent results, but with a resulting large waste of the taxpayers' monies urgently needed for the solution of many other problems.

One of the most significant problems relative to sewerage and water quality for Oahu next to the discharge of raw sewage off Sand Island relates to the discharge of secondary effluent into Kaneohe Bay from the municipal treatment plant at Kaneohe and the military installation at Kaneohe Marine Corps Air Station. A related problem is the discharge of secondary effluent from the Kailua municipal plant off Kapoho Point into Kailua Bay via a short outfall terminating in shallow waters. Because Kaneohe Bay is a very important resource for water related research, recreational activity, and propagation of coral and shellfish, this area was assigned a high priority in the plan for the elimination of undesirable

water quality. The plan area for the Kaneohe-Kailua sewerage district encompasses the communities of Kailua, Kaneohe and Kahaluu as shown in Figure I-1.



OAHU

LEGEND

- EWA      Geographic Districts
- District & Subdistrict Boundaries
- 2      Subdistrict No.

Location Map

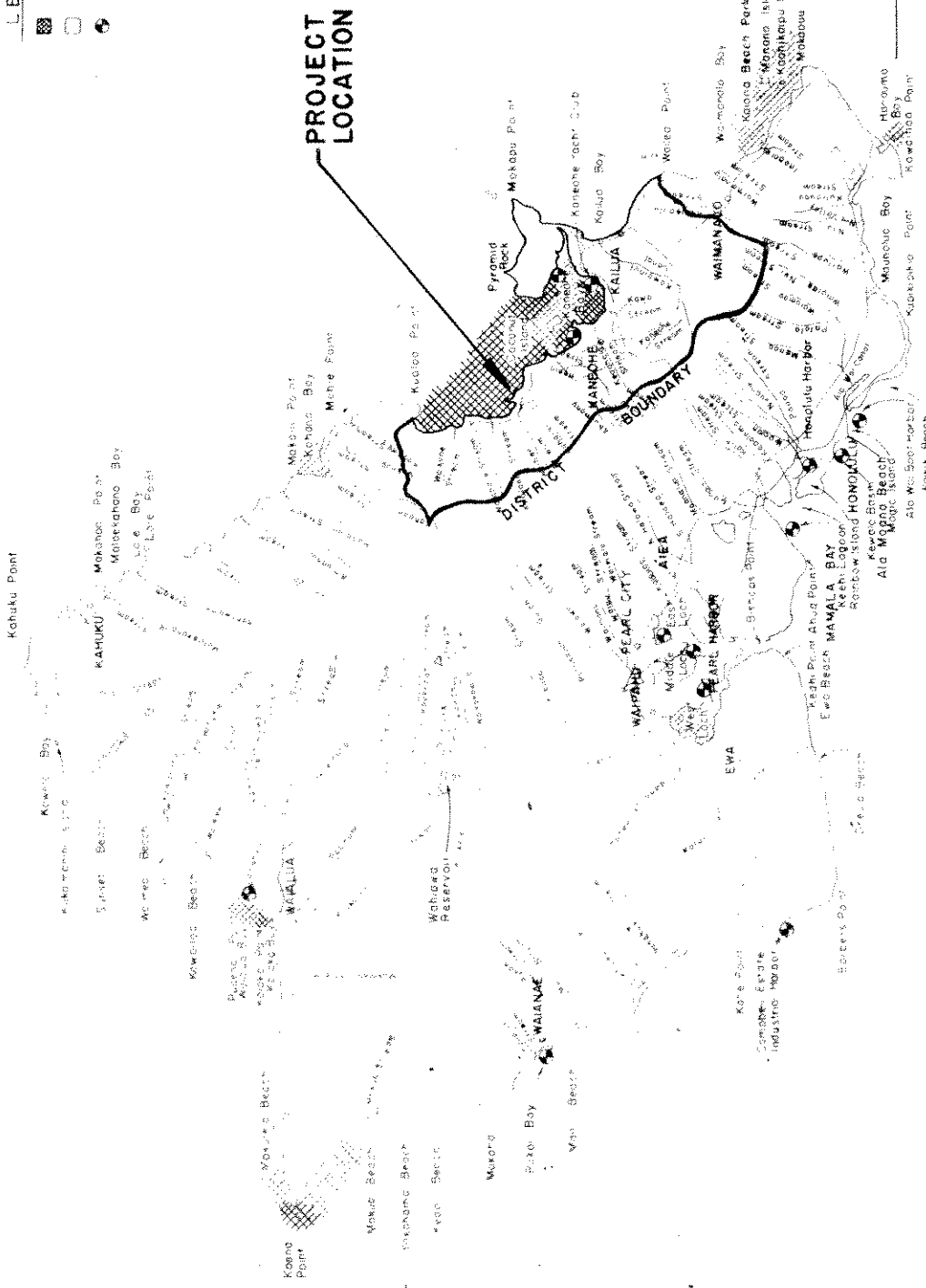
FIGURE I-1

## II. OBJECTIVES

- A. Goals: The water use goals to be achieved for the plan area are as follows:
1. improvement and protection of all high-value water areas within the plan area. These areas include all of Kaneohe Bay and Kailua Bay.
  2. improvement of all other water areas and protection of their beneficial uses. The locations are indicated in Figure I-2 and the uses are indicated in Chapter 37-A of the Public Health Regulations, Department of Health, State of Hawaii.
- B. Achievement of Goals: The goals will be achieved by the following actions:
1. eliminating all effluent discharges from wastewater treatment plants in Kaneohe Bay. These include the discharges from the Kaneohe Wastewater Treatment Plant (WWTP), Kaneohe Marine Corps Air Station (KMCAS) WWTP and the Ahuimanu WWTP.
  2. diverting future effluent from the Kahaluu WWTP to a new ocean outfall sewer.
  3. terminating the effluent discharge from the Kailua WWTP off Kapoho Point in Kailua Bay.
  4. determining and implementing measures to--
    - (a) control all sources of pollution,
    - (b) improve management of receiving waters to reduce adverse impacts of wastes,

**LEGEND**

- Class AA
- Class A
- Class B (as mixed to direct fresh to post dock facilities)
- Surface fresh water areas are Class 2



**WATER CLASSIFICATION  
AREAS FOR OAHU**

- (c) maximize the cost effectiveness of investments in pollution abatement and preventive actions required to achieve national and local water quality objectives, and
- (d) periodic updating of adopted plans.

### III. STATEMENT OF THE PROBLEM

#### A. Kailua Bay

Kailua Bay is affected by urban and rural drainages and a secondary treated sewage discharge. The sewage flow averages about 3.4 (1971) million gallons per day (mgd) and discharges into the Bay through a short and shallow outfall. Because of heavy surf in the area of discharge, the waste plume is seldom visible and thus has little effect on aesthetics. The more aesthetically damaging factors are two major streams draining into the Bay which create ephemeral sanitary and aesthetic problems (e.g. turbidity). Kawainui Canal is a flood control and drainage work which drains Kawainui Swamp. Kaelepulu Stream drains urban and rural areas.

#### B. Kaneohe Bay

Kaneohe Bay is considered by some to be one of the finest estuaries in the State of Hawaii. Its waters support a rich and diverse biota and the Bay is used extensively for fishing, swimming, boating, and other recreational pursuits. There is a water quality problem in the Bay apparently due to storm drainages from an urban area undergoing accelerated growth and waste discharges. The principal waste



discharges are into the southern sector of the Bay and come from the Kaneohe WWTP and KMCAS WWTP. The former is a secondary plant while the latter was a primary plant until 1972 when it was converted to a secondary treatment facility. Eight major perennial streams empty into Kaneohe Bay. These are the Kaneohe, Keaahala, Kawa, Heeia, Kahaluu, Kaalaea, Waiahole, Waikane, and Hakipuu streams.

Waste discharges into Kaneohe Bay appear to affect coral communities in two ways. The first is the killing of corals by toxic substances in the sewage. In situ derived coral mortality estimates, shown to correlate significantly with estimated concentrations of wastewaters in the receiving water, strongly support this contention. The second way waste discharges appear to be degrading the coral communities is through stimulation of a green encrusting algae, Dictyosphaeria cavernosa, which within the past two or three years have grown explosively throughout many parts of the Bay. The algae grow over live (and dead) corals shutting them off from sunlight, thus preventing photosynthesis by their symbiotic algae. In addition, it is believed that within the microzone between the encrusting algae and a coral head the pH may change sufficiently to cause the calcium carbonate skeleton of the corals to dissolve and subsequently break apart.

Freshwater discharges into Kaneohe Bay carry with them heavy loads of silt which can smother corals and other benthic organisms. Presumably, much of this silt comes from lands denuded of vegetative cover by housing and highway construction. The streams also contribute nutrients and other substances to the Bay.

Kaneohe Bay is an excellent example of a water area which on the basis of conventional water quality parameters appears to be in reasonably good condition. Based on what is happening to biological communities in the Bay, however, it is evident that an ecological disaster is taking place. Because of what may be happening in many areas just like it, it is imperative that the quest for new and better indices of water quality be continued and encouraged. Water resource managers must not, and must not be allowed to, limit their thinking to conventional water quality parameters only.

#### C. Impact on Water Quality

The sources of pollution which include effluent discharges from wastewater treatment plants, storm runoff and siltation all contribute to the degradation of the water quality of the plan area.

All aspects of environmental quality protection must be taken into account when planning corrective or preventive action. Efforts should be taken to preserve natural beauty, wildlife, fishlife, coral reefs, clam beds, recreational areas, historic sites, and both public and private properties. The implementation of this plan is a step in that direction.

By implementing an effective course of action, such as constructing properly planned and designed treatment and disposal facilities, water quality can be improved and protected. Growth and propagation of marine and aquatic life in the area should improve and waters for oceanographic research, recreation, and other beneficial uses will be prevented from being further degraded. Coral reefs in the Bay will be protected.

#### D. Geographic Extent

The plan area encompasses the windward portion of Oahu and extends generally from Wailea Point in Lanikai to Kualoa Point in the north and from the eastern slopes of the Koolau Range to the ocean.

For ease of describing the plan area more thoroughly, the area has been subdivided into Study Areas as

shown in Figure I-1. A description of each Study Area, hence the plan area, follows:

1. Study Area 1 - Kahaluu

Study Area 1, from the Koolau Range to the sea, from Ka Oio Point through Kahaluu, is almost entirely rural in nature. More than half this area is in conservation, the rest used for residential and diversified agriculture. The area is sparsely populated with single-family residences and small farms scattered along the highway and shoreline, and larger clusters of houses at Waiahole, Kahaluu, and Ahuimanu. There are no military installations of any significance within the area.

Housing is generally of the single-family type, low-density, scattered, and individual in style; few subdivisions exist in this area, although such developments are possible in the future. The larger clusters of houses at Waiahole and Kahaluu are scarcely villages, really simply large groups of residences.

More than sixty percent of this area is in conservation, the Waiahole Forest Reserve which covers 8,634 acres. The area has diversified agriculture--

bananas, papayas, and vegetables; few pasture-lands exist.

One area, Ahuimanu, is presently served by municipal sewers. The remaining areas are served by cesspools and will be sewerred in accordance with the sewer construction program of the City. The existing sewerred area is shown in Figure I-3.

The Ahuimanu Wastewater Treatment Plant is located in this study area. It is located along Kahekili Highway near Ahuimanu Place and discharges treated effluent into Ahuimanu Stream. Originally designed as a secondary treatment unit with a stabilization pond, this plant has since been enlarged to handle a flow of 1.3 mgd and modified to include tertiary treatment units for phosphate and nitrogen removal. Present flows average 0.200 mgd.

## 2. Study Area 2 - Kaneohe

Study Area 2 is an area from the Koolau Mountain to Kaneohe Bay, Heeia through Kaneohe town, and is primarily single-family residential with commercial and service establishments for residents plus minor commercial tourist attractions.

The area is nearly completely developed, but with about 725 acres outside the conservation district as yet undeveloped. Agriculture, once quite noticeable throughout the area, has virtually disappeared in favor of residential subdivisions. There is no real agriculture left, although a few pastures and some banana tree areas still exist.

There are two military installations in the area. The Navy leases from the State the Kapaa training area and the Haiku Radio Station area. These areas, however, are insignificant and will not affect the City's sewerage plans.

Almost all of the area is served by municipal sewers and wastewater treatment facilities. The existing sewered areas are shown in Figure I-3. A few isolated areas around Kaneohe Bay and Kamehameha Highway are still served by cesspools. These will be sewered in accordance with the sewer construction program of the City.

The City's Kaneohe Wastewater Treatment Plant serves this study area. The design capacity is 4.3 mgd and present flows average about 3.2 mgd. Wastewaters are collected and conveyed to the

treatment plant through a network of pumping stations and gravity sewers along low-lying areas. Effluent from the plant is presently discharged into the southeast part of Kaneohe Bay through a 2,300-foot long ocean outfall sewer.

### 3. Study Area 3 - Kailua

Study Area 3 extends from the Kaneohe Marine Corps Air Station to Lanikai on the shoreline and is generally a densely developed residential area extending about halfway inland to the base of the Koolau Mountain Range.

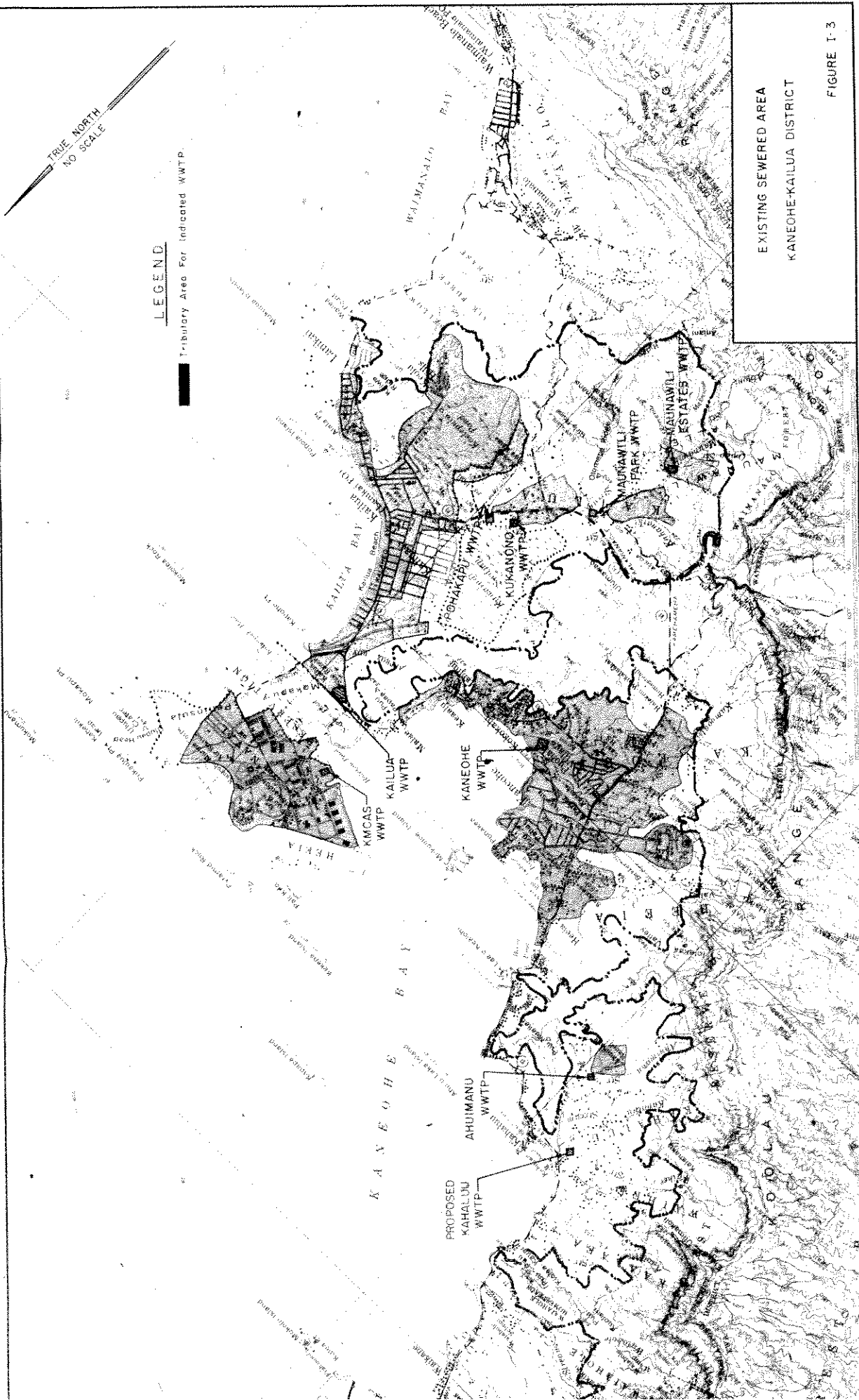
On the western perimeter of the study area is the Mokapu Peninsula which is entirely occupied by the Marine Corps Station. Adjacent to the Marine Corps base is the town of Kailua which is really three pockets of residential areas-- one seaward of the Kawainui Swamp, commonly called Coconut Grove, another further inland in the Pohakapu-Olomana-Maunawili area at the Kailua Road-Kalaniana'ole Highway junction, and a third surrounding the Kaelepulu Pond and Enchanted Lake. All three pockets feed into the town's main artery, Kailua Road.

The town of Lanikai, an entirely residential area, is just east of Kailua and occupies a strip of land between Kaiwa Ridge and the shore.

Considerable open space exists between the mountain base and the residential developments. As the growth of suburban Honolulu increases the need for more residential land, the upper reaches of the swamp in Maunawili Valley may be reclaimed. Possibly additional pressure for reclamation may be exerted when the new H-3 defense highway is constructed, providing a third tunnel to the Windward side and extending directly to the Kaneohe Marine Corps Air Station.

The Kailua Wastewater Treatment Plant, a City facility, serves most of the lower lying areas such as Coconut Grove and the Kaelepulu tributaries. Higher areas are served by four interim municipal plants, the Pohakapu, Kukanono, Maunawili Park, and Maunawili Estate Wastewater Treatment Plants. The locations of these plants are shown in Figure I-3. The effluent from these plants are discharged after chlorination into the Kawainui Swamp tributaries. The combined average wastewater flow from all four of these temporary plants is about 0.53 mgd.





The Kailua Plant is a secondary (trickling filter) plant with a design capacity of 7.0 mgd of wastewater. The present flows to this plant average approximately 3.54 mgd. The effluent is discharged after chlorination into Kailua Bay off Kapoho Point through a 5,300-foot land-ocean outfall sewer. The ocean portion extends about 500 feet offshore in approximately 13-foot deep water.

The Navy is responsible for the Kaneohe Marine Corps Air Station sewerage facilities on Mokapu Peninsula. Wastewater flows from the Air Station are treated by a 2.0 mgd secondary treatment plant which was upgraded from a primary treatment facility in 1972. Present flows average about 1.0 mgd. Effluent is discharged into the southeastern portion of Kaneohe Bay through a 20-inch ocean outfall sewer which extends 500 feet offshore into waters 15 feet deep.

The Navy is currently planning to recycle about 0.5 mgd of effluent for golf course irrigation. The sewerage area of KMCAS and the location of the treatment plant are shown in Figure I-3.

#### IV. PHYSICAL AND HYDROLOGICAL CHARACTERISTICS OF DISTRICT

##### A. Location

Oahu is one of the eight major islands in the Hawaiian chain. The island is third in size with a land area of about 604 square miles, being some 40 miles in length and 29 miles in width. The island is located between Latitudes  $21^{\circ} 15.5'N$  and  $21^{\circ} 43.0'N$  and Longitudes  $157^{\circ} 39'W$  and  $158^{\circ} 17'W$ . The seat of government, both state and county is in Honolulu, about 13 miles from the centroid of the district. Honolulu is blessed with a natural protected harbor and a large international airport; hence, it can truly be called the crossroad of the Pacific.

The Kaneohe-Kailua district is located in Windward Oahu. The land corridor varies in width from 2 to 6 miles between the summits of the Koolau Ranges to the ocean. The length in the northwesterly direction from Keolu Hills to Hakipuu is approximately 14 miles. Elevation ranges from mean sea level to a maximum of just over 3,000 feet for the Koolau peak.

According to Macdonald and Kyselka (Reference 2), Oahu was formed during the mid-Tertiary period by

volcanic activity. Two volcanoes, the Waianae in the southwestern part of the island and the Koolau to the northeast provided the material for the land mass. The Koolau Range is the eroded remnant of the volcano which extends northwestward for 35 miles and serves as the western boundary of the district.

There are a series of relatively narrow, alluvial coastal plains which lie at the foot of the mountain. A large number of valleys have been carved out of the coastal plains during times of lowered sea level which occurred during the Pleistocene epoch. During the time of higher sea level, coral reefs flourished around the island and built a thick platform that now underlies the coastal plain sediments. Kaneohe Bay has been described as a coastal-plain estuary that occupies a number of drowned stream valleys eroded into the sediments of older, deeper valleys cut into bedrock (Reference 3). A barrier coral reef across the bay mouth is the only example of its kind in the Hawaiian Islands. Fringing reefs have formed inside the bay near the shore in shallow depths during sea level fluctuations during the Pleistocene epoch.

#### B. Climate

Although Oahu lies in the tropics, the climate of the island is dominated by its marine location remote

from any continental land mass and the presence of a stationary anticyclone front to the north and east of the Hawaiian archipelago. As a result, steady trade winds normally blow from the northeast across the island and temperatures are pleasant throughout the year. Summer season occurs from May through September and is characterized with a most persistent trade wind of about 80 to 95 percent of the time. The winter season in Hawaii takes place between October and April and the prevailing trade wind frequency is reduced to about 50 and 80 percent of the time because of interruption by storms.

Rainfall can be classified into two types, one associated with stable trade winds and the other with storms which usually occur during the winter. In the Koolau Range, rainfall occurs throughout the year, reaching a maximum of 300 inches near Punaluu. This rainfall is attributed to trade winds flow and the orographic effects of the steep topography. A good portion of the rainfall along the district coast is derived by winter storms and average 35 to 40 inches per year.

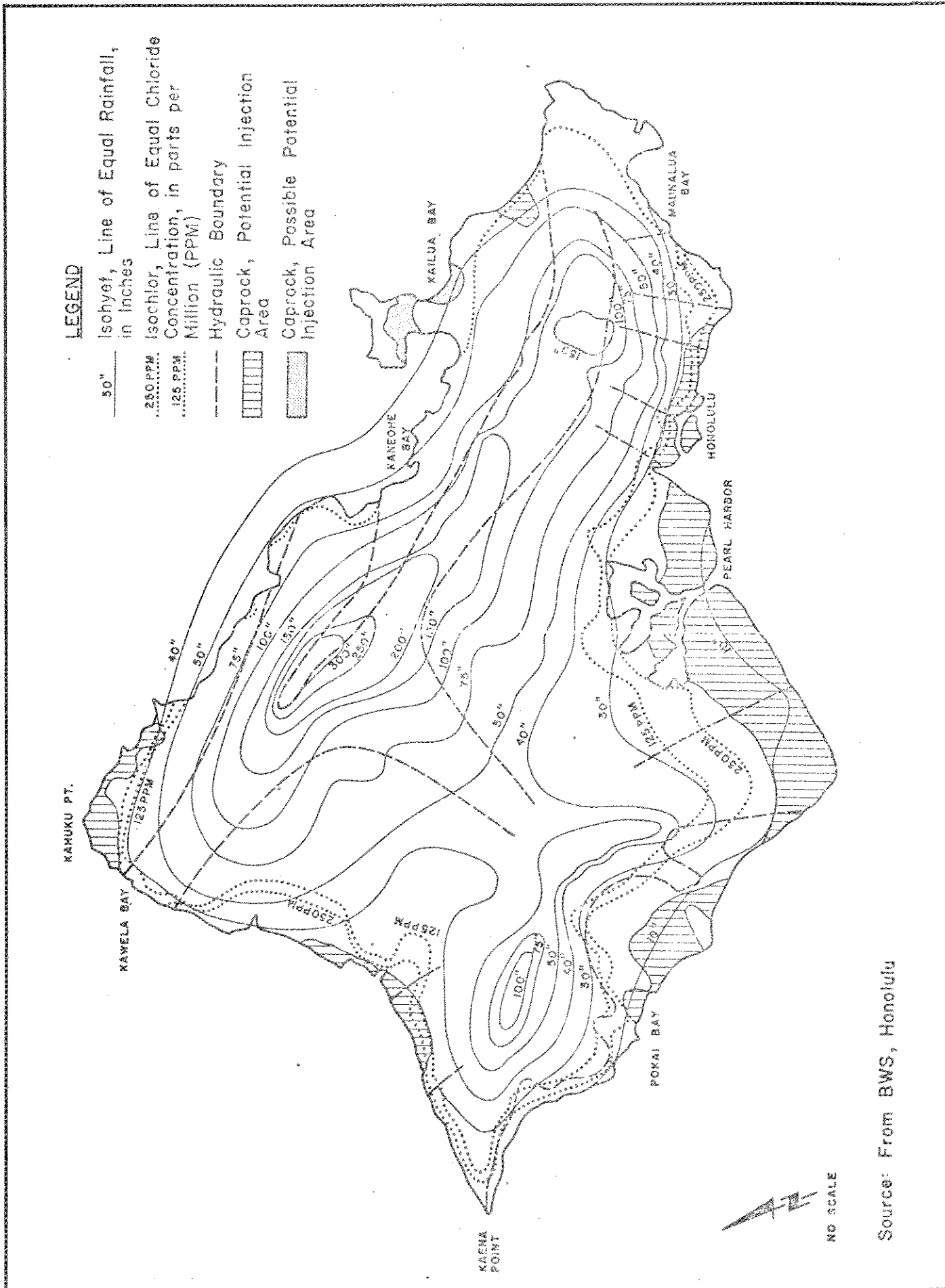
Storm rain can be categorized into four types:

1. Kona storm--this storm moves from the southern

- direction and bring rains to the entire island.
2. Cold front--this comes from the north to northwest and bring heavy though spotty rains.
  3. Hurricane and true tropical storm--these storms are extremely rare.
  4. Low-pressure air mass--this lies above trade wind flow in the upper region.

### C. Caprock

Caprock is formed by the deposition of alluvial and marine sediments alternating with fossil reef additions. Caprock layers are nearly impermeable; however, fossil reefs within (or sandwiched between) them are highly permeable sections. The fossil reefs, because of their permeability, provide for a potential method of dispersion and transport of wastewater effluent by ground injection. An ideal formation for ground injection would contain a near-surface and a deep strata of impervious material within which exists a highly porous and permeable fossil reef. The bottom impervious stratum will eliminate potential effects on municipal groundwater quality while the upper stratum will prevent the effluent from appearing on the beaches. Caprock areas where potentials exist for ground injection of effluent are located in Mamala Bay, Waianae, Waialua, Kahuku and Waimanalo. Within



**LEGEND**

- 50" Isohyet, Line of Equal Rainfall, in Inches
- 250 PPM Isochlor, Line of Equal Chloride Concentration, in parts per Million (PPM)
- Hydraulic Boundary
- Caprock, Potential Injection Area
- Caprock, Possible Injection Area

HYDROGEOLOGIC DATA FOR OAHU

NO SCALE

Source: From BWS, Honolulu

V. POPULATION AND LAND USE

A. Population

The total resident population on the island of Oahu as of April 1970 was 630,497, of which 574,781 were civilian residents and the remaining 55,716 were military personnel. Approximately 13 percent of the total resident population or 85,442 people lived in the Kaneohe-Kailua sewerage district. The bulk of Windward Oahu's population resides in the districts listed in Table I-V-1.

TABLE I-V-1  
WINDWARD OAHU'S POPULATION DISTRIBUTION  
(1970)

<u>Area</u>	<u>Civilian Population</u>	<u>Military Population</u>	<u>Total Population</u>
Oahu	574,781	55,716	630,497
Kaneohe- Kailua	77,856	7,586	85,442
North Oahu	11,082	503	11,855
Waimanalo	6,738	39	6,777

The majority of the island's local residents live in the Mamala Bay sewerage district as expected. This amounts to about 439,787 people. In turn, the majority of the Mamala Bay residents live in



Honolulu proper. A further breakdown of the resident population in the Kaneohe-Kailua district is shown in Table I-V-2.

TABLE I-V-2  
DISTRIBUTION OF POPULATION BY SUB-AREA

Area	Civilian Population	Military Population	Total Population
Total	77,856	7,586	85,442
Kahaluu	8,025	156	8,181
Kailua	40,501	6,502	47,003
Kaneohe	29,330	928	30,258

Between 1960 and 1970, the civilian resident population in the island increased by 120,765 people. The military population was assumed to remain static since no reliable system for predicting this mobile population is available. The greatest population increase occurred in the Mamala Bay area where the number of people grew by 64,100 or 53.08 percent of the total increase of the island. The smallest increase occurred in the Waialua-Haleiwa area which registered gains of only 1,415 people or 1.17 percent of the total increase. After Mamala Bay, the population increase in the Kaneohe-Kailua district was the most substantial, registering a gain of 23.71 percent of the total increase. The increases in the

district by sub-area are shown in Table I-V-3.

TABLE I-V-3

DISTRIBUTION OF TOTAL POPULATION INCREASE BY SUB-AREA

<u>Area</u>	<u>1960 Population</u>	<u>1970 Population</u>	<u>Population Increase</u>	<u>Percent of Total Pop.</u>
Total	56,015	85,442	28,627	23.71
Kahaluu	3,813	8,181	4,368	3.62
Kaneohe	17,393	30,258	12,065	9.99
Kailua	34,809	47,003	12,194	10.10

The greatest population increase by sub-area occurred in Kahaluu which saw its population double by 115 percent. Kaneohe saw its population increase from 17,393 to 30,258 people, a 69 percent increase. Kailua had the smallest increase percentage-wise, increasing from 34,809 to 47,003 or 35 percent. Waimanalo to the south of the drainage district had an increase of 1,213 people, a 22 percent increase, and North Oahu (Kahuku and Hauula) had a 33 percent increase.

Projected future population was made by the WQPO based on population increases made between 1960-1970 and actual and projected annual growth rates in basic employment by industries on Oahu. The projection of the various districts was modified on the basis of

land available for growth and other known factors.

Table I-V-4 shows the projected resident and de facto population by sub-areas.

TABLE I-V-4

PROJECTED DE FACTO POPULATION BY SUB-AREAS

Year:	Area:				
	KMCAS	Kahaluu*	Kailua	Kaneohe	Total
1970	6,500	7,000	40,500	30,000	84,000
1975	6,500	8,500	47,000	36,500	98,500
1980	6,500	10,000	55,000	44,000	115,500
1985	6,500	12,000	64,000	52,000	134,500
1990	6,500	14,500	74,500	63,000	158,500
2000	6,500	19,500	95,000	83,000	204,000
2020	6,500	35,000	153,500	142,000	337,000

The visitor population was added to the projected resident population consisting of civilian and military personnel to arrive at the de facto population. Average daily visitor census for Oahu was prepared by WQPO for the years 1970 to 2020. Average daily visitors for the island ranged from 26,100 in 1970 to 82,050 in 1990 and 122,000 in 2020. Most of the visitor population (amounting to 93 percent in 1970, 80 percent in 1990 and 74 percent in 2020) will probably be concentrated in Waikiki. Other areas where the

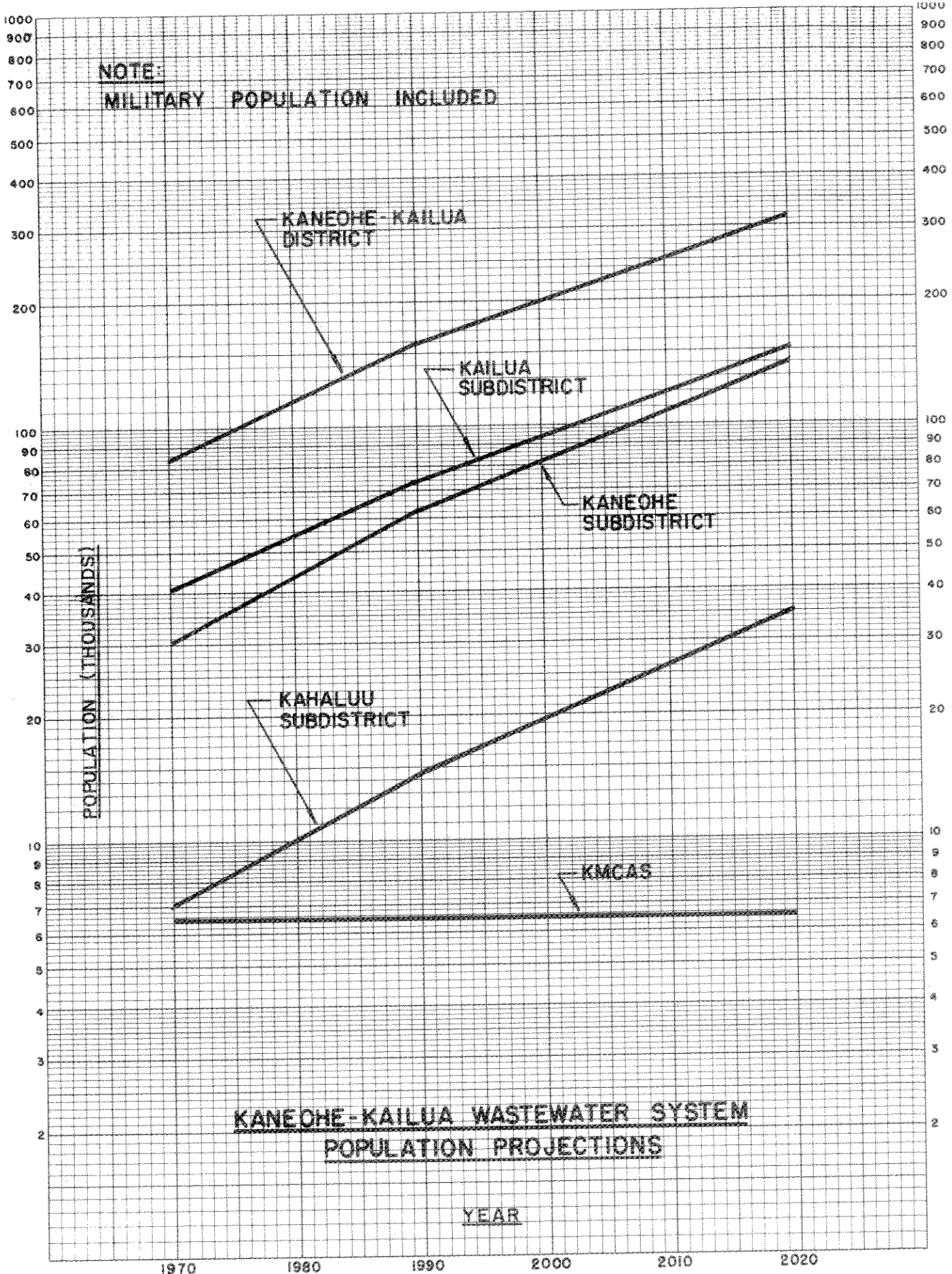
\*Adjusted because of minor boundary changes

visitor population will be significant are the Airport area, Makaha, Kahuku and Hawaii-Kai. No visitor population is projected for the Kaneohe-Kailua district. Hence, the projected civilian and military resident population will be the total de facto population. Figure I-5 illustrates the total de facto population for the sub-areas and total district from the year 1970 to 2020.

#### B. Land Use

Land use in the City and County of Honolulu is governed by the General Plan that was adopted in 1964. The detailed land use map (DLUM) for Kailua, Kaneohe and Kahaluu was adopted at the same time. The State Land Use maps designate boundaries of conservation, agriculture, and urban districts on the island. Presumably, between these documents, land use in the future should be accurately predictable. However, this is more difficult than it appears because of many non-conforming developments, non-conforming pre-existing structures, variances, and zoning changes. In order to accommodate the projected population in the district, zoning and land use changes will have to be made.

The best and most comprehensive land use inventory by census tract was made for the Oahu Transportation



KANEOHE-KAILUA WASTEWATER SYSTEM  
POPULATION PROJECTIONS

YEAR

POPULATION (THOUSANDS)

Study in 1964. Although the data collected in that study was 6 years old, studies were made during WQPO to update it. According to the report, as amended, Oahu is comprised of approximately 380,000 acres. Approximately 75 percent of the area is unused open space in conservation and agriculture. The next block of land comprising 12.9 percent or 49,000 acres is controlled by the military. There are 22,000 acres, not counting streets and highways, in the residential use category.

Land use statistics for the Kaneohe-Kailua district are shown in Table I-V-5. The data came from the Oahu Transportation Study and was updated by the WQPO.

TABLE I-V-5

LAND USE STATISTICS--KANEHOE-KAILUA DISTRICT

(From Oahu Transportation Study-1964)

<u>Land Use Category</u>	<u>Acreage in District</u>	<u>Percent in District</u>
Residential		
Single-Family	4,852	14.21
Multi-Family	69	0.20
Manufacturing	277	0.86
Transportation, Communication and Utilities	191	0.58
Commercial	220	0.64
Public and Quasi-Public Buildings	622	1.82
Public and Quasi-Public Open Space		
Recreation	563	1.65
Cemeteries	448	1.31

TABLE I-V-5 (cont'd.)

Land Use Category	Acreage in District	Percent in District
Unused Open Space, Conservation	19,197	56.24
Agriculture	4,986	14.61
Military	1,629	4.77
Hotels, Resorts	3	0.01
Highways and Streets	1,077	3.16
Total	34,134	100.06

A more recent tabulation of land uses within the district was formulated in 1972, using as a basis, the detailed land use map for Kaneohe-Kailua-Kahaluu for their compilation. This tabulation of land uses is shown in Table I-V-6, and includes lands which may be undeveloped.

TABLE I-V-6

LAND USE WITHIN THE KANEOHE-KAILUA DISTRICT  
(From C.D. Ahn)

Land Use	Area in Acres				TOTAL
	Kahaluu	Kaneohe	Kailua	KMCAS	
Residential	1,460	2,890	3,800	-	8,150
Low Density Apt.	80	110	20	-	210
Medium Density Apt.	30	90	70	-	190
Public Housing	0	20	0	-	20
Resort	100	30	0	-	130

TABLE I-V-6 (cont'd.)

Land Use	<u>Area in Acres</u>				TOTAL
	Kahaluu	Kaneohe	Kailua	KMCAS	
Commercial	50	100	90	-	240
Light Industry	140	50	40	-	230
Heavy Industry	0	0	110	-	110
Park & Recreation	760	1,030	280	-	2,070
Agriculture	2,830	820	1,900	-	5,550
Public Facilities	70	330	770	-	1,170
Hospital	0	250	10	-	260
Military	0	0	0	2,690	2,690
Total	5,520	5,720	7,090	2,690	21,020

The two tables show the amount of land being utilized in various land use categories compared with the amount of land either zoned or designated by the General Plan and the Detailed Land Use Map. Whether there is a need to rezone agricultural land to urban to accommodate the projected future population will depend on several factors many of which are unknown at the present time. Some of these factors are:

1. The present trend to increase residential density in urban zoned lands to provide more open space;
2. The amount of present vacancy in urban and agricultural lands; and
3. The possibility of establishing population limitations in certain critical areas on Oahu as recommended by the Temporary Commission on Statewide Environmental Planning (Reference 36).



## VI. WASTE LOADS

### A. General

Wastes entering the receiving waters are generated from various sources. The main category of wastes entering Oahu's receiving waters either directly or indirectly are municipal waste discharges, industrial waste discharges, pineapple canneries wastewaters, brewery discharges, meat packing operations discharges, refinery wastewaters and tuna packing operation wastewaters. Other pollutant loads are nutrients and sediments from run-off, thermal discharges, shipboard waste discharges, oil spills and radioactive waste discharges.

Wastes entering Kailua and Kaneohe Bays are from military and municipal domestic sewage and run-off. Estimates of the pounds of pollutants in the form of biochemical oxygen demand (BOD), suspended solids, total nitrogen, total phosphorus, and hexane extractable matter entering Kaneohe and Kailua Bays were computed during WQPO. These values are shown in Table I-VI-1.

TABLE I-VI-1

ESTIMATE OF PRESENT WASTE LOADS ON KANEOHE-KAILUA BAY  
(From WQPO 1972)

	Ave. Flow	Mass Emission Rate (lbs/day)				
		BOD	Susp. Solids	Tot. N	Tot. P	Hexane Ex. Mat'l.
<u>Kaneohe Bay</u>						
Domestic Sewage	2.6	880	950	340	150	160
Military	1.0	1,100	900	230	90	200
Run-off from Stream	54.3	(2,300)	192,000	110	15	-
Total	57.9	(4,300)	193,850	680	255	360
<u>Kailua Bay</u>						
Domestic Sewage	3.7	1,600	1,900	850	210	690
Run-off	(14)	(700)	(30,000)	(32)	(5)	-
Total	(18)	(2,300)	(31,900)	(610)	(215)	690

Note: ( ) denote estimates

B. Estimated Wastewater Pollutant Loads

The capacity of the facilities comprising the effluent disposal system and design requirements for new and future modifications for treatment facilities at Kailua, Kaneohe and Kahaluu were determined by the use of population wastewater flow, and pollutant load estimates and projections developed under WQPO. These estimates and projections are discussed in the following sections.

## 1. Population

The present (1970) de facto populations of Kailua, Kaneohe, KMCAS, and Kahaluu are 40,500, 30,000, 6,500 and 7,000 people respectively for a total of 84,000 people. By the year 2020, these populations are expected to increase to 153,500 for Kailua, 142,000 for Kaneohe and 35,000 for Kahaluu; the KMCAS population is assumed to remain constant at 6,500. Total 2020 population is estimated at 337,000 people. Figure I-5 shows the projection of the sub-district and the entire drainage district.

## 2. Wastewater Flows

Studies under the WQPO have determined that the present average waste flow per capita is 75 gallons per day (gpd) for Kahaluu, 85 gpd for Kaneohe and 90 gpd for Kailua. It is estimated that future per capita daily average flow for Kaneohe and Kailua will remain at 85 gpd and 90 gpd respectively; however, Kahaluu's per capita contribution should increase to 85 gpd by the year 2020. The present normal dry weather infiltration into the existing collection system has been determined to average 0.2 mgd for Kahaluu,

0.6 mgd for Kaneohe, and 1.7 mgd for Kailua. The infiltration coefficient for Kahaluu and Kaneohe have been estimated to be 21 gallon per capita per day (gcd). Kailua's coefficient has been calculated to be higher because of high water table condition there and is estimated to average 42 gcd.

For design purposes, the amount of infiltration is projected to increase as more residents are served by their respective sewer system. Infiltration is projected to increase from 0.2 mgd to 0.7 mgd in Kahaluu; 0.6 mgd to 3.0 mgd in Kaneohe; and 1.7 mgd to 6.6 mgd in Kailua at the end of the design period.

Peak wet weather wastewater flows are computed on the basis of maximum hourly flow plus normal dry weather infiltration flow and wet weather infiltration flow. The wet weather infiltration flow occurs during rainy and stormy periods and allowance must be provided in the entire hydraulic conveyance system. Wet weather infiltration rates vary over a wide range depending on the condition of the pipe and the age, location of the sewers with respect to the ground water table

(below or above the ground water table), soil condition, location of manholes, storm drainage system, etc. Infiltration rates above 10,000 gallon per acre per day(gad) have been recorded for certain areas of Honolulu, particularly Wai-kiki and Moiliili. Sewers serving low lying areas along coastal strips not served by adequate storm drainage system usually have high normal and storm water infiltration rates.

For undeveloped areas, storm water infiltration rates used for design vary from 1,250 gad to 2,750 gad for sewers above and below the ground water table respectively. Using data from the existing plants at Kaneohe and Kailua and averaging land areas with low and high water tables, the amount of infiltration in the Kaneohe-Kailua district was determined using the average rate of 2,000 gad.

The wastewaters from Kahaluu, Kaneohe and Kailua are essentially domestic wastes with no significant industrial wastes. The amount and nature of the existing flows are shown in Table I-VI-2, "Present Waste Discharges from Municipal and Military Facilities." Data in Table I-VI-2 include type of treatment, 1969-70 average flows, and wastewater characteristics for BOD, suspended

TABLE I-VI-2

PRESENT WASTE DISCHARGES FROM MUNICIPAL AND MILITARY FACILITIES

Study Area	Collection Point	Type of Treatment	1969-70 Flow (mgd)	WASTEWATER CHARACTERISTICS (C=mg/l & MER=lbs/day)												Receiving Waters
				BOD		S S		Total-N		Total-P		Grease				
				c	MER	c	MER	c	MER	c	MER	c	MER			
1	*Ahuimanu STP	Aero-accelerator & Pond	.11	40	35	45	40	21	20	10	20	10	20	20	20	Ahuimanu Stream
	Sub-total				35		40		20		10		20			
2	Kaneohe STP	Trickling Filter	2.53	40	840	40	910	15	320	6.5	140	7	140			Ocean, into Kaneohe Bay
	MCAS Kaneohe	Primary	1.0	125	1,050	10	900	27	225	10	85	24	200			Ocean, into Kaneohe Bay
	Sub-total				1,890		1,810		545		225		340			
3	Kailua STP	Trickling Filter	3.2	56	1,500	60	1,700	19	500	6.5	170	23	610			Ocean, into Kailua Bay
	*Kukanono	Extended Aeration	0.05	40	20	45	20	21	7	10	4	20	7			Leaching well w/overflow into Kawanui Swamp
	*Maunawili #1	Extended Aeration w/Pond	0.10	40	30	45	35	21	18	10	7	20	18			Maunawili Stream
	*Maunawili #2	Extended Aeration	0.04	40	13	45	15	21	6	10	4	20	6			Maunawili Stream
	*Pohakapu	Trickling Filter	0.27	50	110	45	100	21	50	10	22	20	45			Kawanui Stream
	Sub-total				1,613		1,870		581		207		686			

\* Denotes interim plants

solids, total nitrogen, total phosphorus and grease.

The projected design waste flows for the proposed Kahaluu WWTP and the existing plants at Kaneohe, Kailua, and KMCAS are shown in Figures I-6, I-7, I-8, and I-9 and summarized in Table I-VI-3, "Estimated Pollutant Loads". The design flows for the Mokapu Outfall Sewer include the flows from the four plants and are as follows:

	<u>1970</u>	<u>1990</u>	<u>2020</u>
Average Flow (mgd)	10.3	19.4	41.2
Peak Flow (mgd)	32.6	51.0	92.9

Figure I-10 depicts projections of population, average flow, and peak flow for the Mokapu Outfall Sewer.

### 3. Other Pollutant Loads

The suspended solid loads in Table I-IV-3 are used to provide a basis for the sludge handling system of the wastewater treatment plants. The average quantity of suspended solids in sewage streams for the Kaneohe-Kailua district can be expected to be 0.16 pounds per capita per day (pcd). Similarly, the biochemical oxygen demand (BOD) which will determine the organic load

TABLE I-VI-3

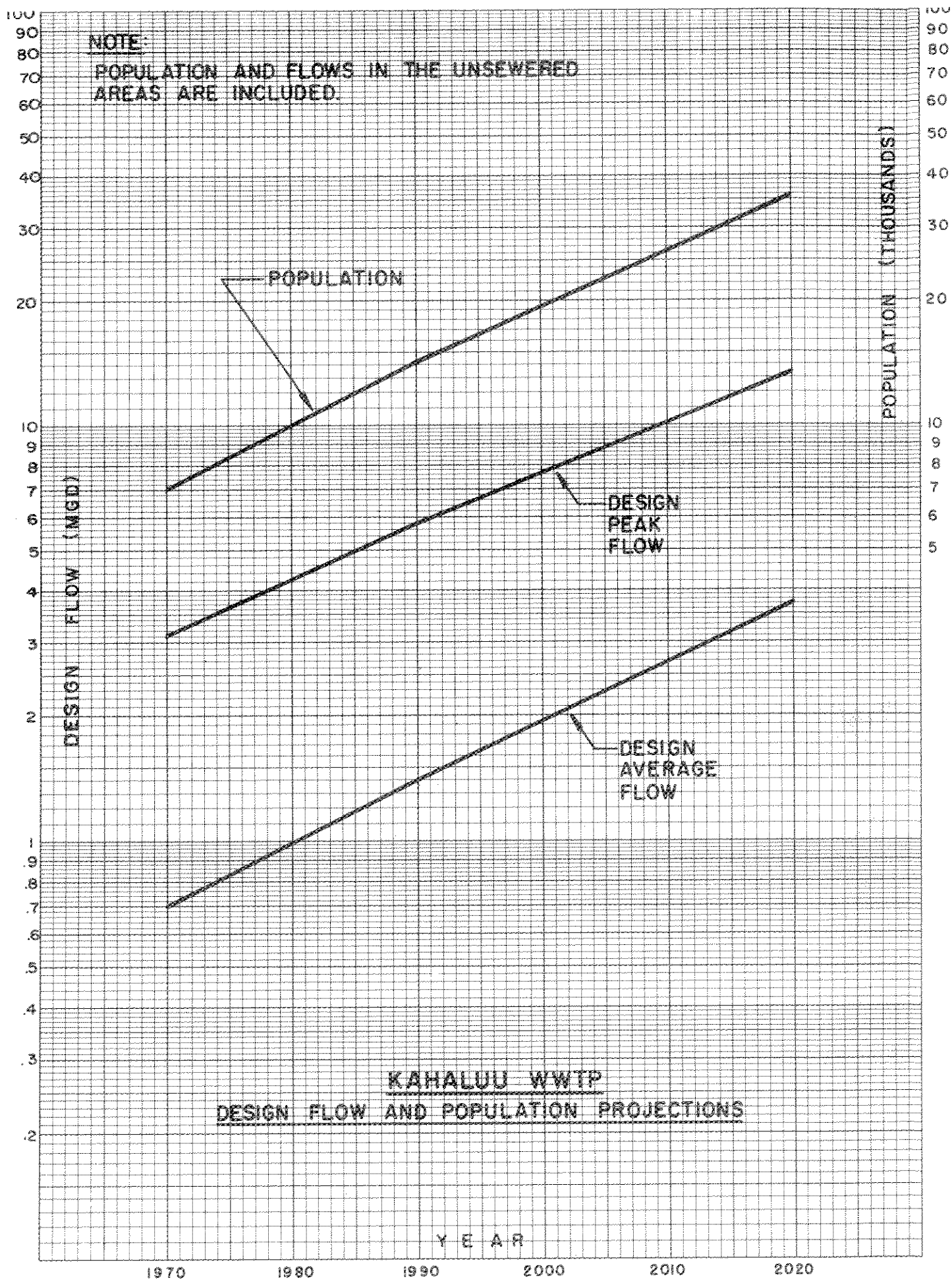
ESTIMATED POLLUTANT LOADS

DESCRIPTION	KAHALUU 2			KANEIHOE			KAILUA			KMCAS		
	1970	1990	2020	1970	1990	2020	1970	1990	2020	1970	1990	2020
	Population (thousands)	7	14.5	35	30	63	142	40.5	74.5	153.5		
Average Flow Per Capita (gpd)	75	78	85	85	85	85	90	90	90			
Average Sewage Flow (mgd)	.5	1.1	3.0	2.6	5.4	12.1	3.7	6.7	13.8			
Dry Weather Infiltration (mgd)	.2	.3	.7	.6	1.3	3.0	1.7	3.2	6.6			
Design Average Flow (mgd)	.7	1.4	3.7	3.2	6.7	15.1	5.4	9.9	20.4	1.0	1.4	2.0
Design Max Hourly Flow (mgd)	1.9	3.6	8.1	7.1	13	25.4	10.4	17.4	31.8	3.2	4.1	5.5
Wet Weather Infiltration (mgd)	1.2	2.3	5.2	4.6	6.5	11.2	4.5	7.0	12.7	2.4	2.4	2.4
Design Peak Flow (mgd)	3.1	5.9	13.3	11.7	19.5	36.6	14.9	24.4	44.5	5.6	6.5	7.9
Average Per Capita BOD (lbs/day)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Total BOD (1,000 lbs/day)	1.3	2.8	6.7	5.7	12.0	27.0	8.0	14.2	29.2	1.9	2.7	3.8
Average Per Capita SS (lbs/day)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Total SS (1,000 lbs/day)	1.1	2.3	5.6	4.8	10.1	22.7	6.5	11.9	24.6	1.6	2.2	3.2

NOTE: 1. Estimated population for KMCAS = 6,500 people; however flows indicated reflect plant capacity.  
 2. Portion of the Kahaluu sub-district will be served by the North Oahu sewerage system



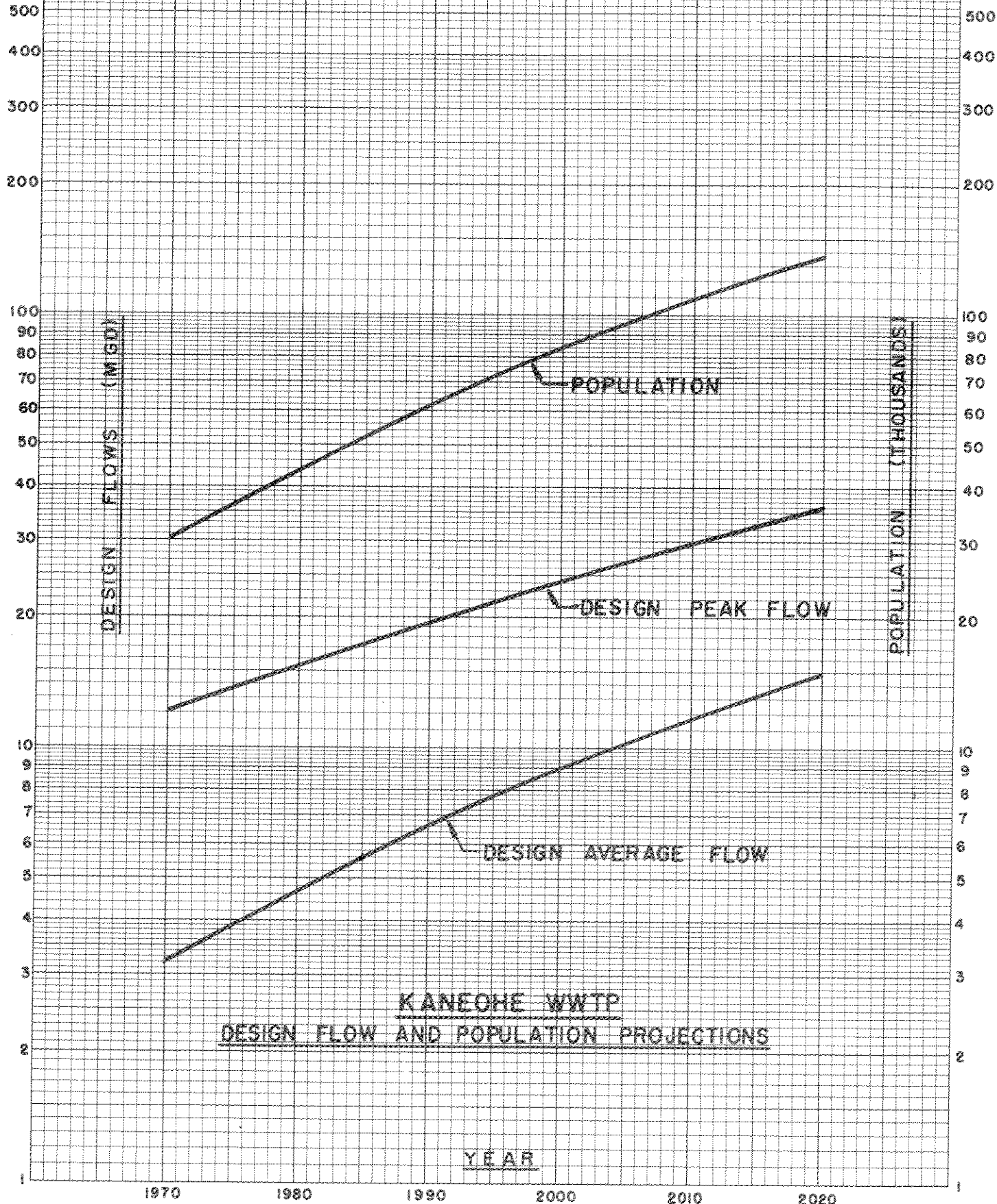
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**NOTE:**

POPULATION AND FLOWS IN THE UNSEWERED  
AREAS ARE INCLUDED.

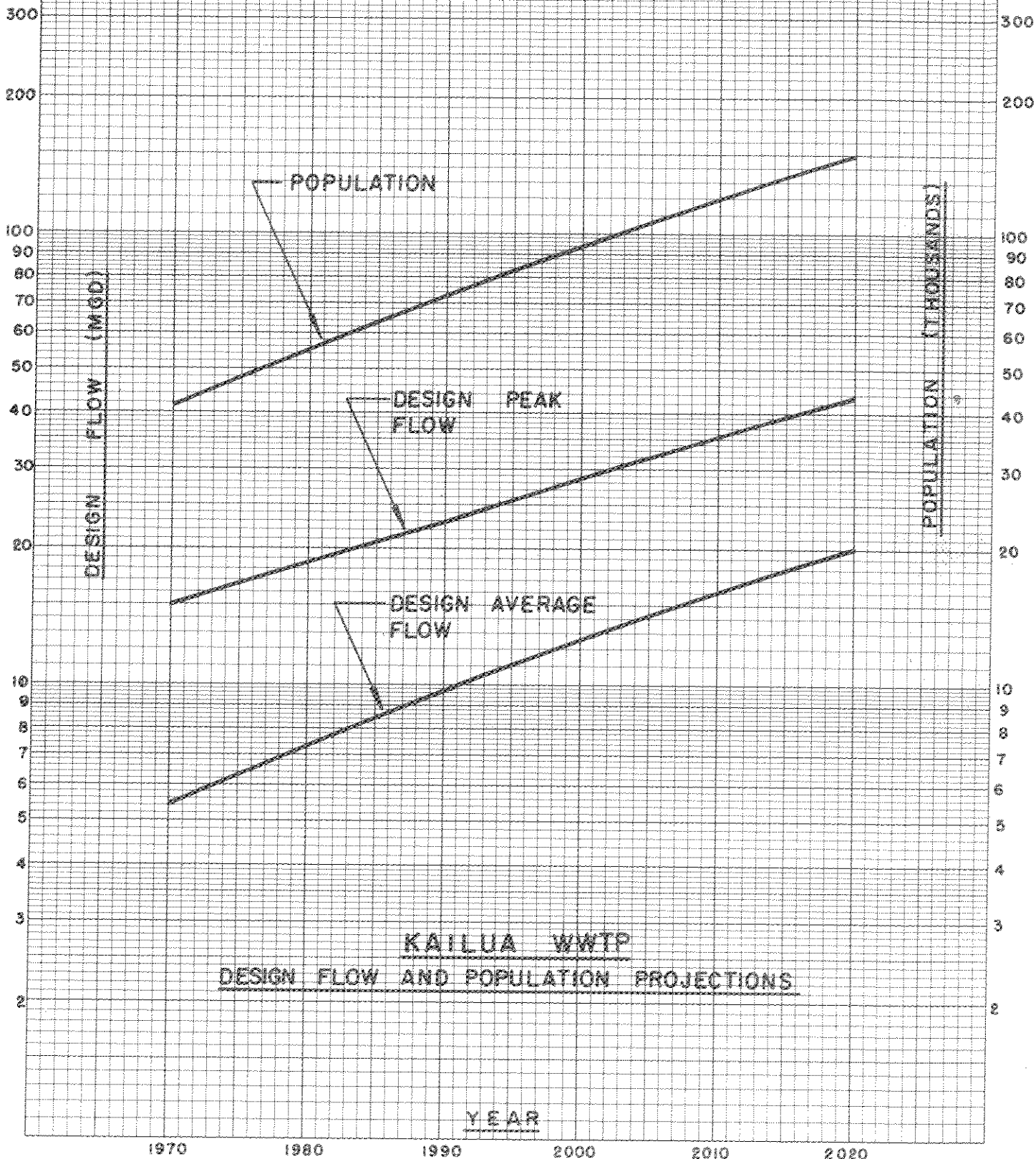
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**KANEOHE WWTP  
DESIGN FLOW AND POPULATION PROJECTIONS**

YEAR

NOTE:  
 POPULATION AND FLOWS IN THE UNSEWERED  
 AREAS ARE INCLUDED.



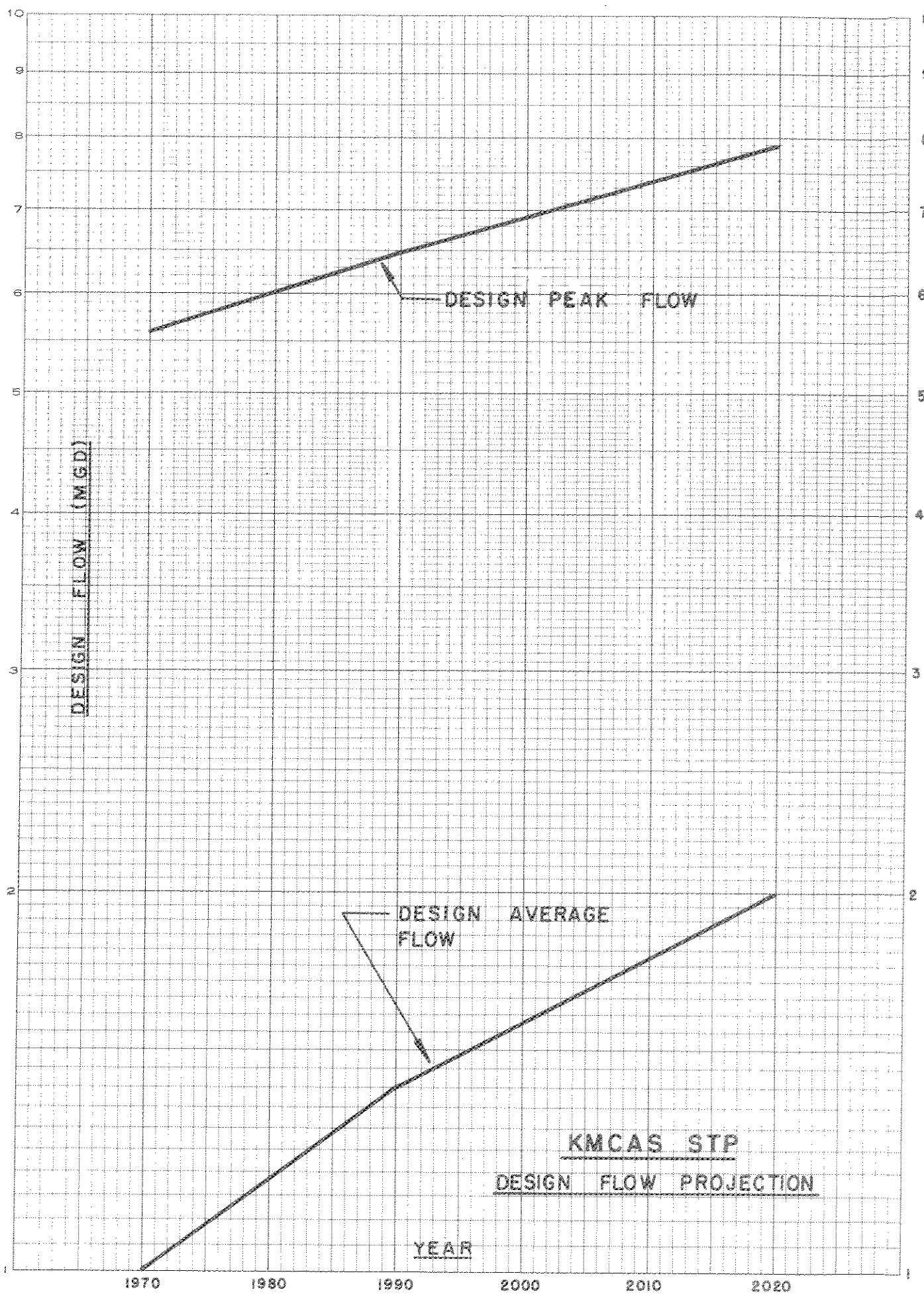
KAILUA WWTP  
DESIGN FLOW AND POPULATION PROJECTIONS

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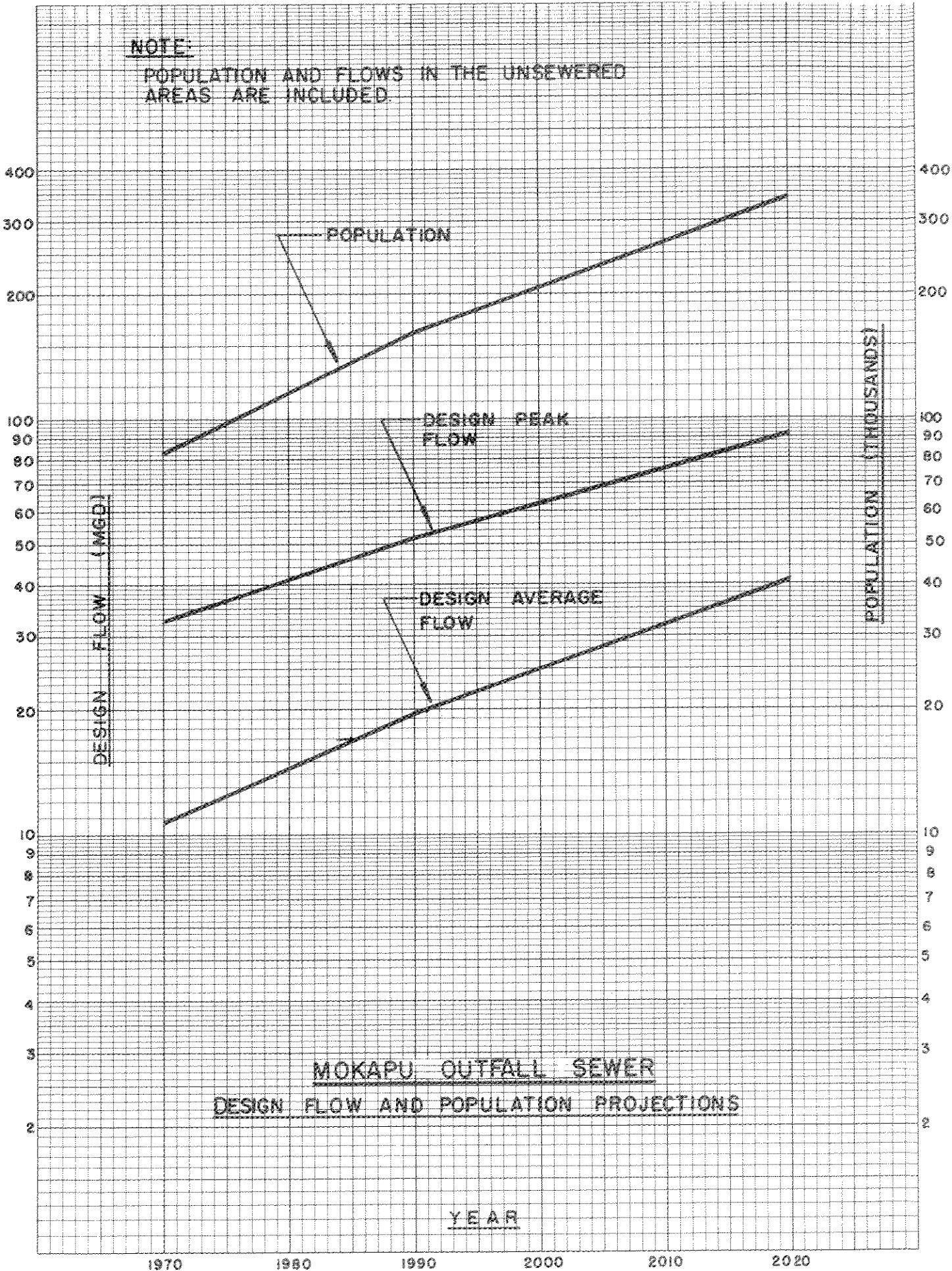
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EUGENE DIETZEN CO.  
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on the treatment plant can be expected to be 0.19 pcd. These coefficients are consistent with estimates from mainland areas. Other raw wastewater coefficients that were determined during the WQPO and will be used in the design or modification of treatment works are total nitrogen, 0.031 pcd; total phosphorus, 0.008 pcd; and grease, 0.04 pcd.

C. Estimated Storm Run-Off Pollutant Loads

1. Nutrients and suspended solid loads from stream run-offs were determined for Pearl Harbor and Kaneohe Bay during the WQPO. Streams in the Kaneohe Bay drainage basin were analyzed for total nitrogen and phosphate-phosphorus ( $\text{PO}_4\text{-P}$ ), and sediment loads. These streams included Kawa, Kaneohe, Keeahala, Heeia, Kahaluu, Kaalaea, Waiahole, Waikane, and Hakipuu streams. The average stream discharge from these and other minor perennial and intermittent streams flowing into Kaneohe Bay totaled 54.3 mgd. Total nitrogen, phosphate-phosphorus, and sediments yielded values of 110 pounds for nitrogen and 15 pounds for phosphorus per day. Sediment loads were estimated at 35,000 tons per year.

The drainage area of Kaneohe Bay is approximately

40 square miles. Nine perennial streams are located within the drainage basin. The length of the streams are relatively short and direct with steep slopes (45-85 degrees) at the head waters to 5 percent at the talus, and 2 percent in the valleys. These are average values. Most of the basin lies between the 70 and 150-inch average annual isohyets. Total annual rainfall is approximately 170 mgd (USGS Water Supply Paper 1894). Discharge into Kaneohe Bay from all sources under natural conditions (pre-development stage) was estimated at 94 mgd. The current estimate is approximately 34 mgd from storm runoff and 60 mgd from other sources.

There was no discernable pattern between the nutrient loads and stream discharges for the Kaneohe Bay streams as indicated by the Pearl Harbor streams. More study on this aspect of the streams is needed.

Nutrient loads per day into Kaneohe Bay from wastewater treatment plants (Kaneohe and KMCAS) were 570 pounds total nitrogen and 240 pounds total phosphorus compared with 110 and 15 pounds respectively from stream run-off (See Table I-VI-4). This indicated that diversion

of all effluent from Kaneohe Bay would result in a substantial reduction of the nutrient levels in the bay.

## 2. Sediments

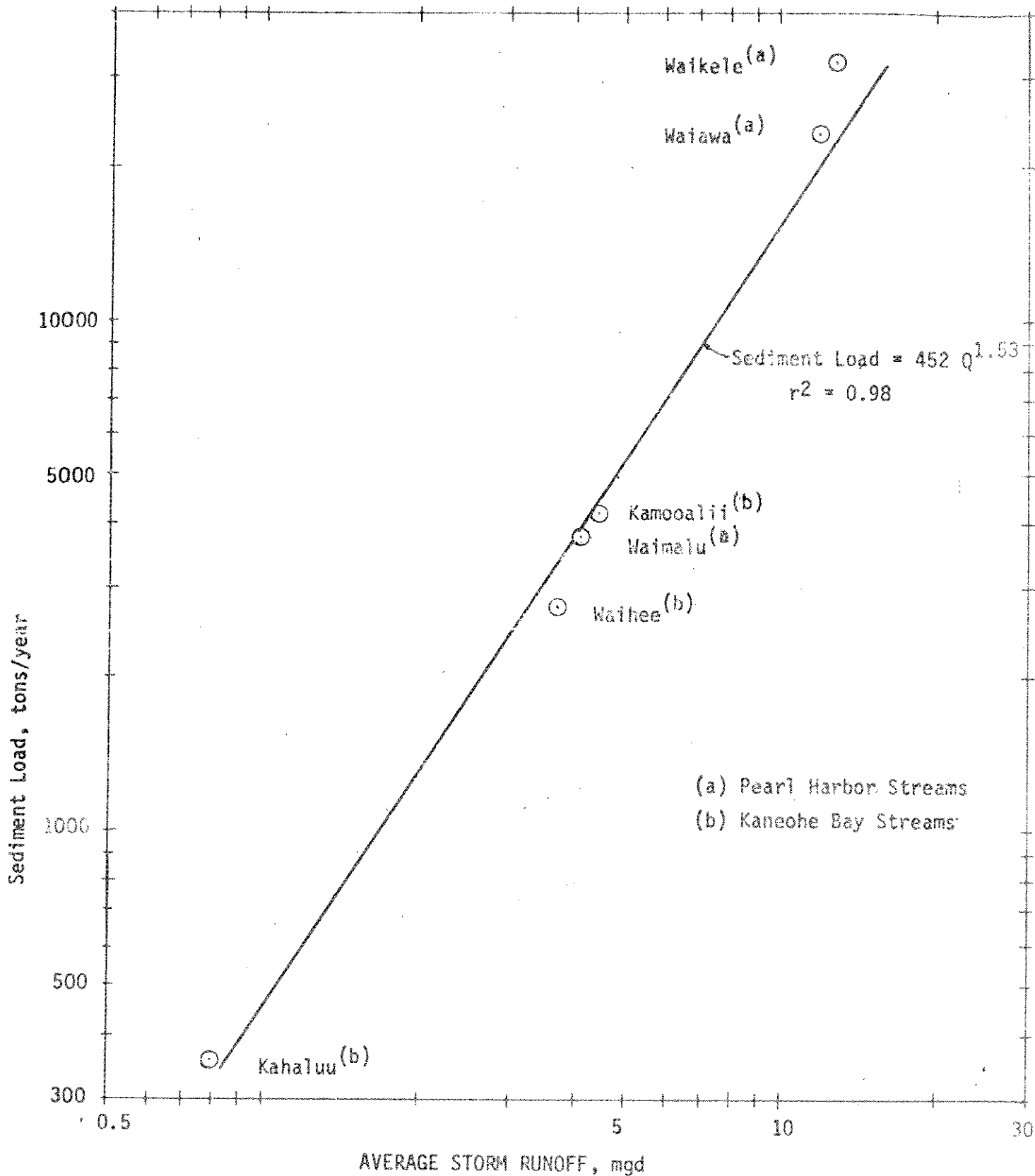
Most of the sediments carried into the bay occurred during a few intense storms in the year. There is a correlation between sediment loads and stream discharges; i.e., increasing sediment concentration with increasing stream discharge. The critical factor in the area appears to be the magnitude of the average storm run-off, notwithstanding land use, topography and ground cover. The WQPO study indicated that available information on the Pearl Harbor and Kaneohe streams do not show discernible differences in the sediment loads attributable explicitly to land use.

A correlation between sediment loads and average storm run-off based on published and unpublished data from USGS was made by WQPO. This relationship is expressed in the following formula and by the curve in Figure I-11.

$$\text{Suspended Sediment Load (ton/year)} = S = 452Q^{1.53}$$

The sediment loads into Kaneohe Bay were tabulated by streams and average storm run-off and





RELATIONSHIP BETWEEN STORM RUNOFF AND SEDIMENT LOAD: PEARL HARBOR AND KANEOHE BAY STREAMS. (Based on USGS Unpublished Data.)

(SOURCE - WQPO)

are shown in Table I-VI-5. The data were mostly extrapolated values and calculated from the aforementioned formula. There was no correlation between sediment loads attributable explicitly to land use for the Pearl Harbor and Kaneohe Bay streams from the available measurements. Unpublished information recently developed by the Agriculture Research Service, University of Hawaii and the Soil Conservation Service concerning sediment load with respect to land uses, soil, topography, vegetation, etc. will be useful in developing a realistic sediment control program for Kaneohe Bay. Ground cover has an effect on sediment loads as Fleming (Reference 4) has shown in a study of 250 basins in Africa, Burma, China, Canada, Great Britain, Pakistan, U.S. and Sweden. The Fleming Study shows that for 10-mgd streams, the sediment load ranged from 1,900 tons per year for mixed broadleaf Coniferous with thick ground vegetation to 260,000 tons per year for desert and scrubland, compared with 15,000 tons per year for Kaneohe Bay and Pearl Harbor.

Maunawili is the only major stream draining into Kailua Bay. The stream which is perennial, actually discharges into Kawainui Swamp, inland of Kailua's Coconut Grove. The stream flows enter Kailua Bay either through Kawainui drainage canal or Kaelepuli Stream. Rainfall in the sub-

TABLE I-VI-4

ESTIMATED NUTRIENT LOADS FROM KANEHOE BAY STREAMS  
(Data from WQPO 1972)

Average Total N = 0.24 mg/l

Average P = 0.022 mg/l

Stream	Average Stream Discharge (mgd)	Nutrient Loads, lb/day	
		Total Nitrogen	Phosphorus (as PO <sub>4</sub> -P)
Kawa	1.0	2.0	0.18
Kaneohe	10.9	21.8	2.0
Keeahala	3.4	6.8	0.62
Heeia	3.3	6.6	0.61
Kahaluu	10.9	21.8	2.0
Kaalaee	2.4	4.8	0.88
Waiahole	8.1	16.2	3.0
Waikane	4.2	8.4	1.5
Hakipuu	1.1	2.2	0.40
Perennial Streams Below Gages	3.0	6.0	1.1
Intermittent Streams	6.0	12.0	2.2
TOTAL*	54.3	110*	15*

TOTAL Rounded

TABLE I-VI-5

ESTIMATES OF SEDIMENT LOADS ON KANEOHE BAY  
(From WQPO)

Stream	Average Storm Run-off (mgd)	Sediment Load (tons/year)
Kawa	0.8	320
Kaneohe	5.4	6,000
Keeahala	1.2	600
Heeia	2.7	2,100
Kahaluu	8.5	12,000
Kaalaea	1.8	1,110
Waiahole	3.7	3,300
Waikane	2.8	2,200
Hakipuu	0.7	300
Intermittent Streams	6.0	7,000
Total Kaneohe Bay		35,000 (rounded)

area ranged from 40-50 inches along the low lands to 75-100 inches in Maunawili Valley and the Pali. The hydrologic budget for Kailua-Maunawili under natural conditions includes a base flow of 4 mgd and storm run-off of 14 mgd for a total of 18 mgd. "Natural conditions" is that condition prior to significant environmental changes being made by man. The budget under present conditions include a total run-off

of 14 mgd and a slightly reduced base flow of 2 mgd for a total of 16 mgd. The soils in the drainage basin are very permeable, sandy sediments into which surface water easily percolates. Pollutant loads estimates entering Kailua Bay daily from run-off is shown in Table I-VI-1.

#### D. Other Pollutant Loads Estimates

##### 1. Thermal

Thermal discharges for Oahu were analyzed under the WQPO. The findings are summarized below (Reference 1):

The power consumption on Oahu from historical data has shown an increase of 9.3 percent per year since 1955 (compared to 6.2 percent for the U. S.). The per capita electric power consumption has increased from 83 KWH/capita/year in 1940 to 4,770 KWH/capita/year. The present thermal discharges from the three Hawaiian Electric Company power plants at Honolulu Harbor, Waiiau, and Kahe have been calculated to average  $4.2 \times 10^{10}$  BTU/day. Future thermal discharges are projected to increase at the same rate (9.3 percent). The average thermal discharge by the year 2000 and 2020 is estimated

at 0.7 trillion BTU/day and 4.4 trillion BTU/day respectively. During the latter period, 53 billion gallons of cooling water would be required. Sometime between 1980 and 1990, new power plants on the windward and leeward sides of the island should become operative.

The tentative plan of Hawaiian Electric was to install a plant at Heeia Kea and Kaneohe Bay, pending outcome of studies on the ecological effects of thermal discharges on Kaneohe Bay. Since then, Kaneohe Bay has been reclassified from Class A waters to Class AA waters. Under these circumstances, thermal discharges into the Bay will not be permitted and a new site presumably will have to be found.

## 2. Discharge from Dairies

Previously there were two dairies in the Kaneohe tributary and one in Kailua. At present there is only one known dairy in Kaneohe. This one produces milk on the order of 5,300 pounds per day (about 160 animals). Most dairies on Oahu dispose of their wastes by lagooning or through irrigation of pasture and banana patches. Pol-

lutants are usually contained except during rainy weather when storm run-off carry the pollutants to receiving waters. There is little effect of dairy wastes on the district's receiving waters, although pollution is present in the local area near the discharge point. Waste flows from the only known dairy in Kaneohe are discharged into a gulch and are used by a banana farmer for irrigation.

## VII. WATER POLLUTION CONTROL SYSTEM

### A. General

The Kaneohe-Kailua Sewerage District encompasses the Kahaluu, Kaneohe, and Kailua areas and extends from Wailea Point near Lanikai to Molii Pond in Kualoa. Development in the Kahaluu area is relatively sparse except at Ahuimanu. Most of the residences are concentrated in and around the Kaneohe and Kailua areas. The Kaneohe Marine Corps Air Station situated on Mokapu Peninsula is also considered part of this sewerage district.

Presently, wastewaters from these areas are basically domestic type waste and are anticipated to remain so in the future.

### B. Existing and Proposed Subdistrict Sewerage Facilities

#### 1. Kaneohe

The Kaneohe drainage area was divided into tributary subdistricts based on topography and on existing and proposed land developments. Sewage flows were computed for the tributaries, after which the interceptors, trunk sewers and sewage pumping stations were sized and located. The proposed and existing overall sewerage im-



provements for the Kaneohe subdistrict are shown in Figure I-12.

Sanitary sewers were first constructed in Kaneohe in 1954 by developers of the Pikoiloa residential tract to serve 289 homes. This system of 8-inch vitrified clay pipes was connected to a wooden septic tank located on the northeastern end of Namoku Street. The effluent of the septic tank was chlorinated and discharged into Kawa Stream. Before long, two additional septic tanks and their system of local sewers were constructed near Puaae Place and Nukumoni Place.

The basic scheme planned was to divide the entire Kaneohe subdistrict into five sections, each to be served by an interceptor, with pumping stations and force mains where needed, and attendant trunk sewers fanning out into the subsections. In turn, each interceptor was to convey its wastewater into another interceptor or directly to the existing wastewater treatment plant located between Kawa and Kaneohe Streams. The five interceptor systems are described on the next page.

- a. Kaneohe Bay South Sewer System--This interceptor system collects wastewaters along Kaneohe Bay Drive from Malae Place to the vicinity of Kokokahi through a series of four pump stations and force mains discharging into alternative sections of gravity sewers.
- b. Kawa Sewer System--This interceptor sewer system was constructed concurrently with the treatment works because of the intense concentration of building activities within Pikoiloa, its tributaries. Prior to its installation, a number of subdivisions were completed with sewers and temporary treatment facilities (septic tanks). The effluents from these septic tanks were discharged into Kawa Stream after being disinfected by chlorination.
- c. Kaneohe Stream Sewer System--This system begins from its junction with the Kawa line, extends up to Kamehameha Highway and mauka past Kapunahala, and ends at Keapuka where the Kaneohe and Kamooalii Streams meet.
- d. Kaneohe Bay East Sewer System--This sewer system serves the town of Kaneohe, part of

Heeia-Heeia Kea and the low, densely populated, residential area of Kaneohe. A chain of pump stations at Kahanahou, Waikapoki and Waikalua lifts the wastewater collected around the shoreline of the bay into the interceptor.

- e. Kam-Heeia Sewer System--This interceptor system will begin at the northern Heeia Kea boundary and drain into a local pump station. Sewage from this station will be pumped just over the ridge separating Heeia Kea from Heeia. From this location, a gravity system will be constructed to convey wastewater into the proposed Heeia station which is now being designed. The flow from this station will be pumped to an existing line which discharges wastewater into the Kaneohe Bay East system. Another local station serves the shoreline lots along Lili-puna Road.

The only treatment facility in the Kaneohe sub-district consists of a 4.3 mgd trickling filter plant in the Waikalua area. The area of the plant site is 16 acres with no need for additional acreage. The main units in the plant

b. Kihapai-Kainui Sewer System--The main sewer of this system will begin in the upper Maunawili Valley beginning at the existing interim Maunawili Estate Wastewater Treatment Plant. The trunk will be routed to Auloa Road west of Maunawili Stream where the existing interim Maunawili Park Wastewater Treatment Plant is located. Both plants presently discharge chlorinated effluent into Maunawili Stream and will be abandoned upon the completion of the proposed sewer.

The proposed sewer will continue downstream, crossing Kalaniana'ole Highway at the State bridge and skirt the eastern edge of Kawai-nui Swamp below Manu-laiki Street. At the lower portion of Kukunono, the sewer will intercept flows entering the subdivision's interim wastewater treatment plant. Flows into another interim facility, the Pohakapu Wastewater Treatment Plant, will be intercepted further downstream and conveyed to the existing Kailua Road wastewater pump station. The station is located off Kailua Road on the mauka side of Kaelepulu Stream.

Effluent from the Kukunono plant is given additional treatment in a detention pond prior to discharge into a sump in Kawainui Swamp. Chlorination is practiced here and at the Pohakapu plant where the effluent is discharged into a ditch that drains into Kaelepulu Stream. Construction funds are available in the current capital improvement program (Fiscal Year 1973) for the construction of the sewer that will eliminate both discharges.

The Kailua Road pump station, which discharges into the interceptor that runs along Kihapai, Kawainui, Oneawa and Kainui Drive, also serves the Kailua business district and the mauka portion of Enchanted Lake. The mauka section of Coconut Grove along Kihapai Street will be served by an existing pump station located on Hooula Street. Other portions will be connected directly to the interceptor.

- c. Mokapu Sewer System--The Mokapu tributary is served by an existing trunk sewer on Mokapu Boulevard. A pump station will have to be constructed in the upper region in the event the area is developed in the

trickling filter facility which was put into operation in late 1965. In land area, the 25 acres site has ample room to accommodate the ultimate average flow of 20.4 mgd. The major components of the Kailua plant are the raw wastewater pump station, primary sedimentation tank, trickling filter, final clarifier, sludge holding tank, high-rate mechanical sludge digester, sludge drying beds and the chlorination facility. Present average flow (1973) is approximately 3.6 mgd.

The final treated effluent is being discharged off Kapoho Point via a 5,500-foot long land and ocean outfall sewer. The subaqueous sewer is an open-ended 42-inch diameter pipe terminating in about 13 feet of water. This interim terminus was scheduled to be extended to its ultimate length of 3,700 feet in 35 feet of water in 1968; however, because of the impending passage of the State water quality standards, the project was delayed until the WQPO was completed.

### 3. Kahaluu

At present, the only treatment facility located in the Kahaluu area is the Ahuimanu Wastewater Treatment Plant. The plant is an interim facility with a design capacity of 1.4 mgd and provides tertiary treatment for nitrogen and phosphorus removal. The plant is located on Kahekili Highway and Ahuimanu Place and discharges its effluent into a 0.8-acre holding pond discharging into Ahuimanu Stream, which is a tributary to Kaneohe Bay. Present plant flow (1973) is approximately 0.20 mgd.

Three sewer systems will serve this area. These are described below:

- a. Kahaluu Sewer System--Except for the Ahuimanu area, the Kahaluu subdistrict is being served by individual household cesspools. Hence, the first phase of the construction of the proposed treatment plant at the proposed site off Waihee Road would include the construction of the proposed Kahaluu interceptor sewer. This proposed line will begin at the existing Ahuimanu plant and will generally follow the alignment of the highway and stream.

It will enter the proposed treatment plant on the southeast side of the site. This proposed sewer will serve, in addition to Ahuimanu, the area in the vicinity of Ahaolelo Road and the upper valley of Kahaluu Stream.

- b. Kamehameha Highway Sewer System--The proposed sewer system will serve the area along Kaneohe Bay from the old Hygienic Store to Maelieli. Three pump stations will be needed because of the terrain and the steep slopes used for small diameter pipes. The proposed stations will be located at Maelieli, Honekoa and Lahikai.
  
- c. Kualoa-Waiahole Sewer System--This proposed system will serve the area from Molii Pond to Waiahole, Pulama, Wailehua, and Waihee. The sewer will generally follow the alignment of the state highway, located on or between it and the shoreline. Two pump stations are proposed to serve the tributaries. One will be sited near Molii Pond and the other will be constructed near the Waiahole Stream.



#### 4. Kaneohe Marine Corps Air Station

The KMCAS plant, located on Mokapu Peninsula also discharges treated effluent into Kaneohe Bay. The treatment plant has a design capacity of 2.0 mgd and was recently upgraded to a secondary plant. The main components of the facility are the air degriter unit, primary clarifier, digester, trickling filter, final clarifier, one-acre detention pond, and effluent pump station. About 500,000 gallons of the treated effluent is used daily to irrigate the golf course and the balance is presently discharged through a 20-inch outfall extending between Halekou Pond and KMCAS Pier approximately 500 feet offshore into 15 feet of water.

### C. Proposed District Sewerage Facilities

#### 1. Introduction

Water quality objectives for Kaneohe Bay are such that under present technological constraints, it is impossible to apply treatment on any rational basis for a discharge to these waters. A number of tertiary processes have been developed recently for removing specific nutrients from a waste stream; however, the question of which nutrient compound causes primary productivity with specific types of treated effluents

and specific aquatic environments (estuarine, reparation, or marine) is as yet unanswered. Other nutrients which exert a growth rate limiting effect are trace metals (such as iron or manganese), vitamins, exoenzymes, amino acids, etc. As a result, the costly treatment processes which remove specific nutrients such as nitrogen and phosphorus may not remove the growth-rate limiting substances necessary to preclude biological response in an aquatic environment.

Tertiary processes cannot be shown to improve the effluent characteristic regarding biostimulation and toxicity. It is also considerably more expensive, notwithstanding the fact that it would accomplish no meaningful purpose.

Of major concern in this area is the apparent degradation of Kaneohe Bay. Presently three wastewater treatment facilities discharge effluent into the Bay. These include the Kaneohe and Ahuimanu municipal plants and the KMCAS plant. The present average flow for the three plants is approximately 4.4 mgd.

## 2. Alternative Wastewater Management and Disposal

## Systems

A brief summary of the alternative systems considered is mentioned here. A complete discussion of the alternatives will be in Part II of this statement.

Alternative 1 considered the feasibility of maintaining the three existing facilities, (Ahuimanu, Kaneohe and KMCAS treatment plants) providing tertiary treatment at each, and continuing discharge into Kaneohe Bay.

Alternative 2 also considered utilization of the three existing facilities but their secondary effluent being conveyed to the Kailua treatment plant and disposed of through an extended ocean outfall of Mokapu Peninsula.

Alternative 3 considered the feasibility of a single secondary treatment facility at Kailua and eliminating the existing plants at Ahuimanu and Kaneohe. It was assumed that the KMCAS plant will continue to be operated.

Alternative 4 is a modification of alternative 2 in that it considered the eventual construction of a new treatment facility in Kahaluu and phas-

ing out of the existing Ahuimanu plant. Effluent under this scheme would be conveyed to the Mokapu Outfall for disposal.

Alternative 5 considered the eventual elimination of the existing Ahuimanu plant but with all raw waste from the Ahuimanu-Kahaluu area being conveyed to the existing Kaneohe plant for treatment in lieu of constructing a new plant in Kahaluu.

Alternative 6 considered the feasibility of a treatment facility in the vicinity of Kualoa Point with a separate ocean disposal system to serve the Kahaluu area. Under this scheme the effluent from Kaneohe and Kailua would be conveyed to the Mokapu Outfall.

Alternative 7 considered the employment of ground injection of effluent in lieu of ocean disposal.

Alternative 8 considered the disposal of the effluent from the Kaneohe plant to the proposed Corps of Engineers Kaneohe Flood Control Reservoir. Under this alternative, flows from the Kailua plant would be disposed off Mokapu Peninsula and the Kahaluu plant effluent would

be discharged off Kualoa.

### 3. Alternative Ocean Disposal Systems

The following ocean disposal schemes were considered. The alternatives are discussed fully in Part II.

Alternative 1 considered advanced primary treatment with deep ocean disposal (depth greater than 200).

Alternative 2 considered secondary treatment with shallow ocean disposal (depth between 80-100 feet).

Alternative 3 considered the extension of the existing Kailua outfall to about the 100-foot ocean depth. This would require approximately 12,000 feet of 54-inch diameter pipe.

Alternative 4 considered the construction of 14,600 lineal feet of 54-inch pressure main along the shoreline of KMCAS toward Mokuapu Point. A 48-inch ocean outfall sewer, approximately 5,000 feet long, would be required to reach water depth of 105 feet.

Alternative 5 considered an extended Kaneohe Outfall to the open ocean and an outfall off

Mokapu.

Alternative 6 considered ocean outfalls off Kualoa and Mokapu Peninsula.

#### 4. Recommended Wastewater System

The WQPO recommended wastewater system for the Kaneohe-Kailua sewerage district is shown in Figure I-12. Projections indicate that the population for this sewerage district could total 337,000 by the year 2020. To accommodate this population, it was assumed that land use designations will change in the future. However, if the projected population does not materialize, the system will not become inefficient or obsolete since treatment and pumping facilities will be built in increments.

Most of the Kaneohe and Kailua subdistricts are presently sewerred. If densities do not change appreciably, the existing sewers should be adequate until at least 1990. Relief sewers and modifications to existing pumping stations may then become necessary in certain localities depending on future growth and development of each locality.

The existing Kailua and Kaneohe secondary plants

**LEGEND**

- EXISTING SEWAGE PUMP STATION
- EXISTING SEWAGE TREATMENT PLANT
- △ EXISTING TREATMENT FACILITIES (TO BE ABANDONED)
- ..... EXISTING GRAVITY SEWERS
- - - - EXISTING PRESSURE MAIN
- PROPOSED SEWAGE PUMP STATION
- PROPOSED SEWAGE TREATMENT PLANT
- PROPOSED GRAVITY SEWERS
- - - PROPOSED PRESSURE MAIN
- · - · - PROPOSED EFFLUENT LINE
- - - SEWERAGE DISTRICT BOUNDARY
- - - SUBDISTRICT SEWERABLE BOUNDARY



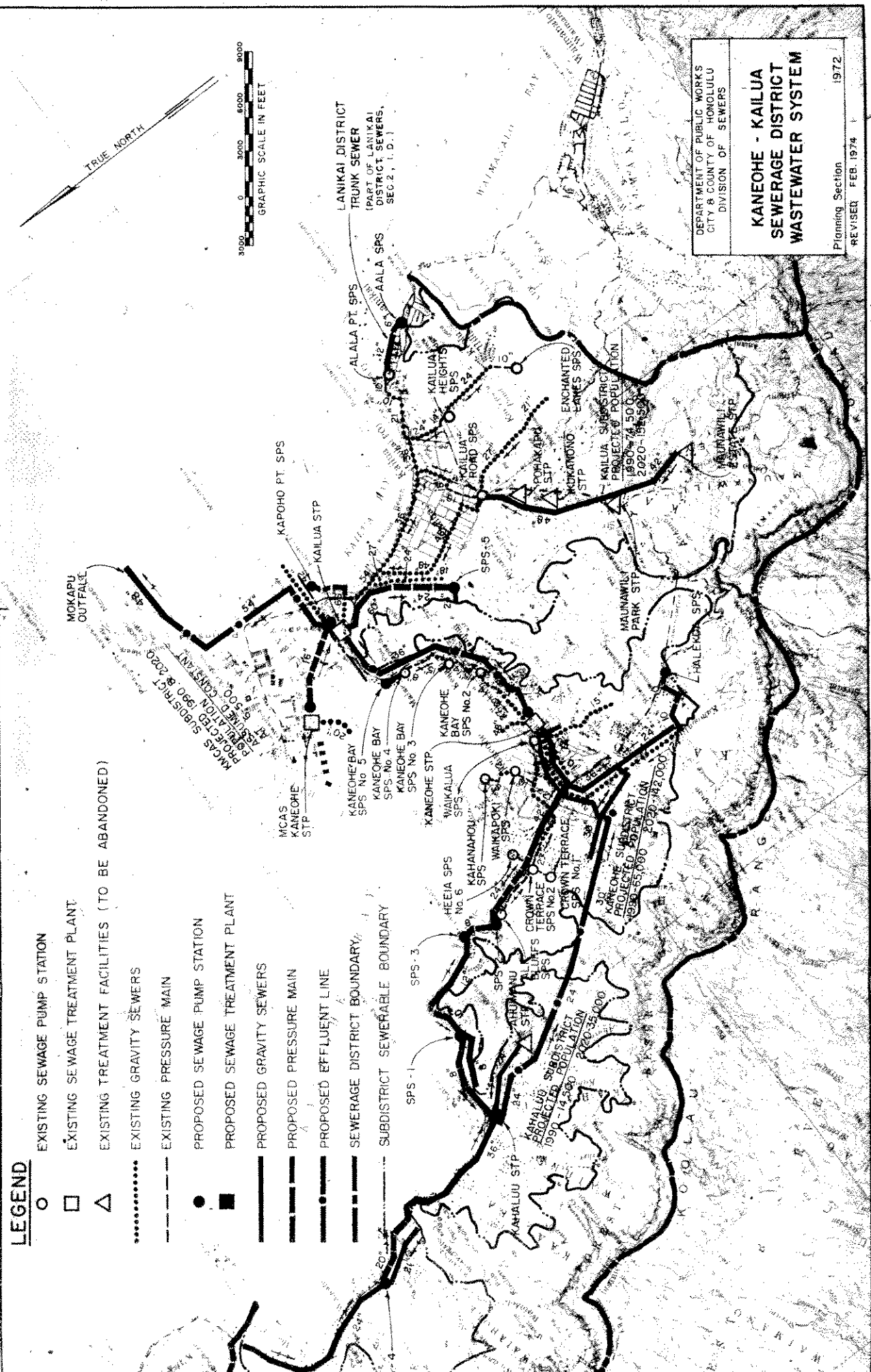
DEPARTMENT OF PUBLIC WORKS  
CITY & COUNTY OF HONOLULU  
DIVISION OF SEWERS

**KANEHOE - KAILUA  
SEWERAGE DISTRICT  
WASTEWATER SYSTEM**

Planning Section 1972  
REVISED FEB. 1974

1-79

FIGURE T-10



will be expanded as required. Upon reaching its present design capacity, the plants will be converted from the trickling filter process to the activated sludge process in order to provide for higher removal efficiencies. A new secondary treatment plant (activated sludge) will be constructed at Kahaluu and the existing Ahuimanu plant phased out. The KMCAS plant will be maintained. Each plant will have an effluent pumping station. Effluent from the Kahaluu plant will be pumped to the effluent pumping station at the Kaneohe plant. This station will then pump the aggregate flows to the Kailua effluent pumping station which will pump the entire district's effluent (flows from Kahaluu, Kaneohe, KMCAS and Kailua plants) to the Mokapu Ocean Outfall Sewer for disposal. The City's Advisory Board concurred with the district wastewater system recommended by the City's engineering consultants. In addition, the Advisory Board recommended that the Mokapu Ocean Outfall be constructed along the shoreline of the marine base toward Mokapu Point and extended into the ocean to a depth of approximately 100 feet for final disposal of the effluent.



VIII. JOINT CITY-MILITARY USE OF MUNICIPAL SEWERAGE FACILITIES

Use of the municipal sewerage facilities by Federal agencies has been a long established precedent with metropolitan Honolulu and Pearl Harbor. Wastewater flows from the Federal Building, U.S. Immigration Building, Punchbowl Cemetery, Coast Guard Headquarters at Pier 11, the U.S. Naval Reservation opposite Pier 4, Camp Catlin and Radford Terrace Housing, Fort Armstrong, Fort Ruger, Fort DeRussy and the Army Honolulu Port enter the City's East Mamala Bay sewer system and are discharged into the ocean through the Sand Island Ocean Outfall.

In the Pearl Harbor area, wastewater flows from McGrew Point Housing, Manana Capehart Housing and Pearl City Peninsula Housing enter the municipal Pearl City sewer system and are treated at the Pearl City wastewater treatment plant and discharged into Middle Loch, Pearl Harbor. Plans now call for the elimination of effluent discharges into Pearl Harbor and the construction of a new regional treatment and disposal system in Honouliuli. Included in this plan are the abandonment of the Navy's primary treatment plants at Barbers Point Naval Air Station (BPNAS) and Iroquois Point Capehart Housing and connection to the new municipal sewer system.

There are ample examples where cooperation with the City and the Military services have resulted in joint use of the City's sewerage system. The cooperation has been strengthened by the President's Executive Order of February 4, 1970 for the Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities. The Executive Order states under Section 4(3) that "The use of municipal or regional waste collection or disposal systems shall be the preferred method of disposal of wastes from Federal facilities." Further, under Section 5(a), it is required that pollution abatement actions at existing facilities be completed or be underway no later than December 31, 1972. Full justification as to the extraordinary circumstances necessitating any extension of the time specified under Section 5(a) shall be required of any request for such extension.

As early as December 1969, the U.S. Navy by letter requested inclusion of waste treatment requirements for BPNAS, Iroquois Point Capehart Housing, and KMCAS in the City's sewage systems. This request was reiterated in January 1971 during the water quality program study. The Navy's request for inclusion of KMCAS wastewater was accepted and incorporated in the conceptual plans of the City water quality manage-

ment plans for the Kaneohe-Kailua sewage system.

Wastewater from KMCAS will be treated by an existing secondary (trickling filter) treatment plant on the base. The effluent will be chlorinated and screened before it is detained in a 1.0 mg pond. It is intended that part of the effluent be recycled for grass sod irrigation on the base golf course. The remaining effluent will be pumped directly into the Kailua WWTP effluent pump station for further transmission to the Mokapu Outfall Sewer.

## IX. OCEANOGRAPHIC STUDIES

### A. Introduction

Coastal waters, estuaries, and the open ocean have been the recipients of most of man's liquid-borne waste materials, as well as some of the atmospheric-borne and solid wastes. Because of its insularity, topographical features, and tourist-oriented economy, wastewater disposal into all marine waters has special significance for the Island of Oahu.

The concept of marine disposal necessitates a thorough knowledge of near-shore oceanography as related to the dispersal capability of the receiving waters, the physical placement of the pipeline on the ocean bottom, and other factors that influence transport, bacteria decay rate, and reduction of the deleterious components of wastewater.

The data specifically needed for the oceanographic survey for the Kaneohe-Kailua district include the following.

1. Ocean currents, velocity and direction frequency.
2. Water quality standards including marine biology.
3. Topography of ocean bottom.

4. Density stratification.
5. Bacteria (coliform) decay.
6. Winds.
7. Wave conditions.

B. Ocean Survey Program

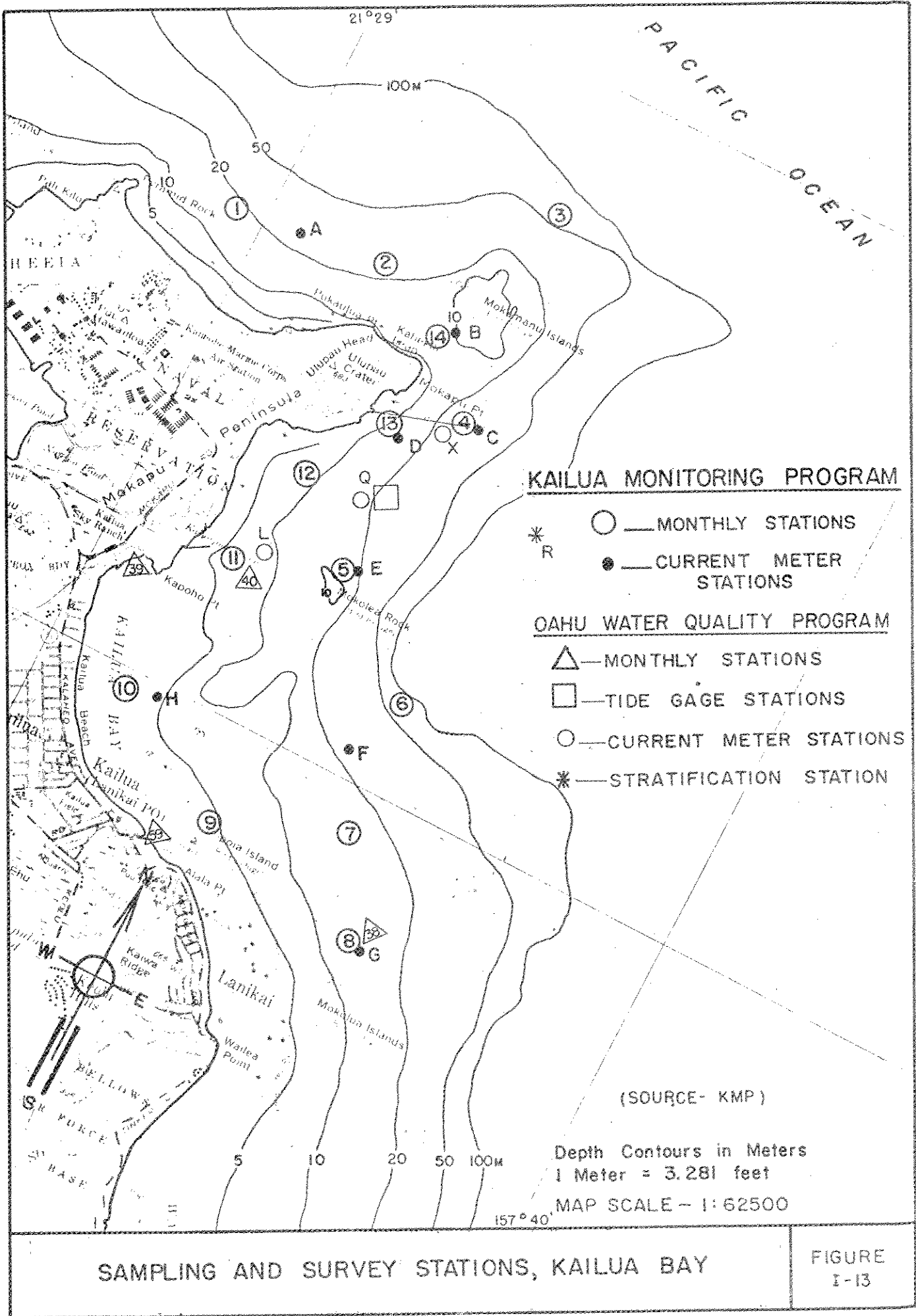
A wide variety of information has been accumulated in the past by government agencies, the University of Hawaii, private organizations and individuals. Data available from the above sources were evaluated as to applicability to the proposed project and the City's water quality program. Following the WQPO oceanographic studies, an additional twelve months of intensive current and water quality studies by the University of Hawaii, under the direction of Dr. Karl H. Bathen was initiated by the City. The studies were incorporated in a report titled "A Descriptive Study of the Circulation and Water Quality in Kailua Bay, Oahu, Hawaii During 1971 and 1972" and will hereafter be referred to as the Kailua Monitoring Program (KMP). Much of the information in KMP serve as the basis for discussion in this statement. KMP was started in September 1971 and was completed in September 1972. Sampling and survey stations established during

WQPO included stations 38, 39, 40, 59, "L", "Q", "R", and "X". Twelve stations were established during KMP, including eight current meter stations, numbering from "A" to "H". Stations "D" and "C" are located on the proposed alignment of the outfall sewer at midpoint and the terminous respectively. Depths at these stations are 33 meters (108 ft.) at Station "C" and 15 meters (49 ft.) at "D". Location of all the stations are shown in Figure I-13.

The WQPO oceanographic studies provided general coverage of the entire island with special emphasis on potential ocean outfall sites and areas under stress or presumed to be under stress. The KMP studies were concentrated in Kailua Bay and adjacent waters and included ocean current circulation and water quality under the influence of summer and winter conditions.

The following surveys were made for Kailua Bay and Mokapu Peninsula by WQPO, KMP, U.H., City's consultants and staff.

1. Parameters
  - a. Temperature
  - b. Secchi Disc Transparency



- c. pH
  - d. Dissolved Oxygen
  - e. BOD
  - f. Nitrite Nitrogen
  - g. Nitrate Nitrogen
  - h. Ammonia Nitrogen
  - i. Total Organic Nitrogen
  - j. Reactive Phosphorus
  - k. Total Phosphorus
  - l. Total Coliform Bacteria
  - m. Salinity
  - n. Phytoplankton (Periphyton)
2. Sediment analyses included -
- a. Particle Size Distribution
  - b. Mineralogical
  - c. Bicarbonate Extractable Phosphorus
  - d. Ammonia Nitrogen
  - e. Total Organic Nitrogen
  - f. BOD (Index of Putrescibility)
  - g. Chlorinated Pesticides
  - h. Sulfides
  - i. Heavy Metals
  - j. Benthic Organism
3. Oceanographic measurements included -



- a. Ocean Currents and Circulation
  - b. Density Stratification
  - c. Bathymetric Profile and Bottom Configuration
  - d. Wind, Sea, and Wave Characteristics
  - e. Optical Properties (Light Attenuation and Transmission)
4. Other studies included -
- a. Bacteria decay rate
  - b. Monitoring videotapes for number and types of benthic biota
  - c. Observation of biota by SCUBA divers
  - d. Artificial substrate for chlorophyll and biomass

#### C. General Offshore Circulation

The offshore and nearshore circulation patterns around the Hawaiian archipelago are extremely complex and only a simplified generalized description can be made here. The results of past oceanographic studies have shown that the offshore circulation and the resultant net transports vary seasonally and vary remarkably from location to location around Oahu, and are strongly under the influence of the tides or winds, depending on the location. A transport chart for the North Pacific Ocean was

proposed by Sverdrup (Reference 5), showing the Pacific North Equatorial Current and a large anticyclonic (clockwise in S. Hemisphere, counterclockwise in N. Hemisphere) gyre around the Hawaiian Archipelago. Additional evidence of its existence has been advanced by others (References 6, 7, 8 and 9).

Based upon the present evidence, it appears that an East Pacific Gyre exists and that the position of this gyre changes seasonally. During the late spring, summer, and early fall months, the East Pacific Gyre is probably centered south-southeast of the island of Hawaii. If so, this gyre would produce a general north or northwest flow in the area of the Hawaiian Archipelago. Though the Hawaiian Islands would break up this basic flow into more complex patterns around the islands, the water would generally approach the island of Oahu from the southeast. The northern portion of this flow moves around Makapuu Point, flows parallel to the shore across Waimanalo Bay, across Kailua Bay, and is deflected to the north by Mokapu Point. Once around Mokapu Point, this flow probably deflects northwestward to Kahuku Point. At Kahuku Point, it begins flowing to the north

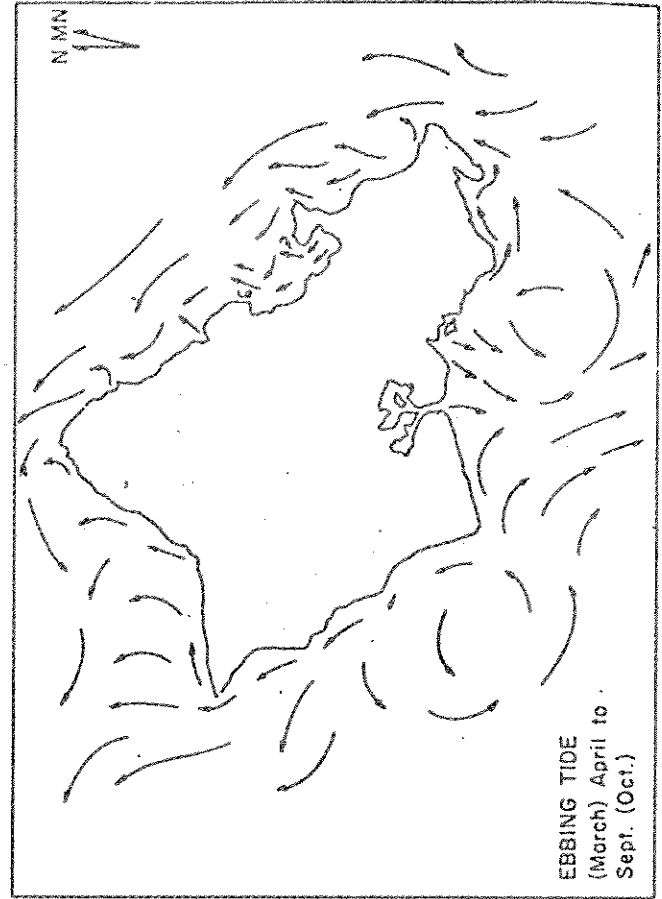
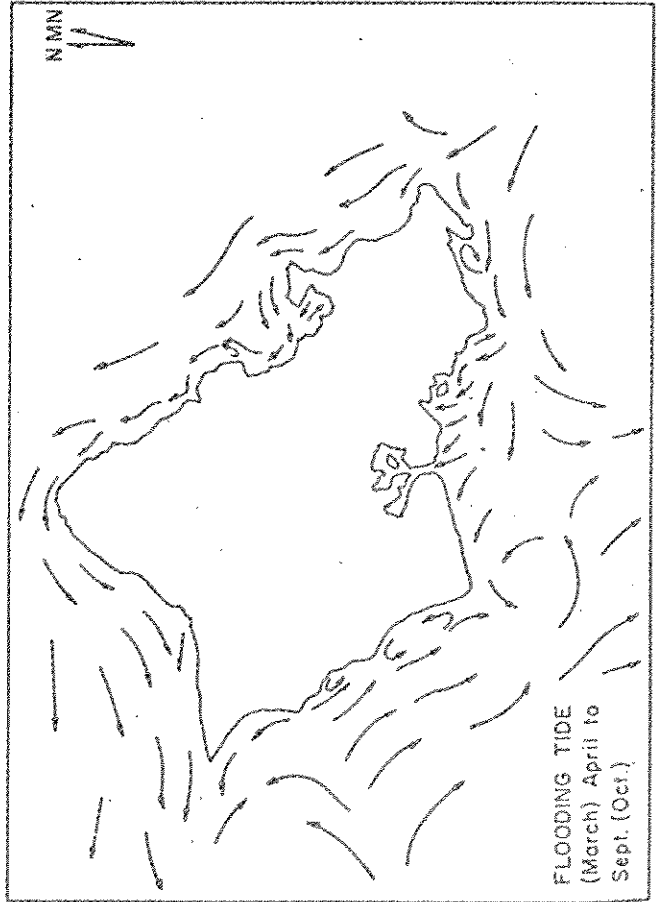
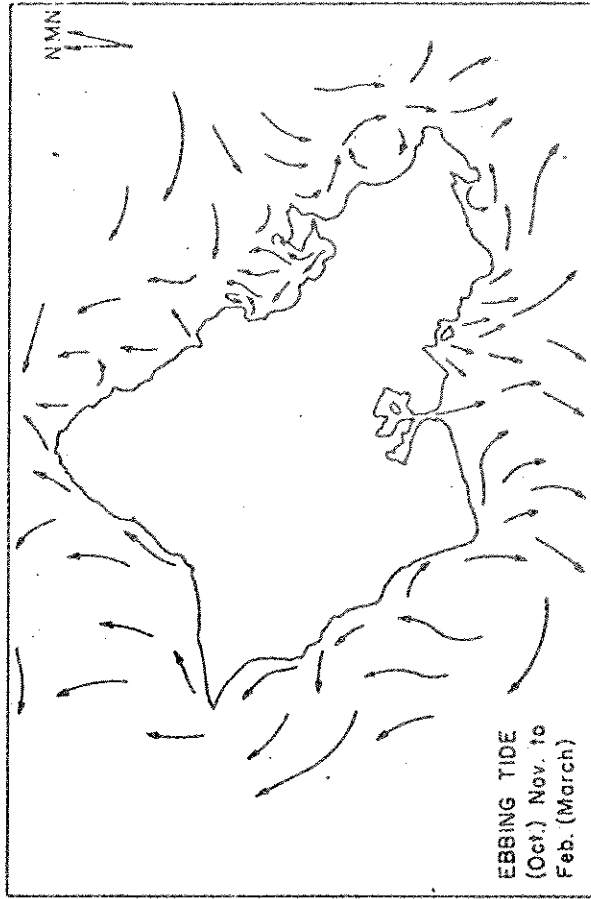
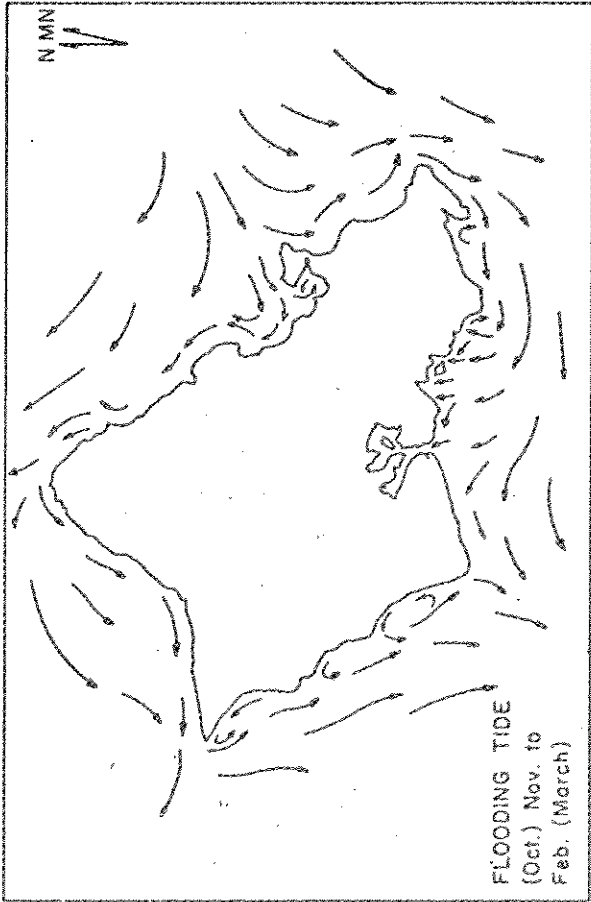
again slowly shifting to the west far offshore. The southern portion of the flow dividing at Makapuu Point moves along the entire south coast of Oahu into Mamala Bay, resulting in a southwest transport leaving the bay during the summer months. At Barbers Point, a portion of this flow probably meets water moving southeastward along the Waianae coast. The possible result is a formation of cyclonic eddies off Barbers Point and off the Waianae coast primarily during the late spring and early fall. Eddies would more likely occur with the changing tide during the periods when the tradewinds are strong (Reference 10). The configuration of the coastline off both the windward side of Oahu and the leeward side from Makapuu Point to Barbers Point strongly influences the flow throughout the year in the shallow areas (less than 30-feet deep) close to the shoreline. Behind prominent points, such as Kawaihoa Point (Koko Head), eddy patterns may develop and change with each changing tide.

During the winter months, the location of the East Pacific Gyre probably moves southward. This would allow the westward drift north of the Hawaiian Archipelago to also move slightly southward. The

result would be that the flow approaching the Hawaiian Archipelago would be basically from the northeast and, therefore, the flow would reach Oahu from the north or northeast. This flow is divided off Kaneohe Bay. The northern portion moves northwest toward Kahuku Point. The southern portion is diverted around the east coast of Oahu, Maunaloa Bay, and continues moving around Diamond Head into Mamala Bay. This flow becomes increasingly influenced by the tides and less influenced by the wind as it moves toward Mamala Bay. Once in the bay, the net westward transport decreases and the influence of the coastline configuration (bathymetry) deflects this flow to the southwest. During both the winter and summer months (except during Kona storms) a southwest transport would be expected in Mamala Bay from off Kewalo Basin to Keehi Lagoon. The southwest transport off Barbers Point turns westward offshore and moves toward Kaena Point. The result is that weak anti-cyclonic eddies may form off the southern portion of the Waianae Coast.

Four grossly simplified general circulation patterns for the island of Oahu are shown in Figure I-14. These represent speculations of what occur

GENERAL CIRCULATION PATTERNS AROUND OAHU



during flooding and ebbing tides conditions from (October) November to February (March) and (March) April to September (October). These diagrams have been developed from past information supplemented by the results of the WQPO field program.

D. Currents in Kailua Bay

Two current meter stations were established during WQPO in Kailua Bay off Mokapu Peninsula. Station "X" was located near the terminous of the proposed outfall in 60 feet of water with the meter located at 30 feet depth. Station "Q", the other was located in 60 feet of water with the meter located at the 30 feet depth also. The latter station is sited about midpoint from Station "X" and Mokolea Rock. Location of current meter stations established during KMP and their depths are:

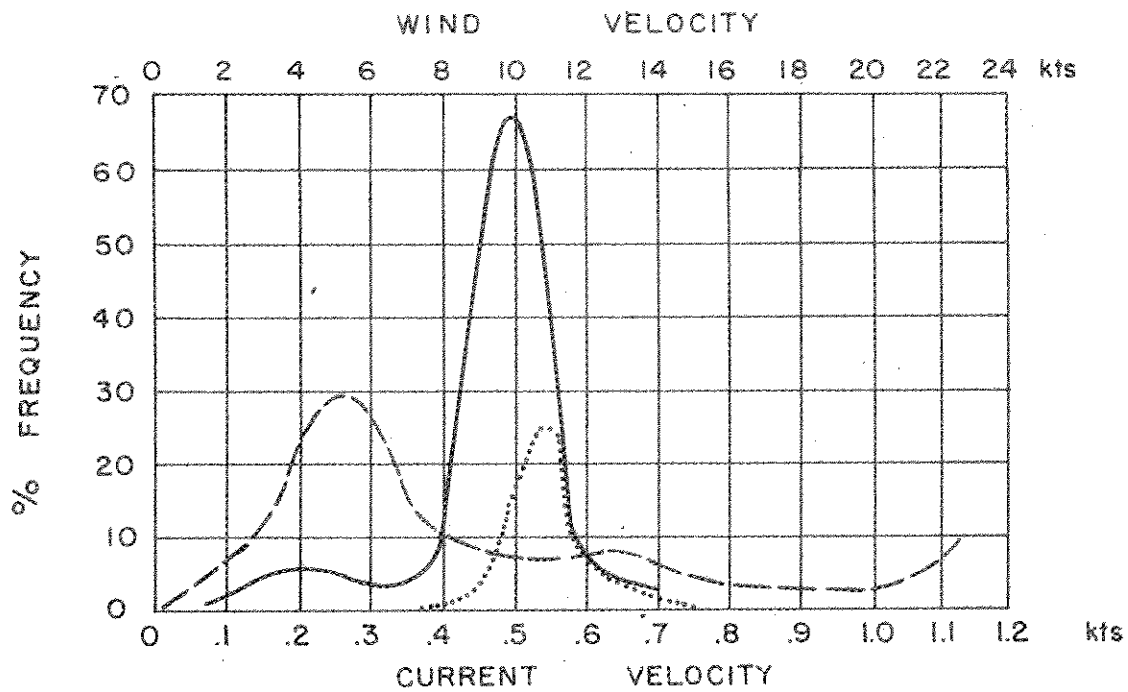
<u>Station</u>	<u>Depth (ft.)</u>	<u>Location</u>
A	82	North of North Beach
B	33	Mokapu Pt. - Mokumanu Is. Channel
C	108	Proposed diffuser section site
D	49	660 feet off Flyers Monument
E	66	North of Mokolea Rock

<u>Station</u>	<u>Depth (ft.)</u>	<u>Location</u>
F	72	North-northeast of Popoia Is.
G	49	North of Mokulua Is.
H	16	East of Kailua Beach

During WQPO, currents recorded at Station "X" at the 30-foot depth in 60 feet of water showed only one hourly recording of 415 hourly recording (frequency of 0.24 percent) of a current with a shoreward component. This lone current reading, however, was the maximum velocity recorded with a magnitude of 0.72 knot. Even a sustained current of this magnitude and in the given direction would require over two hours of transport time to shore. The net transport at this station was generally East-South-East ( $117^{\circ}$  magnetic) at 0.25 knot. During this period, Kona winds prevailed with some periods of light trade winds. When the winds shifted to strong trade winds, the net transport was to the north. Current velocity and direction frequency for Station "X" are shown in Figure I-15. Almost similar characteristics of the currents were recorded for Station "Q" (See Figure I-16, I-17).

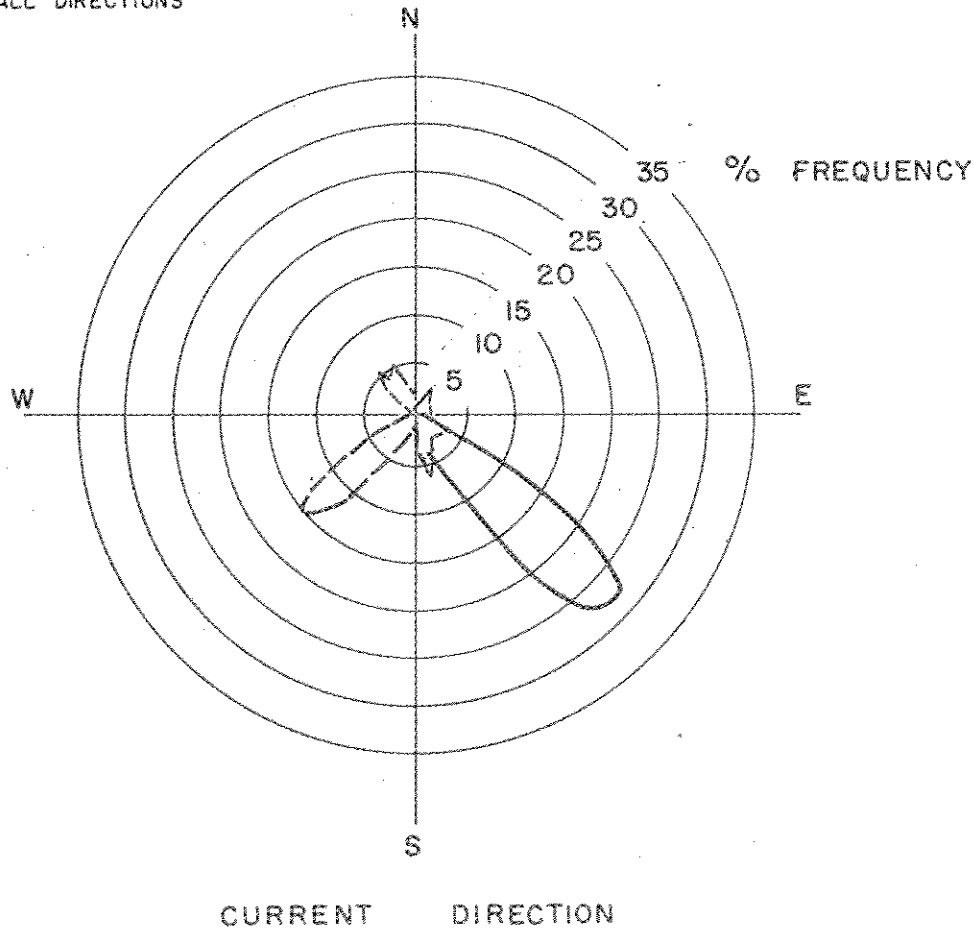
On the windward side of Oahu, the direction of the net transport in inshore waters (less than 400-feet

NOTE: 1 KNOT = 1.2 MILES/HR.  
(APPROX.)



**LEGEND:**

- CURRENT (ALL DIRECTIONS)
- ..... CURRENT (SHOREWARD COMPONENTS)
- WIND (ALL DIRECTIONS)



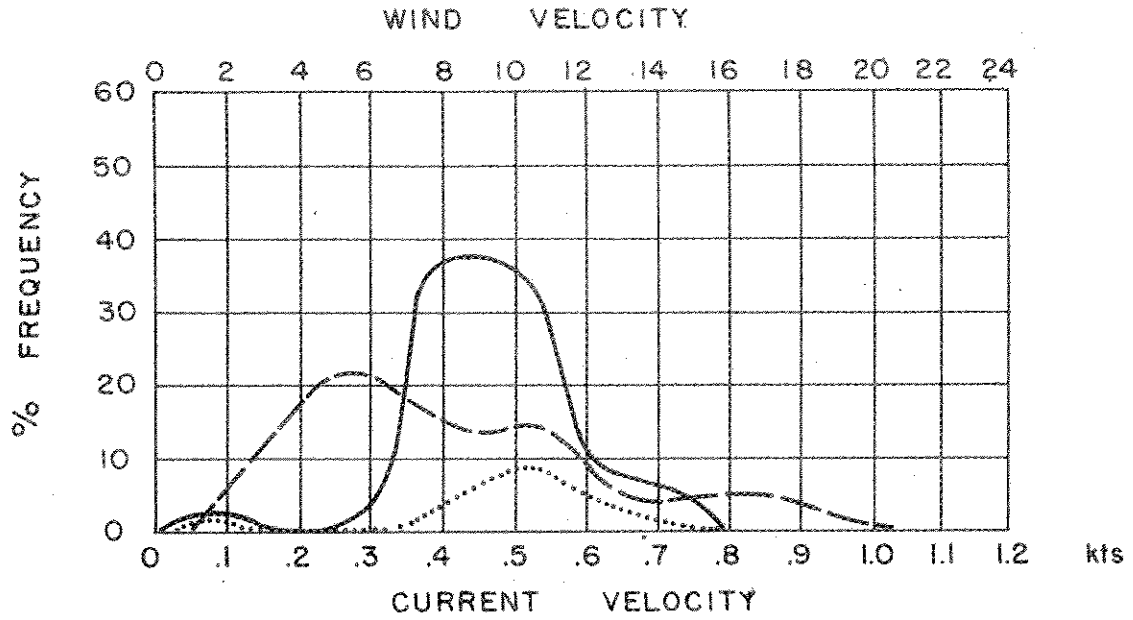
(SOURCE - WQPO)

CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
Station X, Depth 30 feet, 2-5-71 to 2-21-71

FIGURE  
I-15

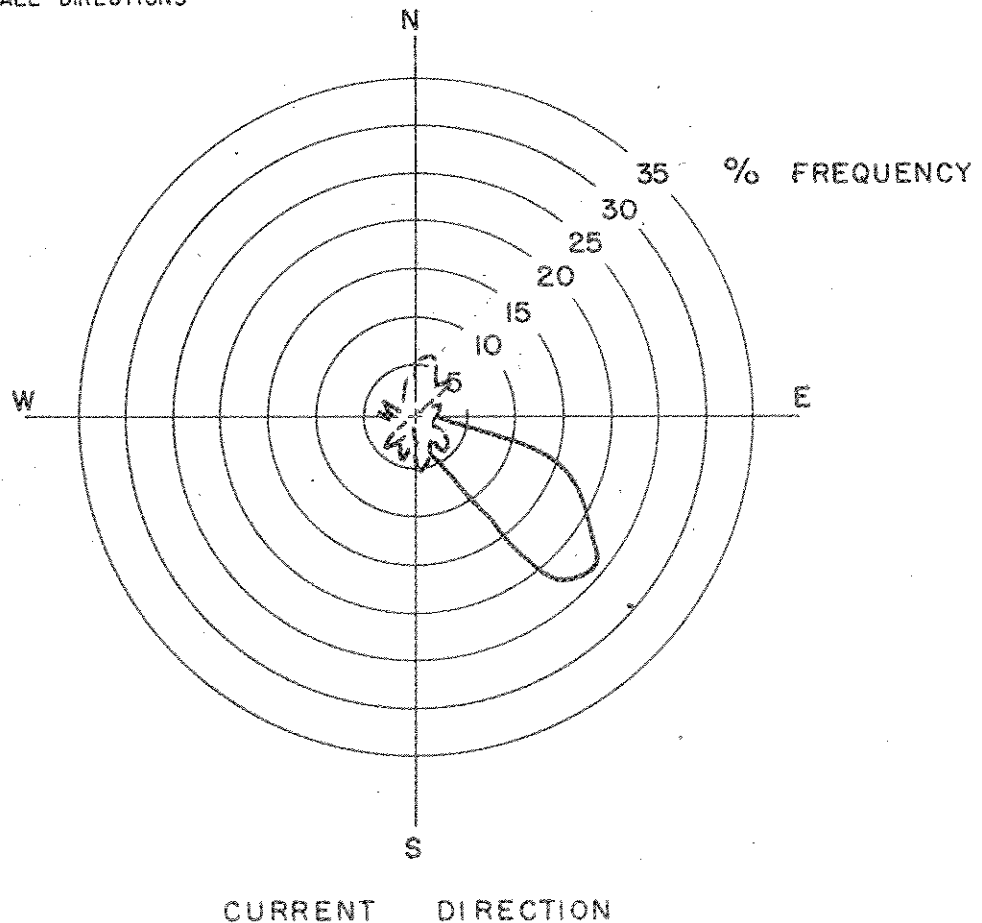


NOTE: 1 KNOT = 1.2 MILES/HR  
(APPROX.)



**LEGEND:**

- CURRENT (ALL DIRECTIONS)
- ..... CURRENT (SHOREWARD COMPONENTS)
- - - WIND (ALL DIRECTIONS)

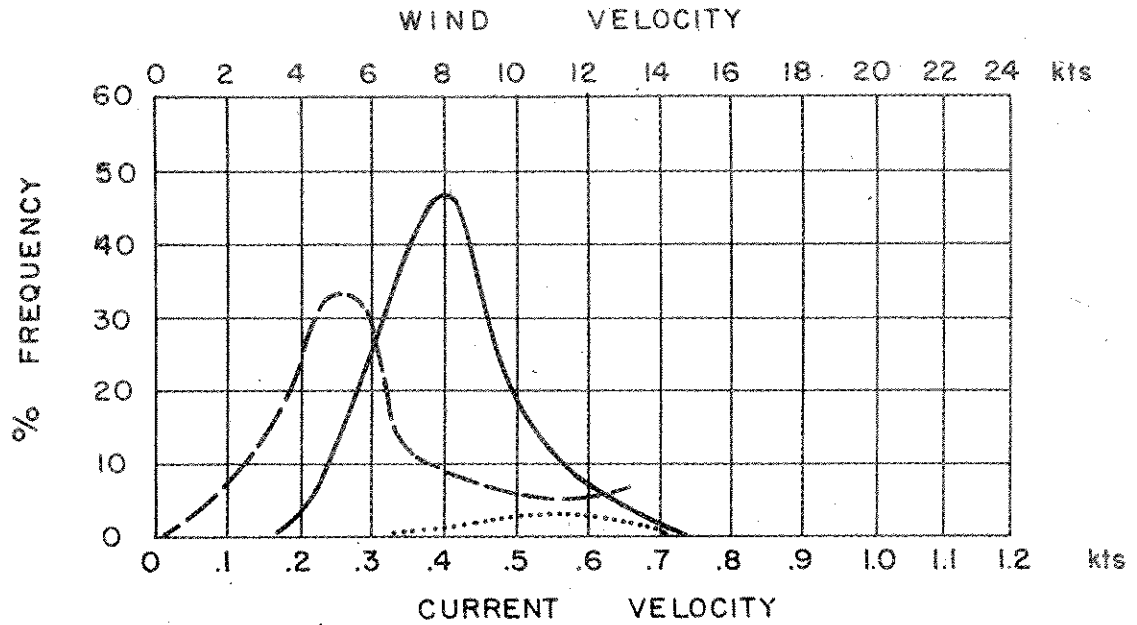


(SOURCE - WQPO)

CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
Station Q, Depth 30 feet, 1-8-71 to 1-30-71

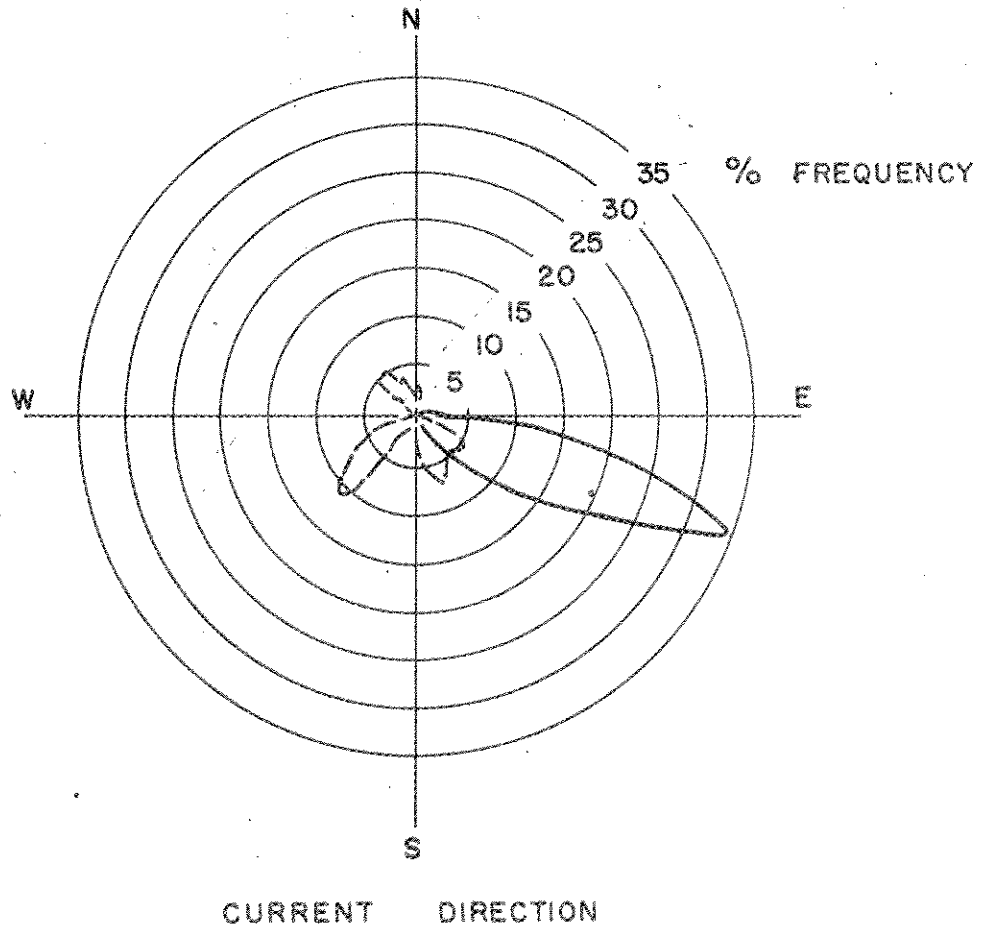
FIGURE  
I-16

NOTE: 1 KNOT = 1.2 MILES / HR  
(APPROX.)



**LEGEND:**

- CURRENT (ALL DIRECTIONS)
- ..... CURRENT (SHOREWARD COMPONENTS)
- WIND (ALL DIRECTIONS)



(SOURCE- WOPO)

CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
Station Q, Depth 30 feet, 2-5-71 to 2-16-71

FIGURE  
I-17

deep) varies seasonally. Under tradewind conditions during the late spring, summer, and early fall months, the transport along the entire windward coast appears to be to the northwest. Under Kona wind conditions during the winter months, the direction of the transport is northwest along the coastline north of Kaneohe Bay but it is southeast between Kaneohe Bay and Makapuu Point. The net transport in Kailua Bay was observed to change from the southeast to the north during February, when the observed winds changed from Kona winds to strong tradewinds.

The influence of the tides in changing direction of flow and velocity of currents varies with the location around Oahu. The influence is strongest in Mamala Bay and is weakest off windward Oahu and East Oahu.

According to KMP, the dimension of Kailua Bay from Mokapu Point southward to Mokulua Island is approximately 5.5 miles long and 2.2 miles wide. The average area of the bay is approximately 7.8 square miles at MLLW. The average depth is 34 feet and the deepest area (164 feet) is just east of Mokolea Rock in the northeastern part of the bay.

The volume of the bay is approximately 5,390 million gallons at mean lower low water and approximately 325 million gallons are added or subtracted during a typical daily tidal change.

Extensive ocean current measurements and circulation patterns were determined during KMP for surface and subsurface layers, using drift cards, dyes, and drogues for the former and current meters for the latter. Using in-situ current meters, approximately 4,600 hours of data in the early fall, winter and early summer months were obtained. A total of 837 drift cards were cast during an 11-month period and 3 dye and 6 drogue experiments were completed during March and June 1972. Tidal and meteorological data for an entire year were also taken.

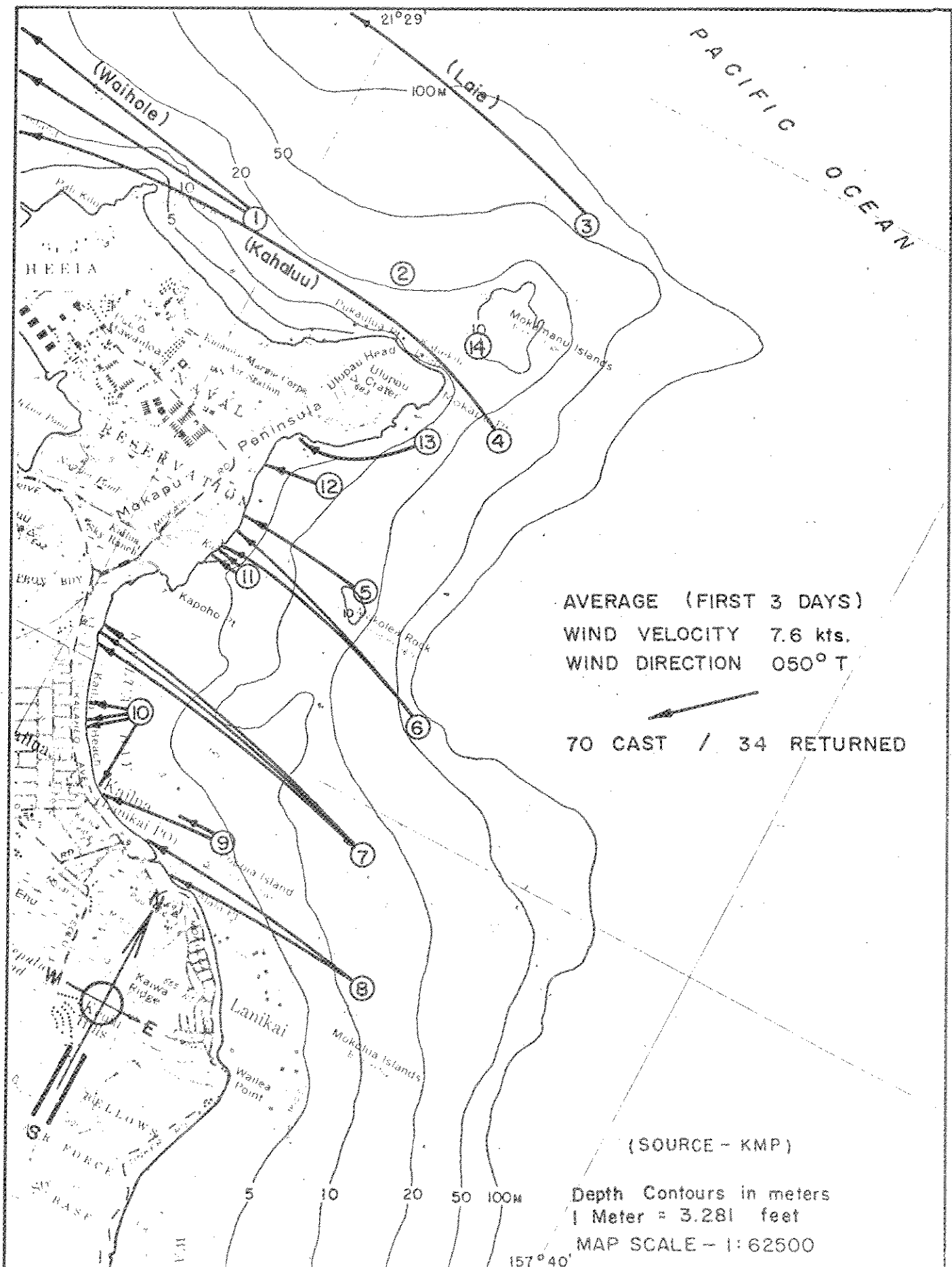
Five (5) surface drift cards, measuring 4 x 5½ inches and enclosed in clear plastic envelopes were released from 14 stations each month for 10 months from September 1971 through July 1972. As the cards were received by mail, their point of origin and recovery were plotted on monthly maps. A high number (23 percent) of cards were recovered and returned within three days following each monthly cruise.

Monthly plots of the surface drift card results were

plotted and are shown in Figure I-18 through I-26. Just the points of release and recovery are significant and the paths shown are thought to represent the most probable path taken by each card. These data provide reasonably complete information on the surface wind drift existing seasonally throughout Kailua Bay.

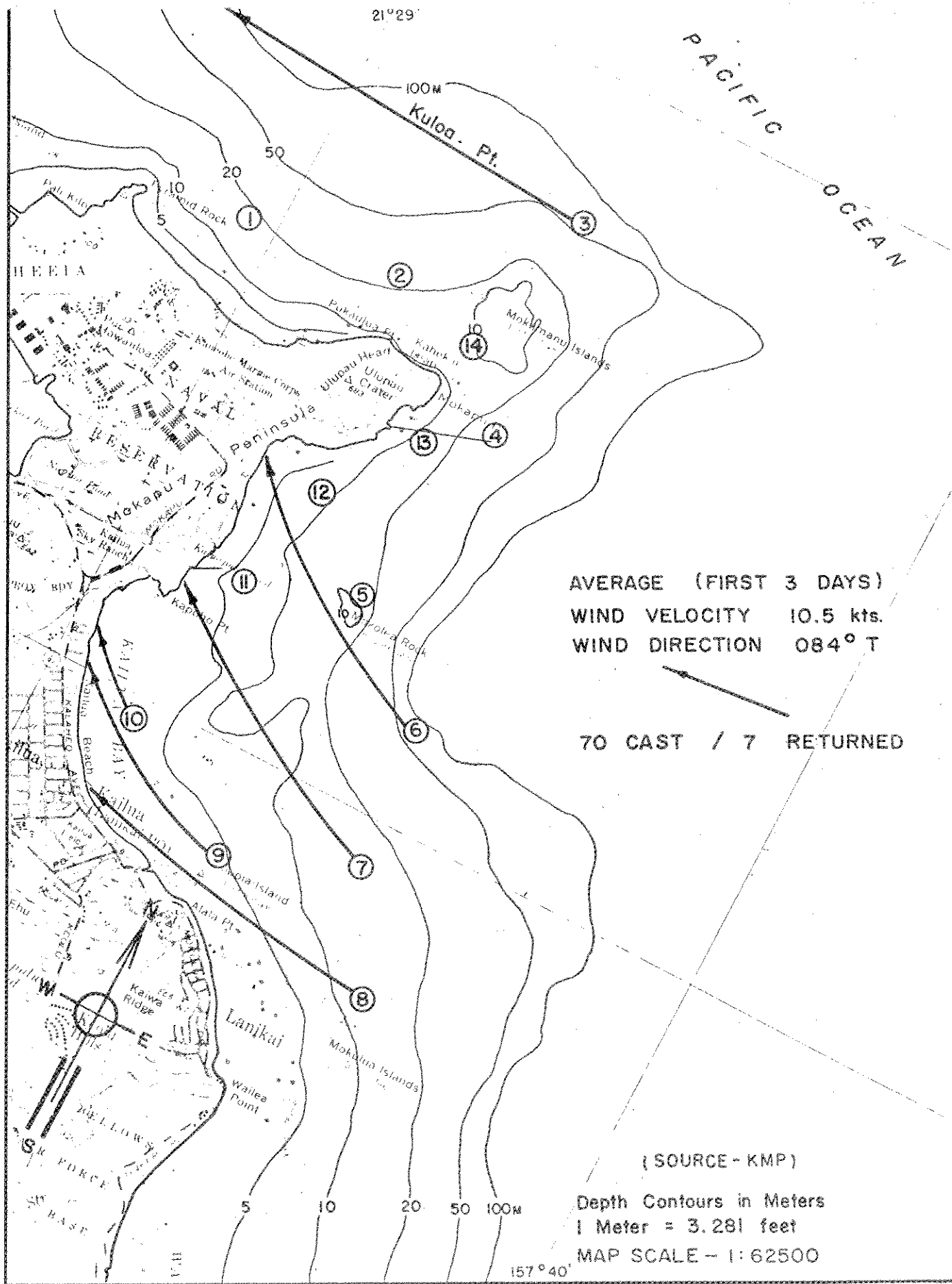
The results principally show that the direction of flow in the surface layer in Kailua Bay is strongly influenced by the prevailing wind direction. The cards cast at Station 5 through 13 and off North Beach at Station 1 and 2 moved essentially directly downwind. Very few cards, however, were recovered from Stations 2, 3, and 4, particularly from Station 3 just seaward from Mokumanu Island. Drift cards released at Station 4, the outfall terminus generally were not recovered in Kailua Bay except during July 1972. One card was recovered at Kahaluu on the October 1971 cast and another at Bellows Field during January 1972. During July 1972, all cards from Station 4 released were recovered in the bay.

Three significant exceptions to the pattern of behavior should be noted. The first is that



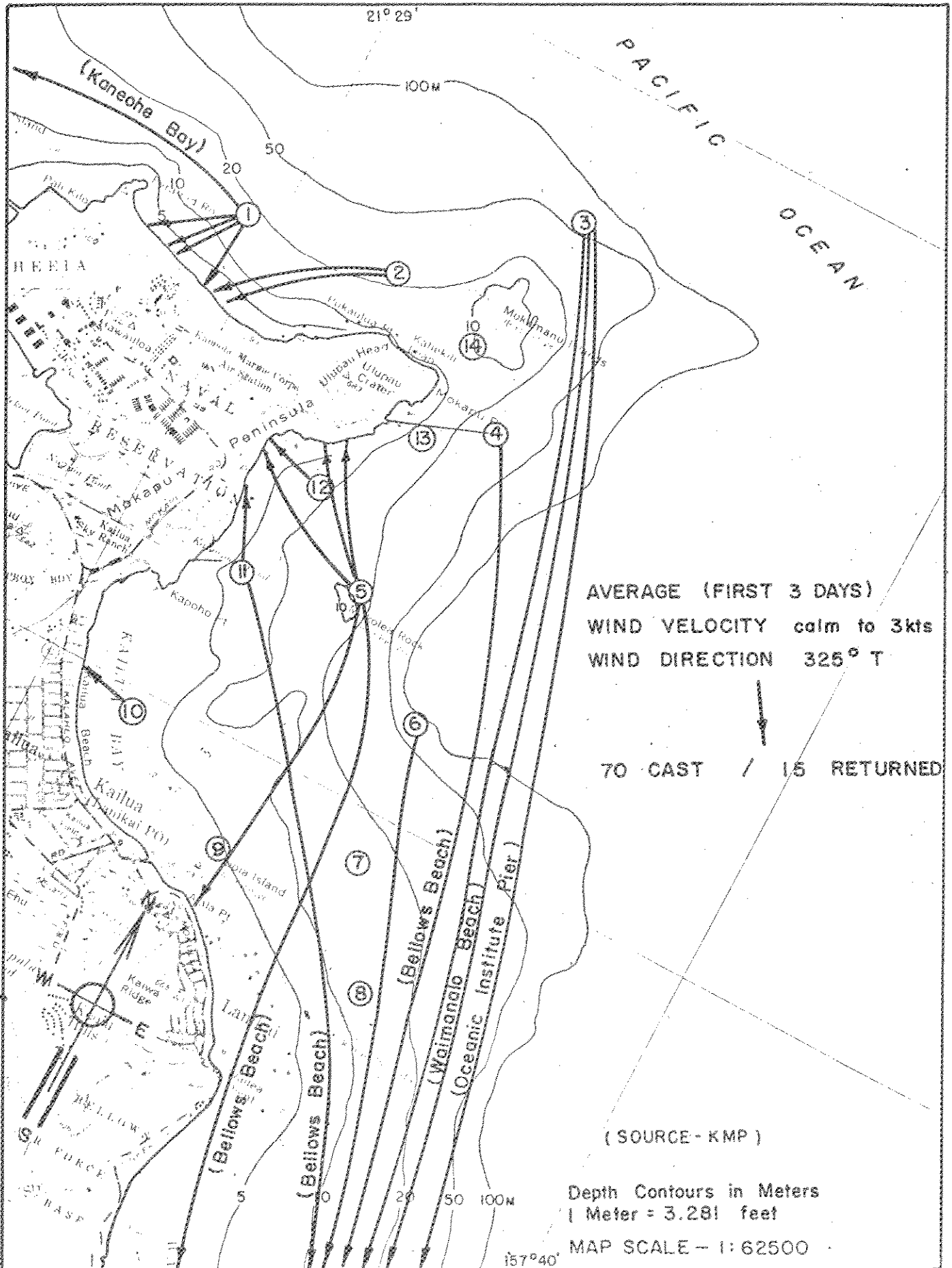
DRIFT CARD RESULTS, KAILUA BAY - OCT. 1971

FIGURE I-18



DRIFT CARD RESULTS, KAILUA BAY - NOV. 1971

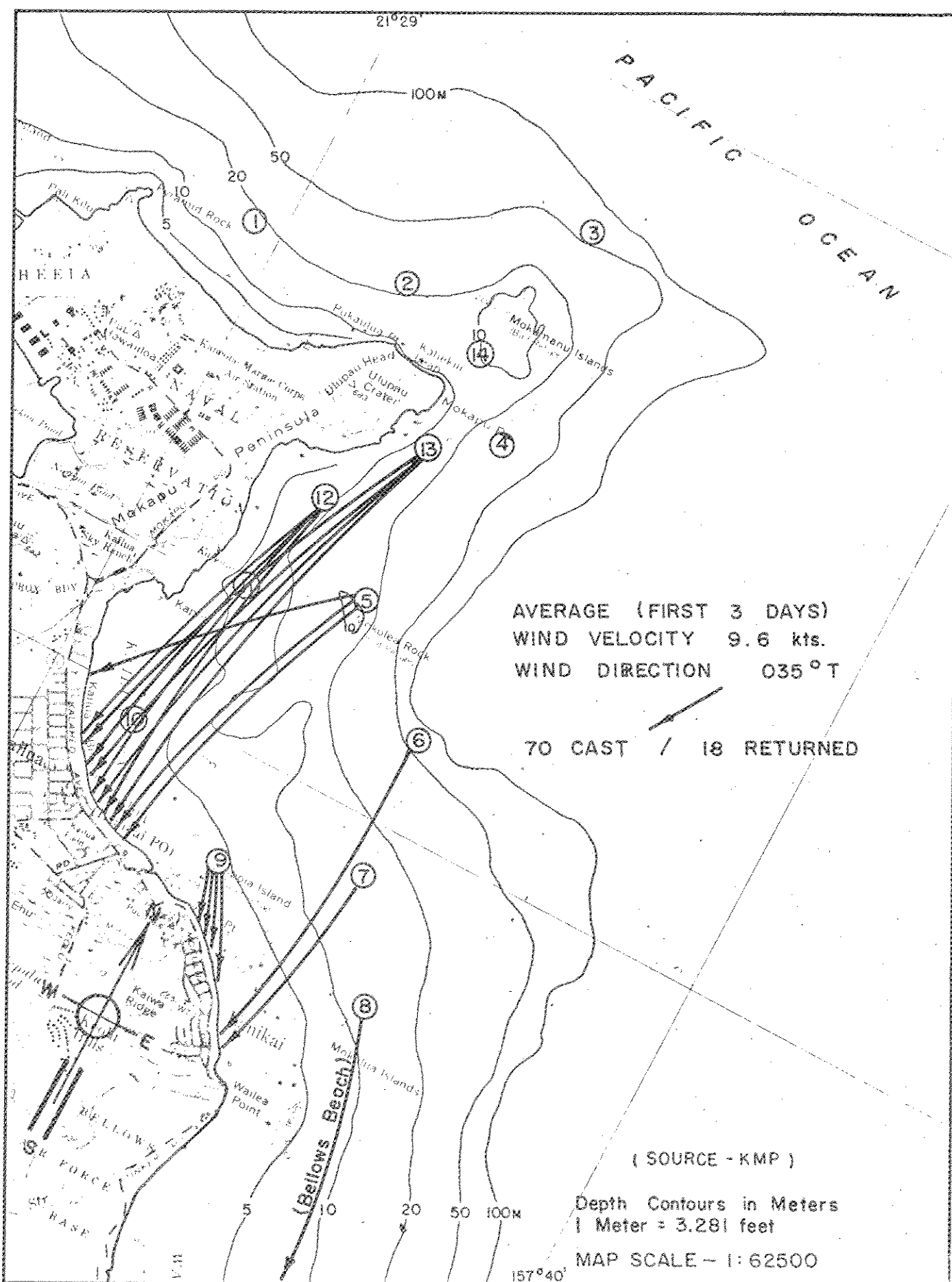
FIGURE I-19



DRIFT CARD RESULTS, KAILUA BAY - JAN. 1972

FIGURE  
I - 20

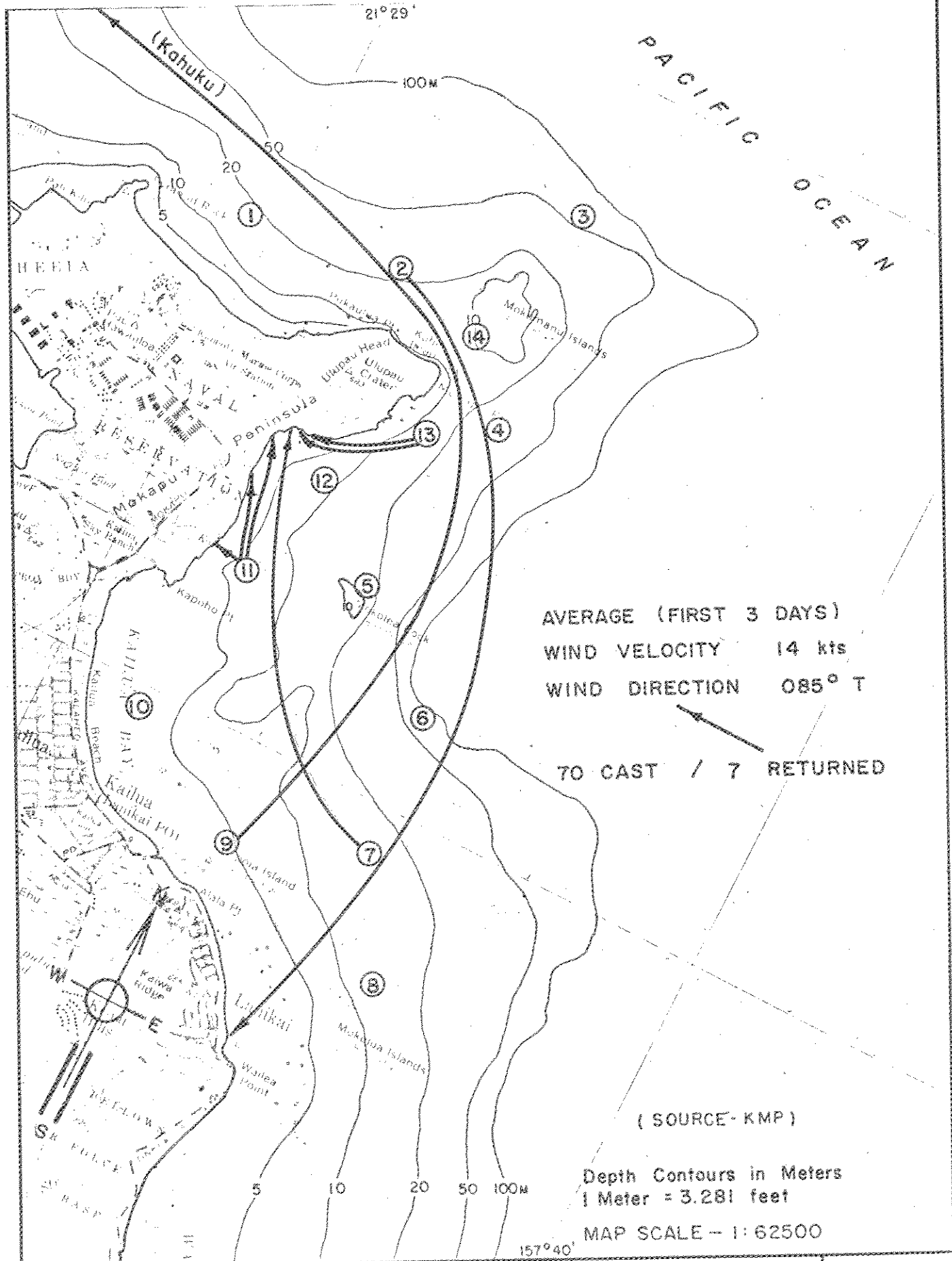




DRIFT CARD RESULTS, KAILUA BAY - FEB. 1972

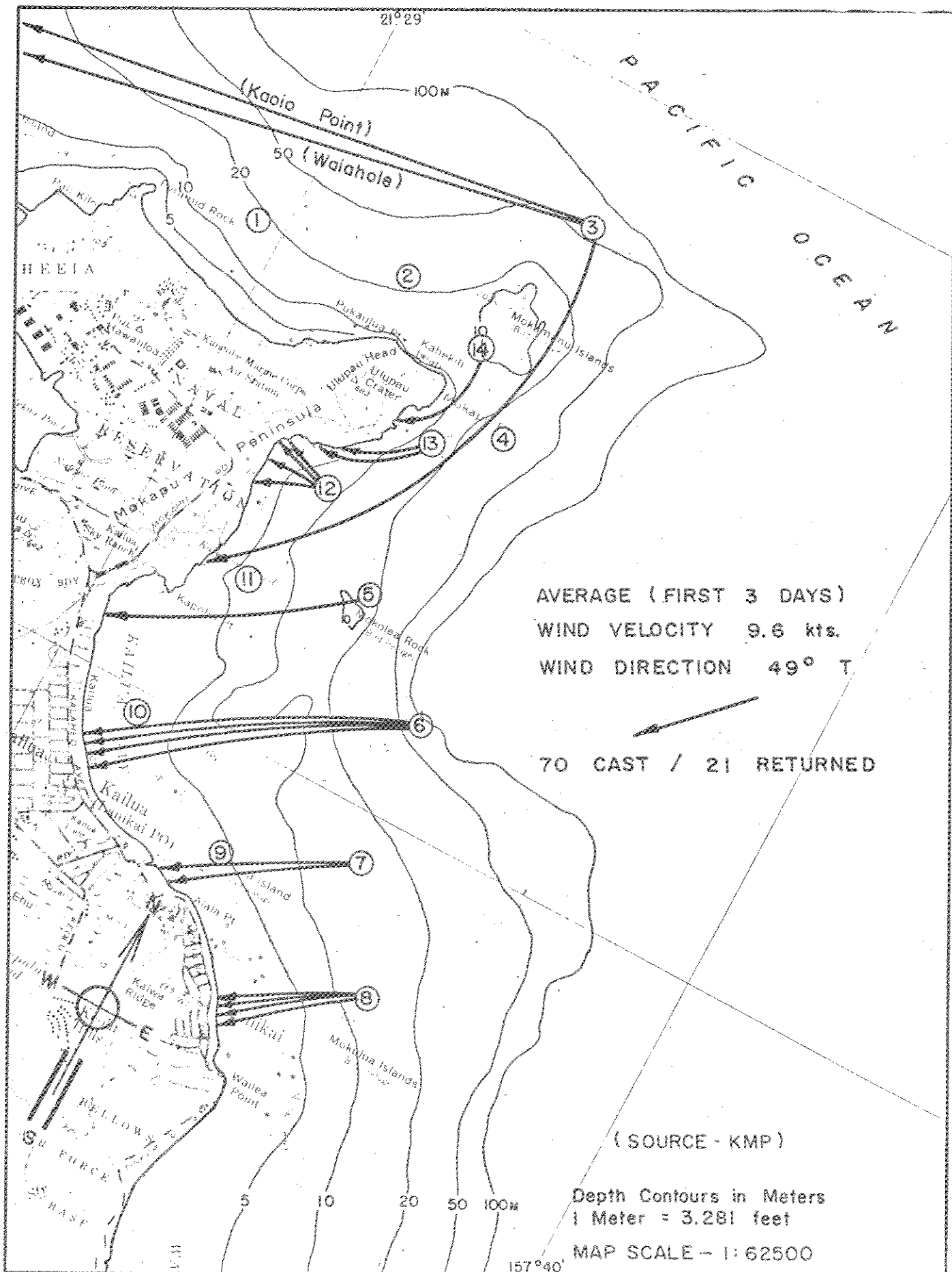
FIGURE I-21





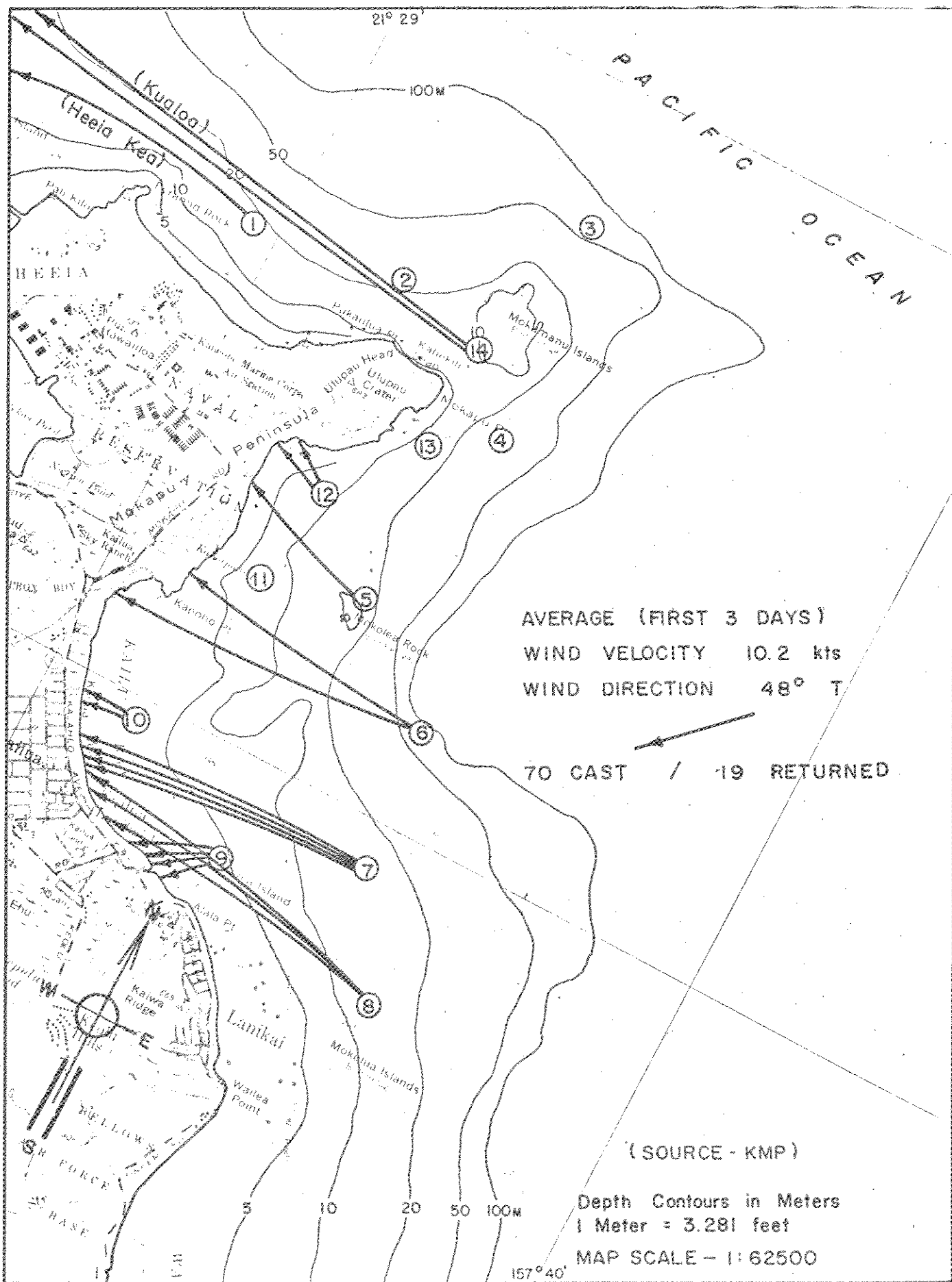
DRIFT CARD RESULTS, KAILUA BAY-APRIL 1972

FIGURE I-23



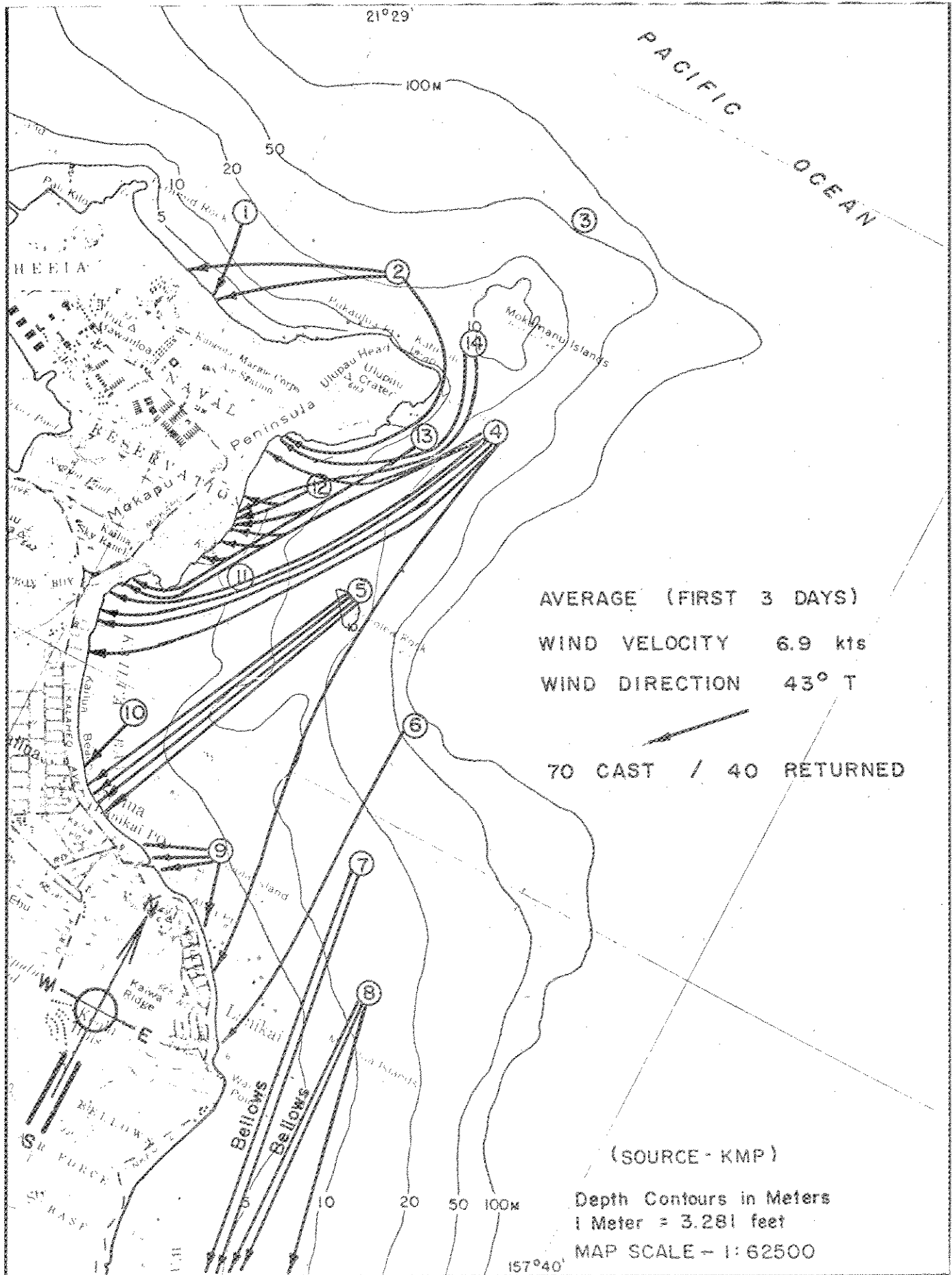
DRIFT CARD RESULTS, KAILUA BAY - MAY 1972

FIGURE I-24



DRIFT CARD RESULTS, KAILUA BAY - JUNE 1972

FIGURE I-25



AVERAGE (FIRST 3 DAYS)

WIND VELOCITY 6.9 kts

WIND DIRECTION 43° T

70 CAST / 40 RETURNED

(SOURCE - KMP)

Depth Contours in Meters

1 Meter = 3.281 feet

MAP SCALE - 1:62500

DRIFT CARD RESULTS, KAILUA BAY - JULY 1972

FIGURE  
I-26

tidal currents during April, May and July 1972 around Mokapu Point apparently initially moved cards eastward, against the wind, until they were just east of the channel between the Point and Mokumanu Island. The combination of the next change in tide and the prevailing trade-winds then moved these cards toward the Kailua shoreline. Most of the cards behaving in this manner were subsequently recovered along the Fort Hase shoreline adjacent to Stations 11, 12, and 13.

The second exception to be noted is that none of the seventy cards released during March 1972, were recovered. Winds during the first 48-hour period following release were blowing offshore at 12 to 15 knots (14 to 17 mph). In the subsequent days, however, strong onshore tradewinds returned. Nonetheless, no cards were subsequently found along the windward coast of Oahu.

The third exception is pertinent to cards released at Station 13, southeast of Mokapu Point. Most cards recovered from this area were found on the Fort Hase Beach south of the station.

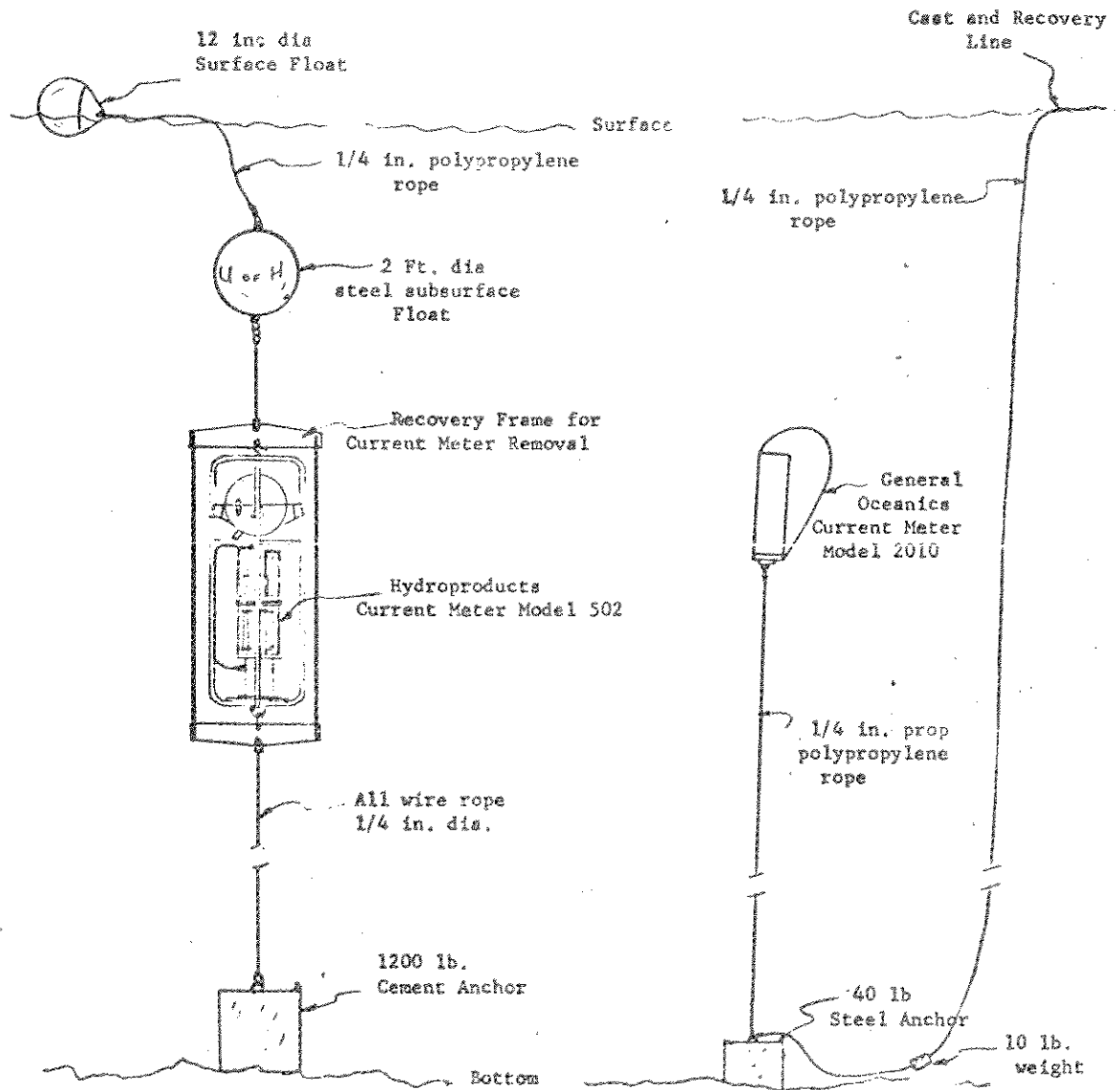
Subsurface circulation patterns in the bay were

speculated from data collected from in-situ current meters during the fall (September, October, and November), winter (January and February), and summer (May and June) months. Current meters used were Hydro Products Model 502 In-situ Savonius rotor current meter for 4,600 hours of hourly measurements and a General Oceanics Model 2010 film recording inclinometer current meter used on two occasions to obtain data from 8 stations in the bay within a 3-hour period. Current meter installations used are shown in Figure I-27.

Additional circulation data from the surface, 23 and 65-foot depths around Mokapu Point were obtained through the use of drogues. These data were taken during various tidal and wind conditions.

Data from the in-situ currents meters were reduced to show the frequency of the current velocity (in all directions) and direction and are shown in Figures I-28 through I-35. Summaries of the direction histograms are shown in Figure I-36 to I-38 and a summary of analysis of long series current meter data including past data from WQPO are shown in Table I-IX-1.



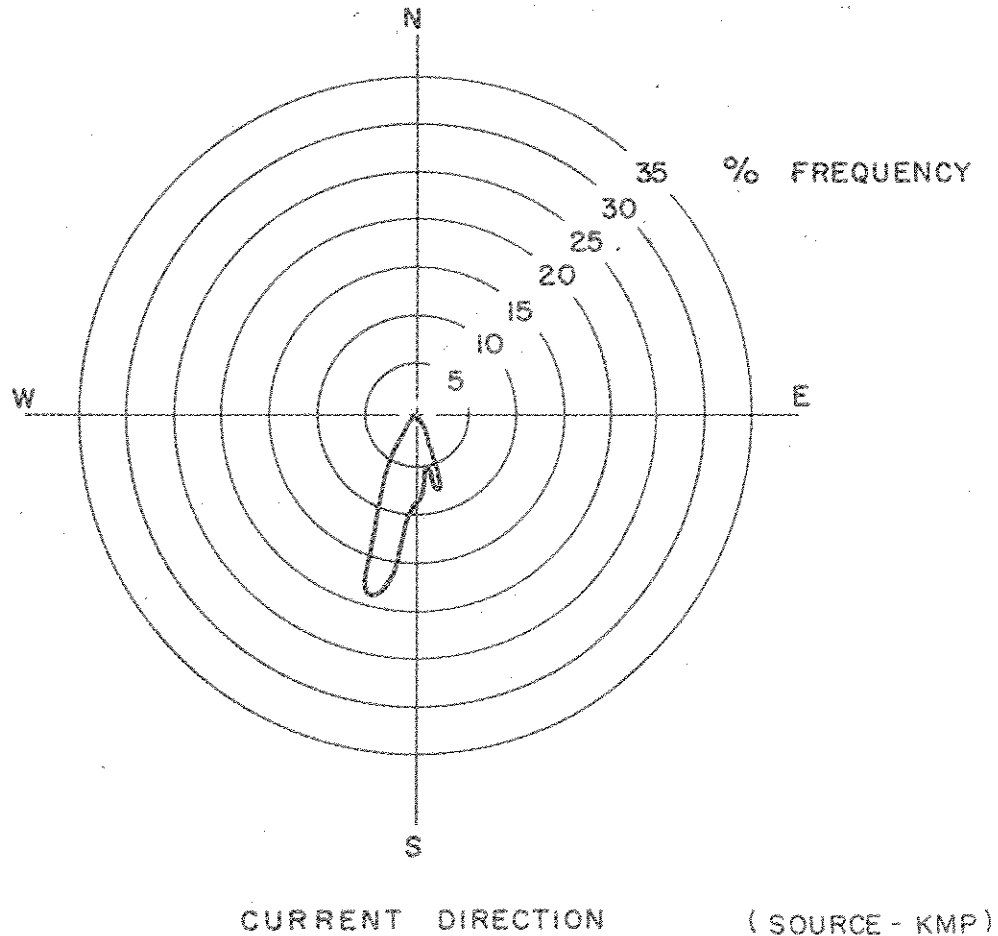
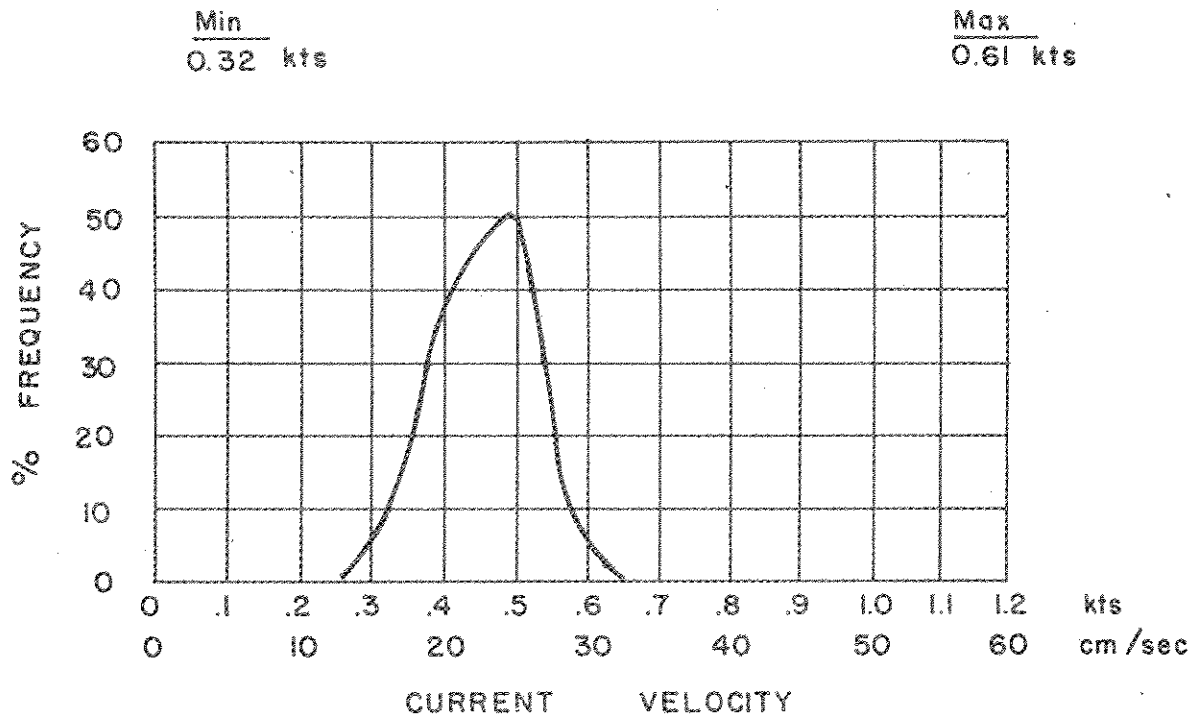


(Source: KMP)

CURRENT METER CONFIGURATIONS USED

FIGURE  
I-27

NOTE:  
1 KNOT = 1.2 MILES/HR.  
(APPROX.)

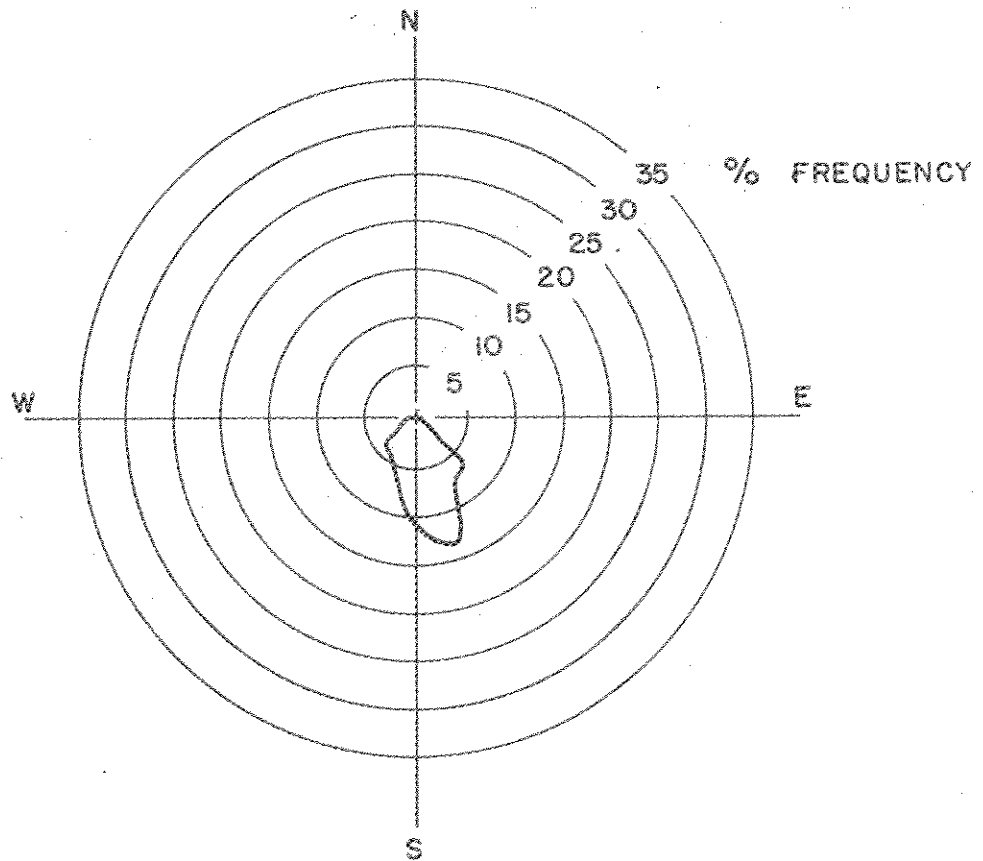
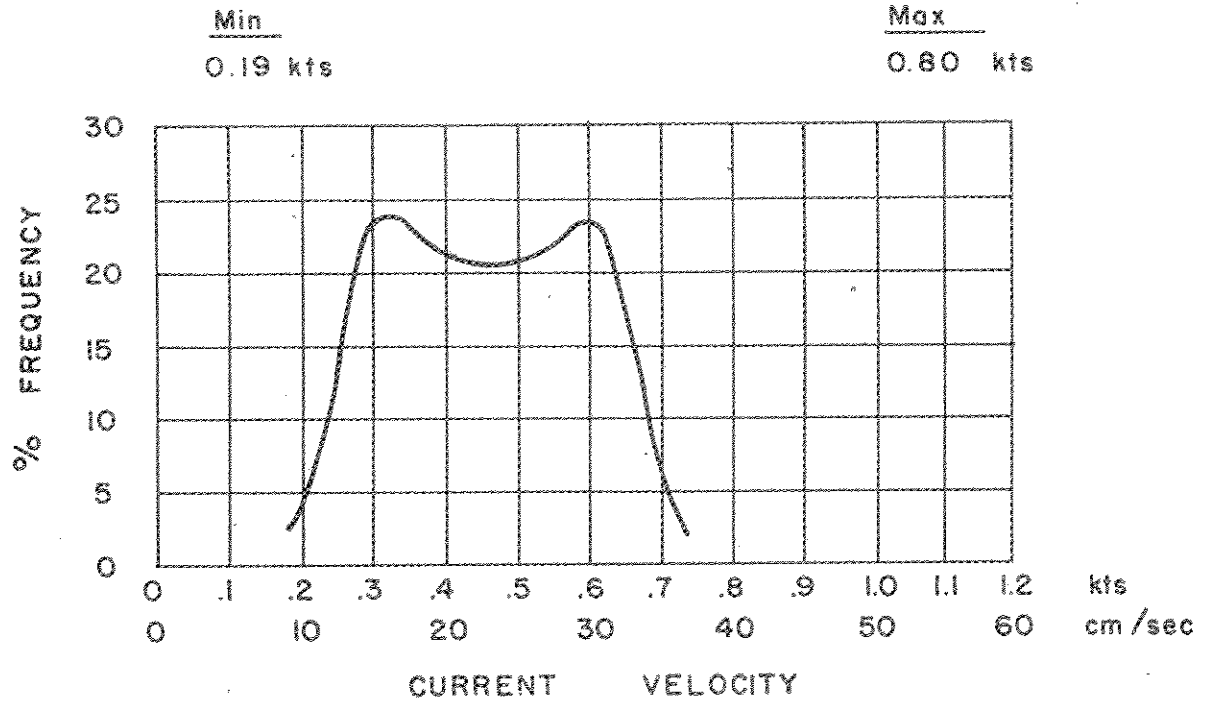


CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
Station D, Depth 7 in 15 meters 9-17-71 to 10-12-71

FIGURE  
I-29

NOTE:

1 KNOT = 1.2 MILES/HR.  
(APPROX.)



CURRENT DIRECTION

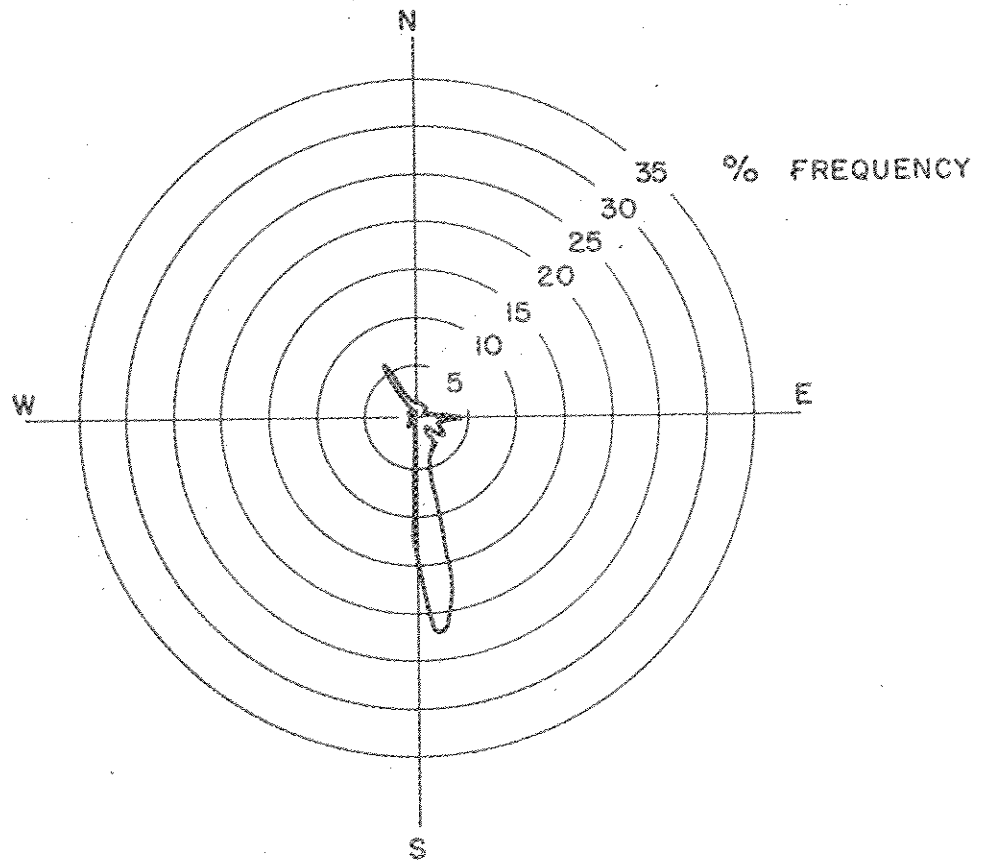
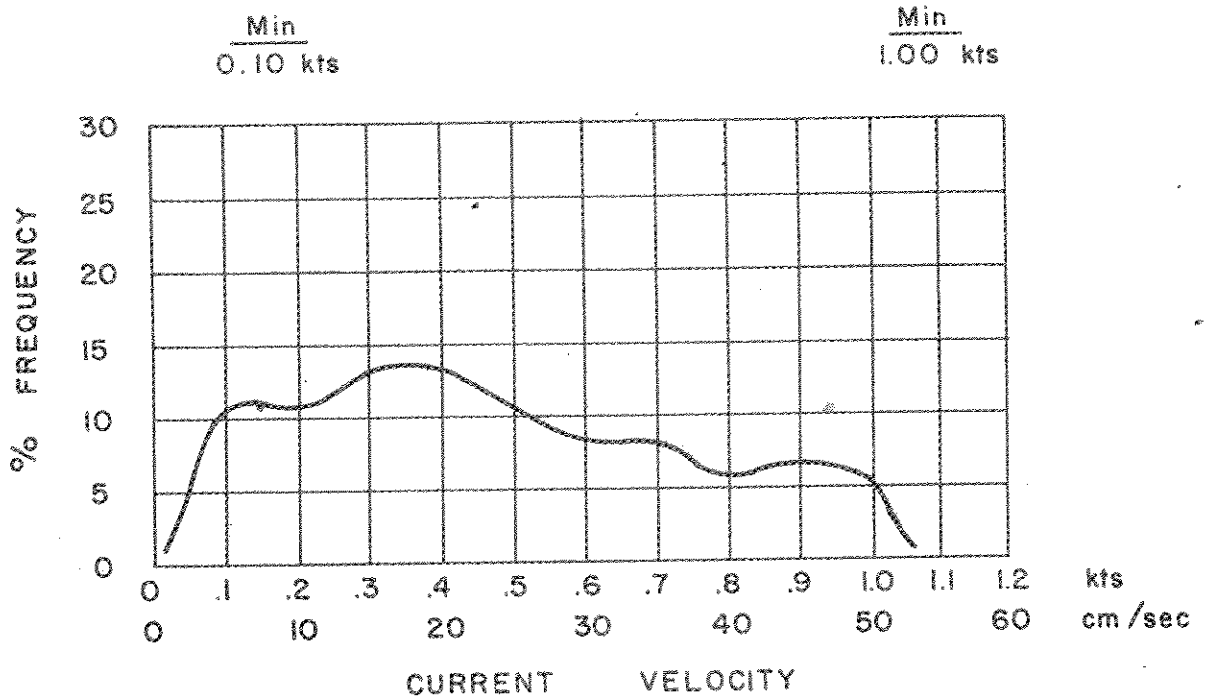
(SOURCE - KMP)

CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
Station E, Depth 7 in 20 meters 9-17-71 to 10-17-71

FIGURE  
I-30

NOTE:

1 KNOT = 1.2 MILES/HR.  
(APPROX.)

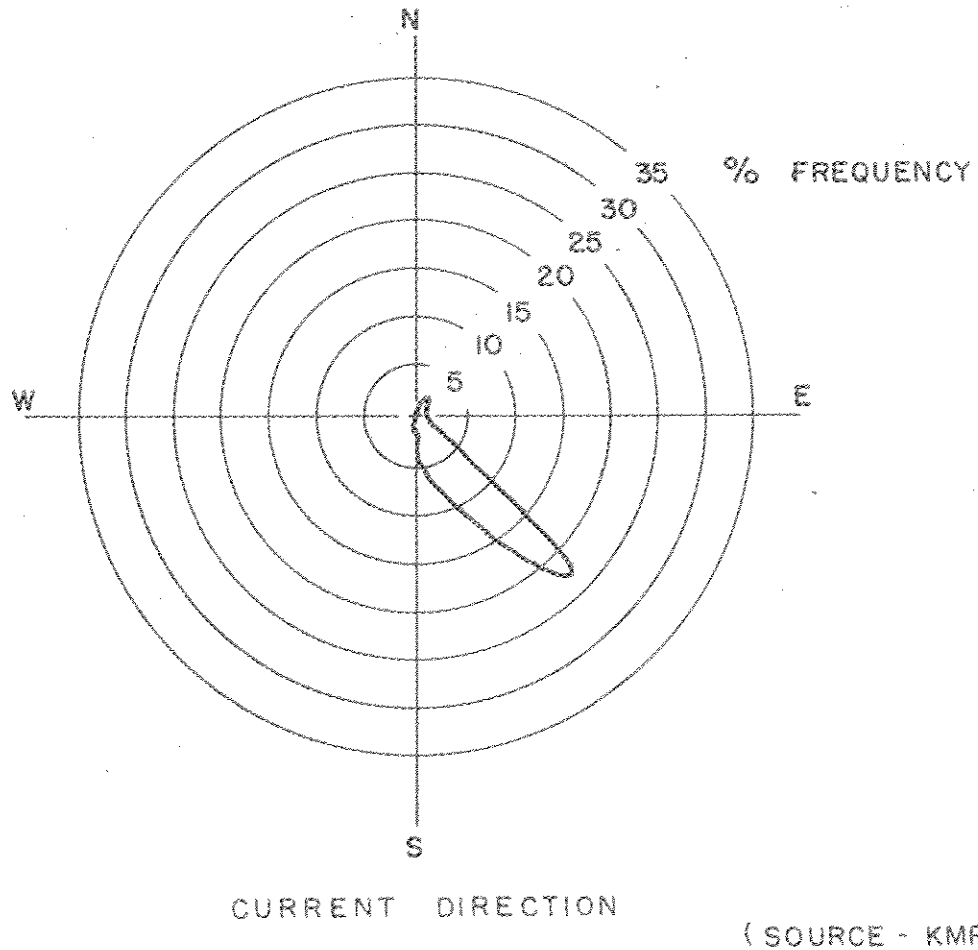
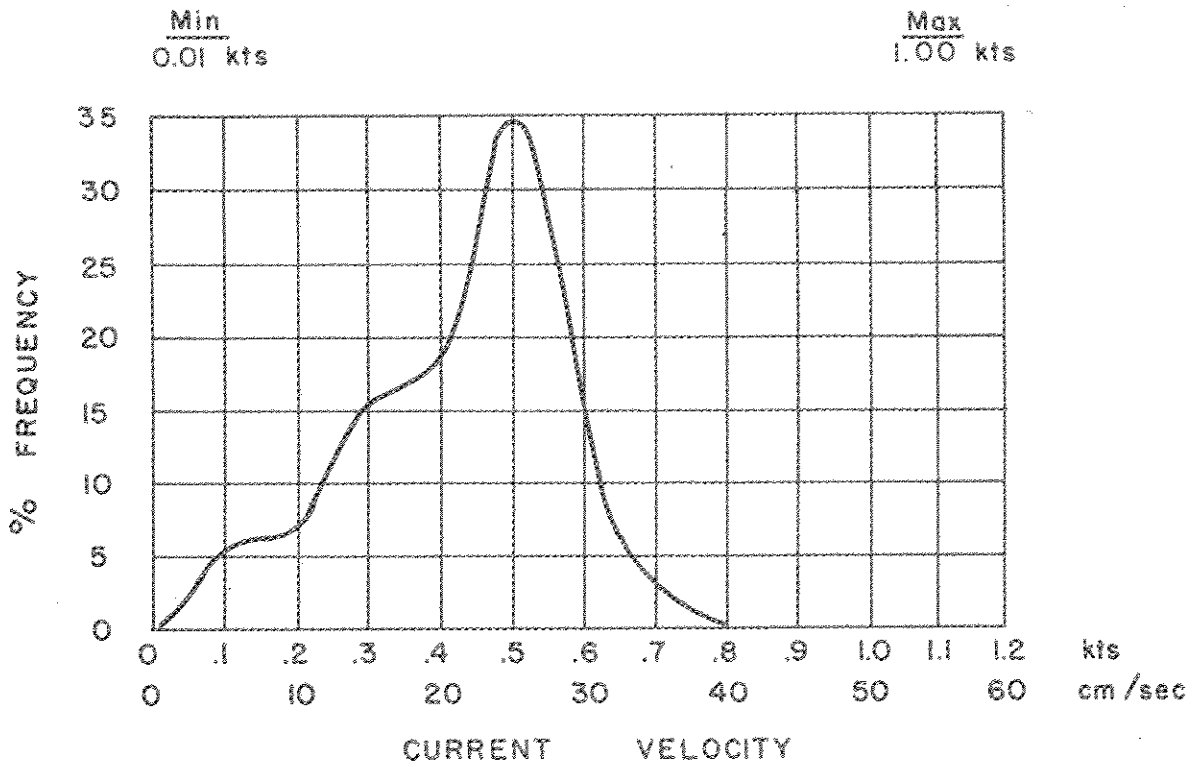


(SOURCE - KMP)

CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
Station C, Depth 10 in 33 meters 11-22-71 to 12-1-71

FIGURE  
I-31

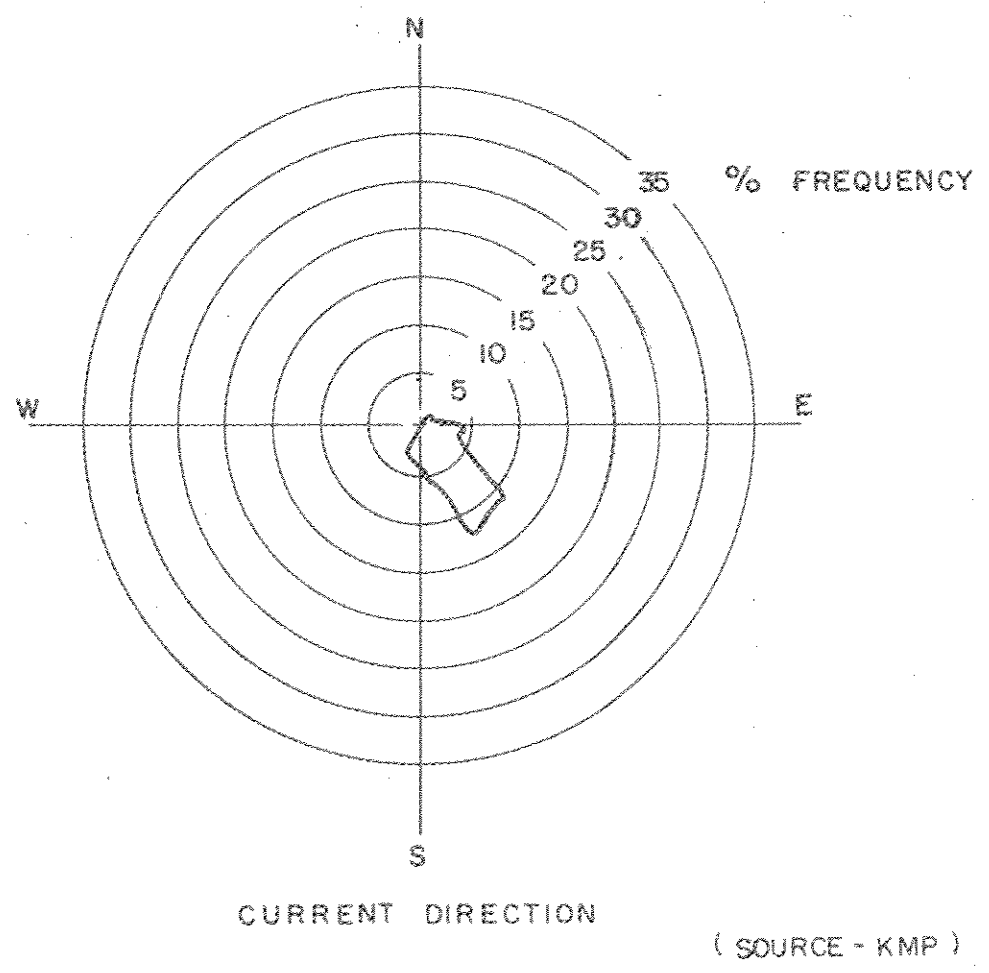
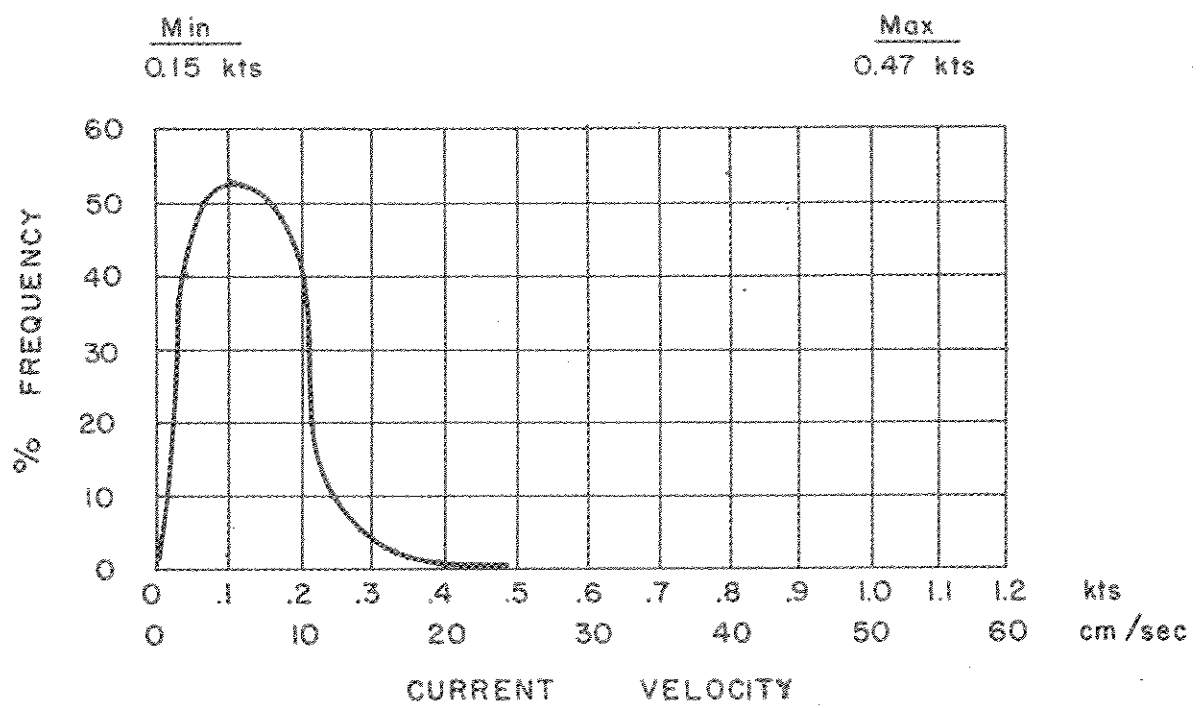
NOTE: 1 KNOT = 1.2 MILES / HR.  
(APPROX.)



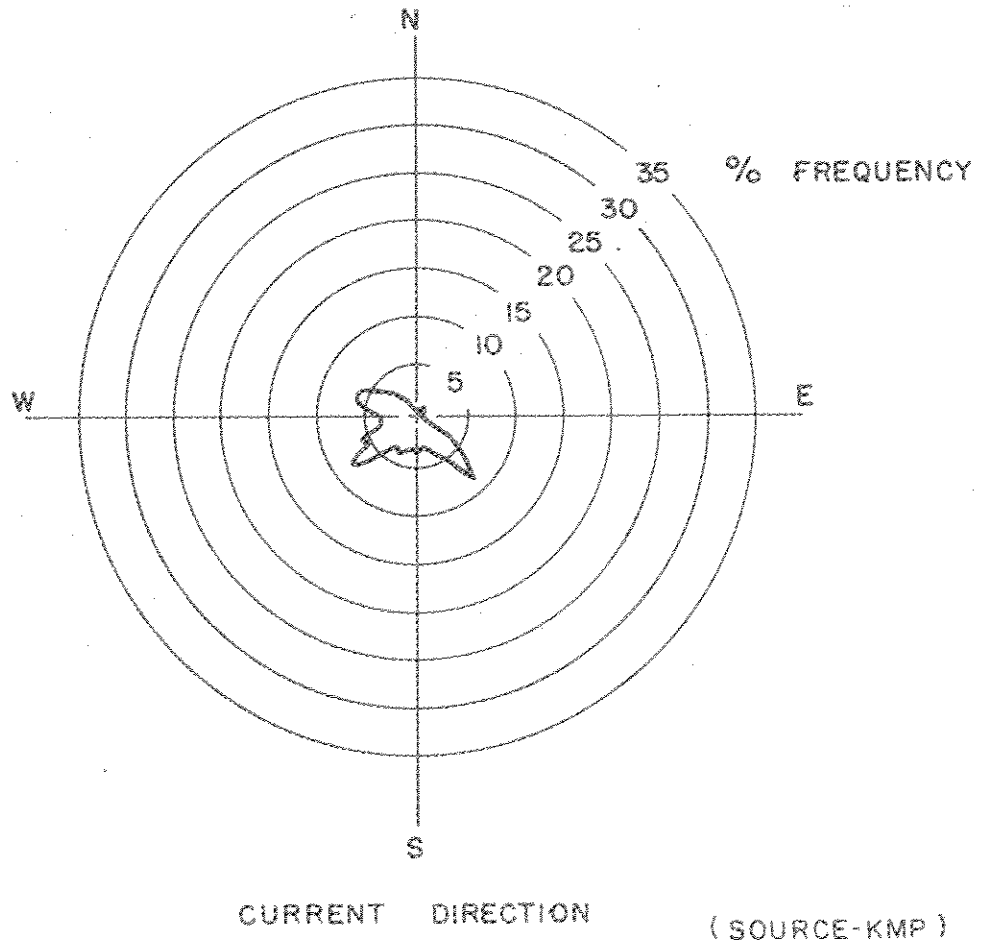
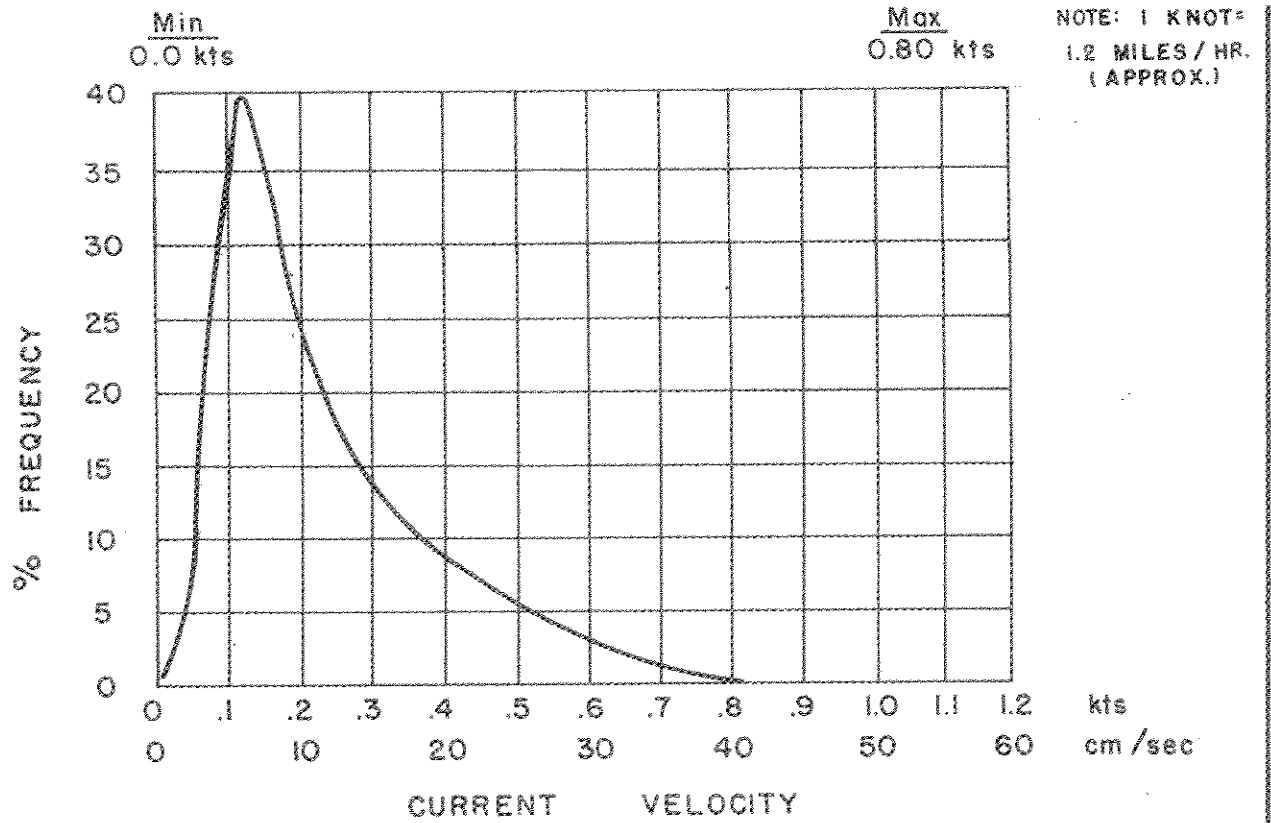
CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
Station C, Depth 7 in 33 meters 1-7-72 to 2-6-72

FIGURE  
I-32

NOTE:  
 1 KNOT = 1.2 MILES / HR.  
 (APPROX.)



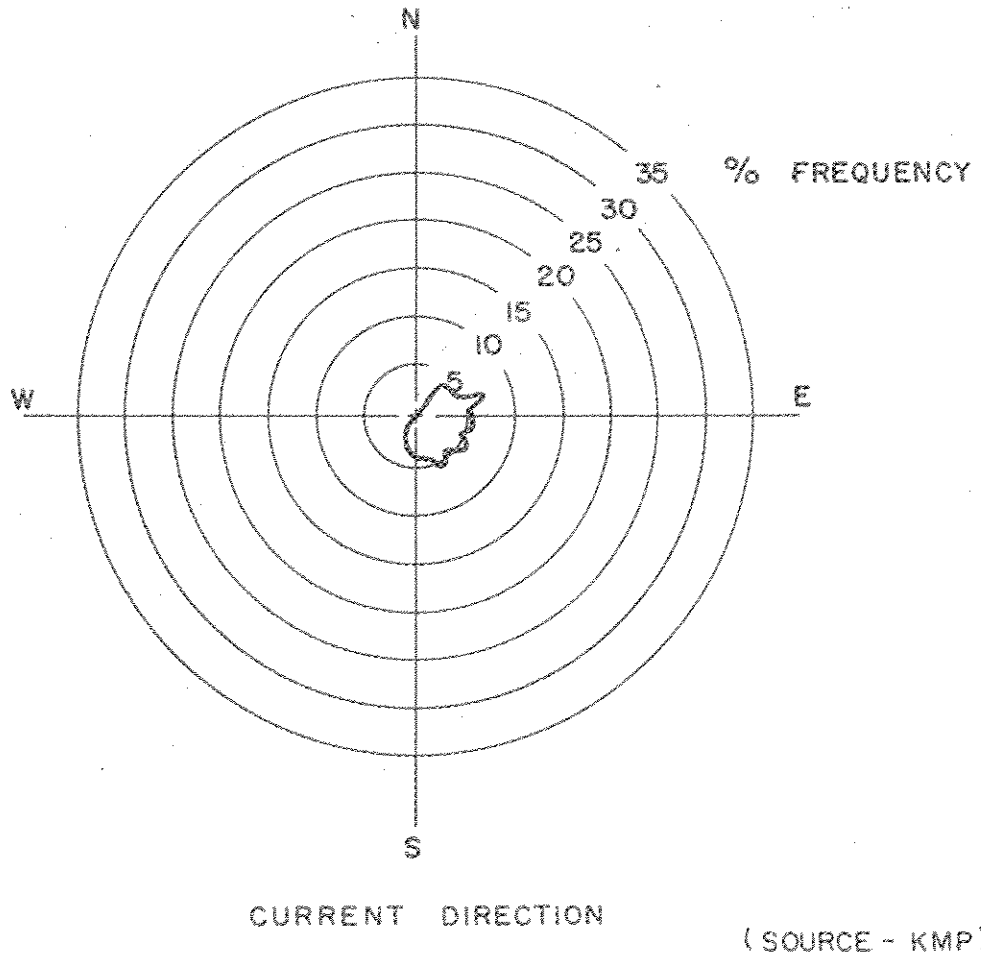
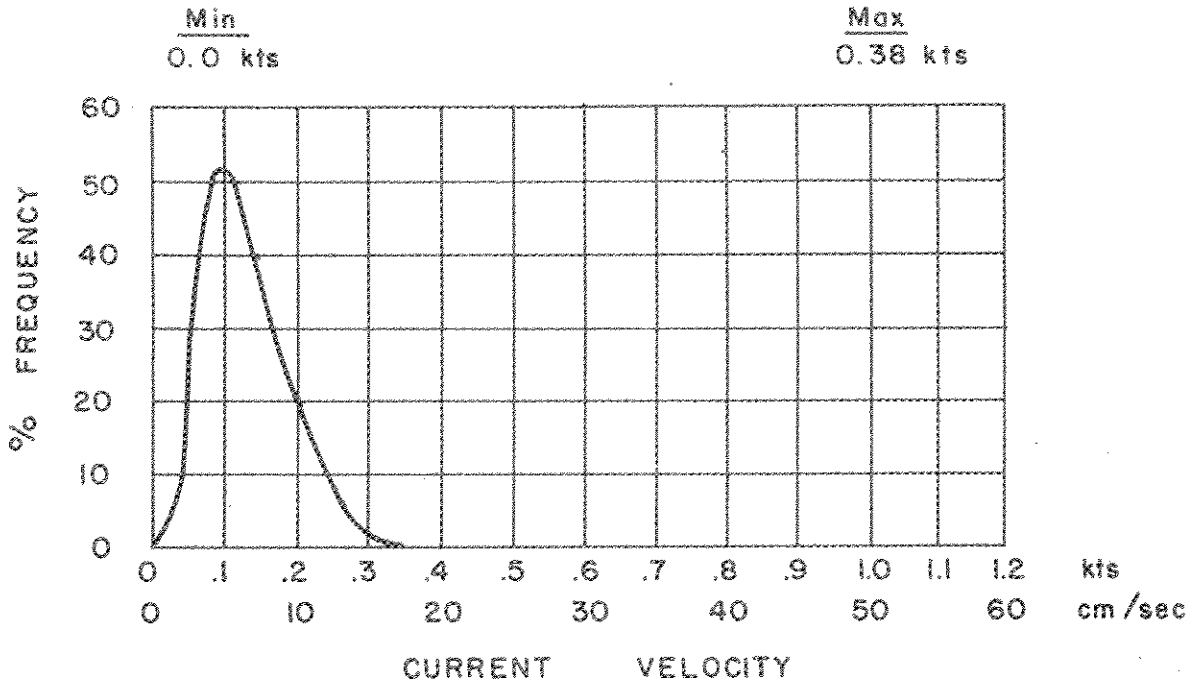
CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY Station C, Depth 25 in 33 meters 1-7-72 to 2-6-72	FIGURE I-33
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CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
Station C, Depth 7 in 33 meters 5-17-72 to 6-9-72

FIGURE  
I-34

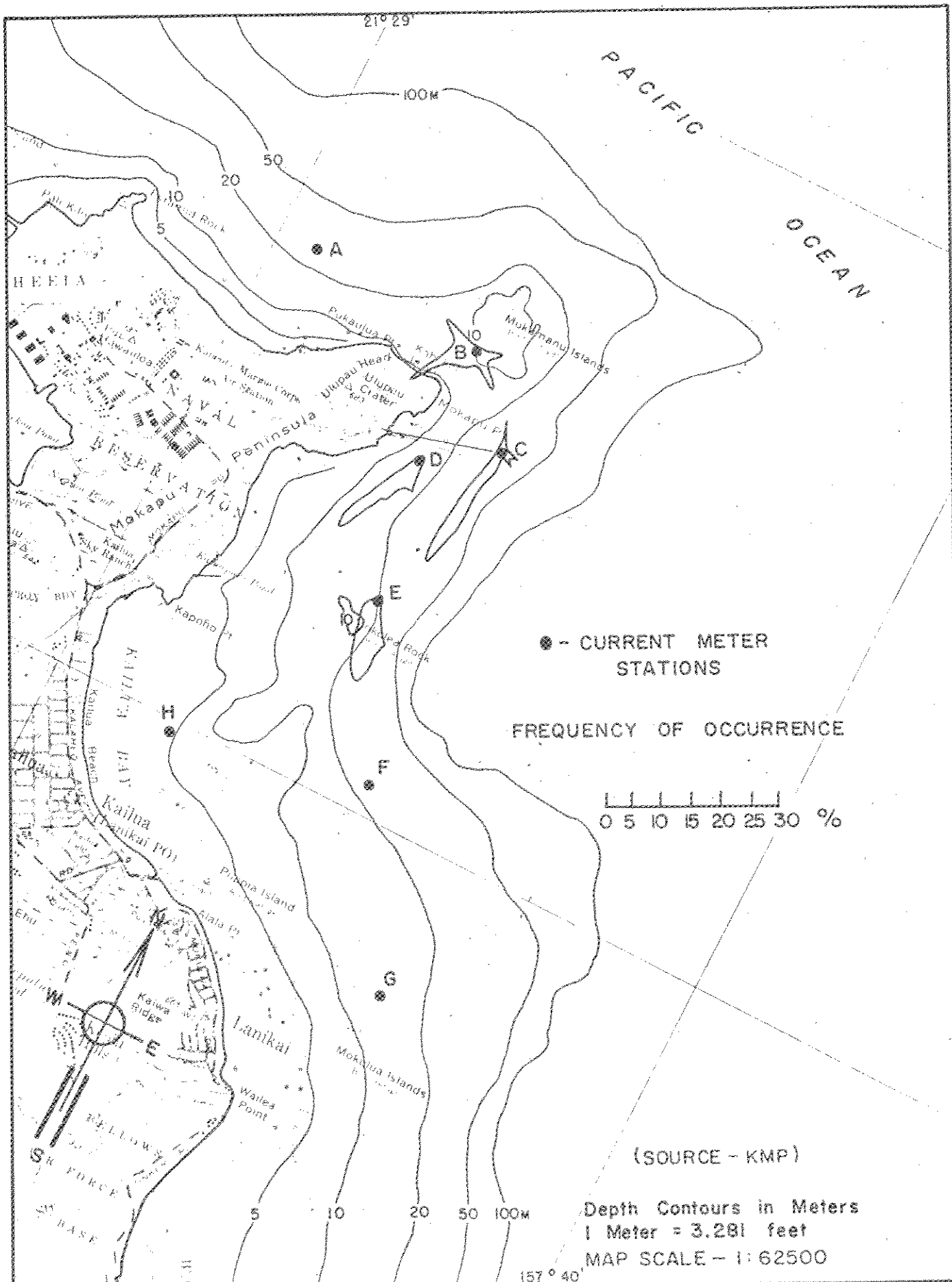
NOTE:  
 1 KNOT = 1.2 MILES/HR.  
 (APPROX.)



CURRENT VELOCITY AND DIRECTION FREQUENCY DIAGRAM FOR KAILUA BAY  
 Station C, Depth 25 in 33 meters 5-17-72 to 6-9-72

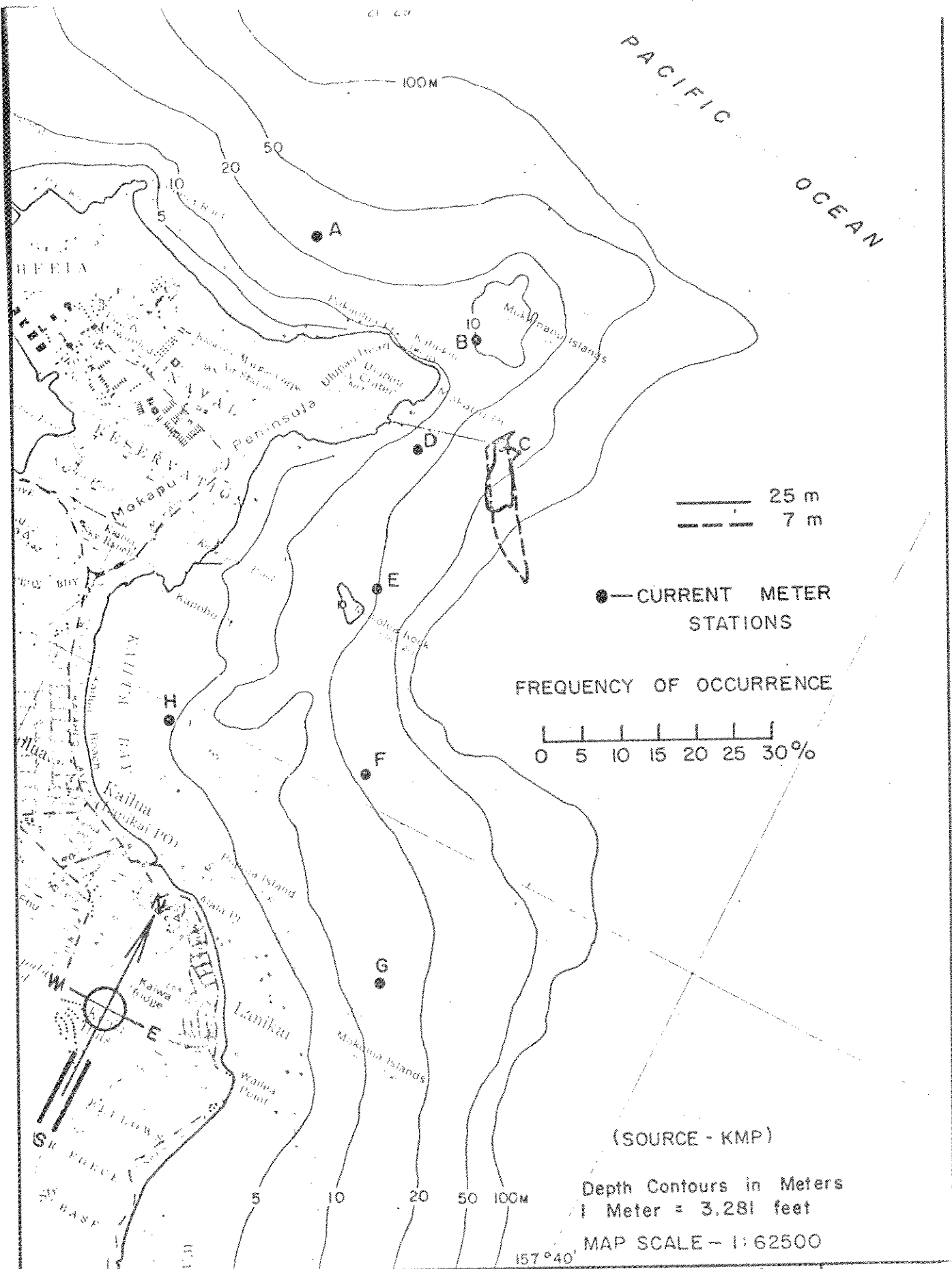
FIGURE  
 I-35





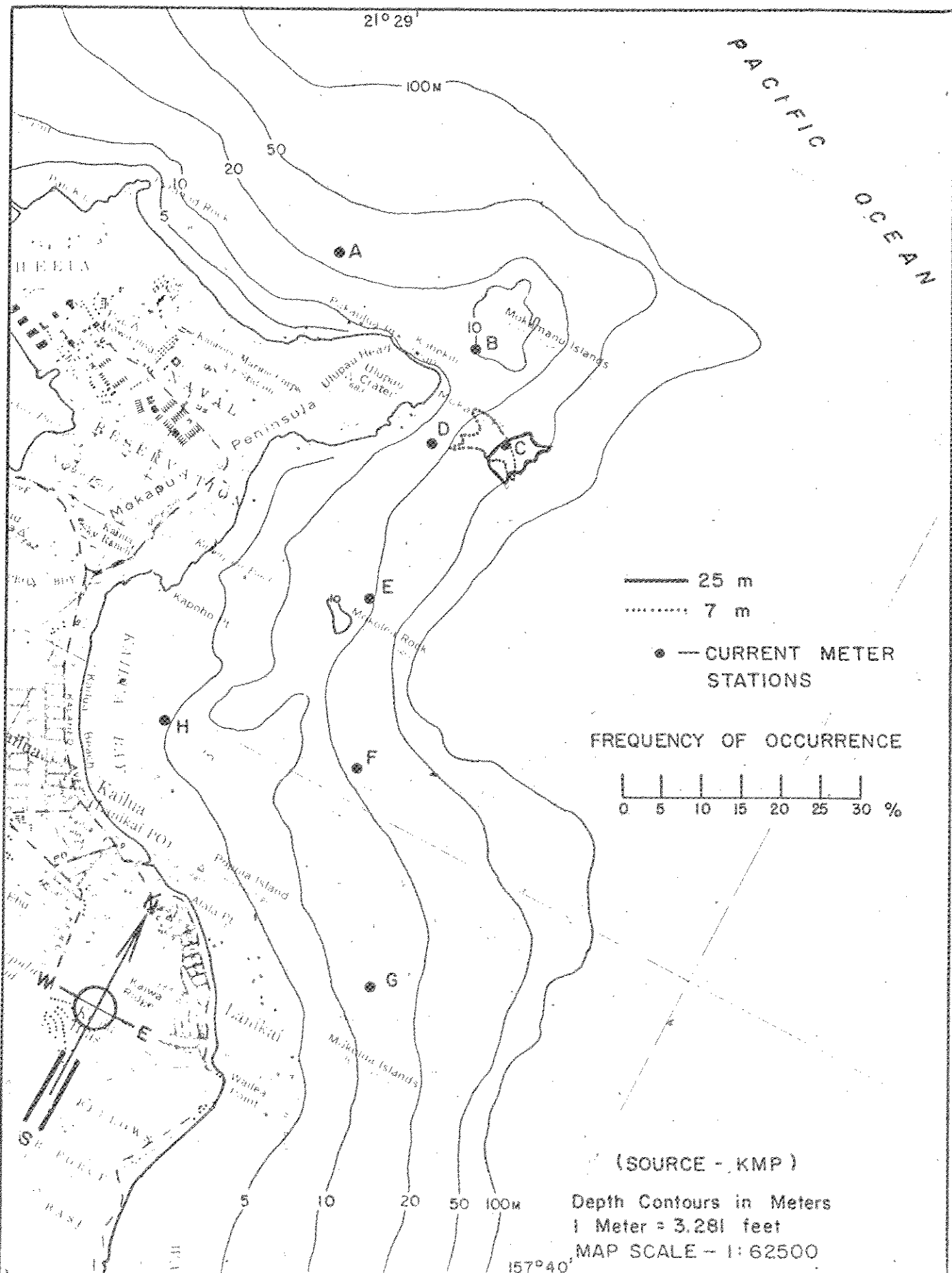
SUMMARY OF CURRENT METER DIRECTION HISTOGRAMS  
9-17-71 to 10-11-72 RESULTS

FIGURE  
I-36



CURRENT METER DIRECTION HISTOGRAMS  
 Station C, Depth 7 in 25 meters 1-7-72 to 2-6-72

FIGURE  
 I-37



**CURRENT METER DIRECTION HISTOGRAMS**

At The Proposed Outfall Diffuser Site  
 Station C, May 17 - June 19, 1972, 7m & 25m in 3/3m

FIGURE  
 1-38

TABLE I - IX - I

SUMMARY OF ANALYSIS OF LONG SERIES CURRENT METER DATA

Station	Dates	Depth	Average Flood Direction	Standard Deviation	Average Ebb Direction	Standard Deviation
<u>Program Data</u>						
B	9/17/71 - 10/11/71	7m/10m	192°	67°	144°	45°
D	9/17/71 - 10/12/71	7m/15m	192°	15°	180°	19°
E	9/17/71 - 10/17/71	7m/20m	181°	32°	165°	24°
C	11/22/71 - 11/25/71	10m/33m	340°	45°	190°	35°
C	1/05/72 - 02/06/72	7m/33m	141°	33°	137°	32°
C	1/05/72 - 02/06/72	25m/33m	145°	41°	143°	40°
C	5/17/72 - 06/09/72	7m/33m	295°	25°	252°	27°
C	5/17/72 - 06/15/72	25m/33m	121°	102°	110°	80°
<u>Past Data</u>						
X	2/05/71 - 02/22/71	9m/21m	125°	33°	124°	29°
Y	2/05/71 - 02/16/71	9m/21m	154°	18°	150°	15°

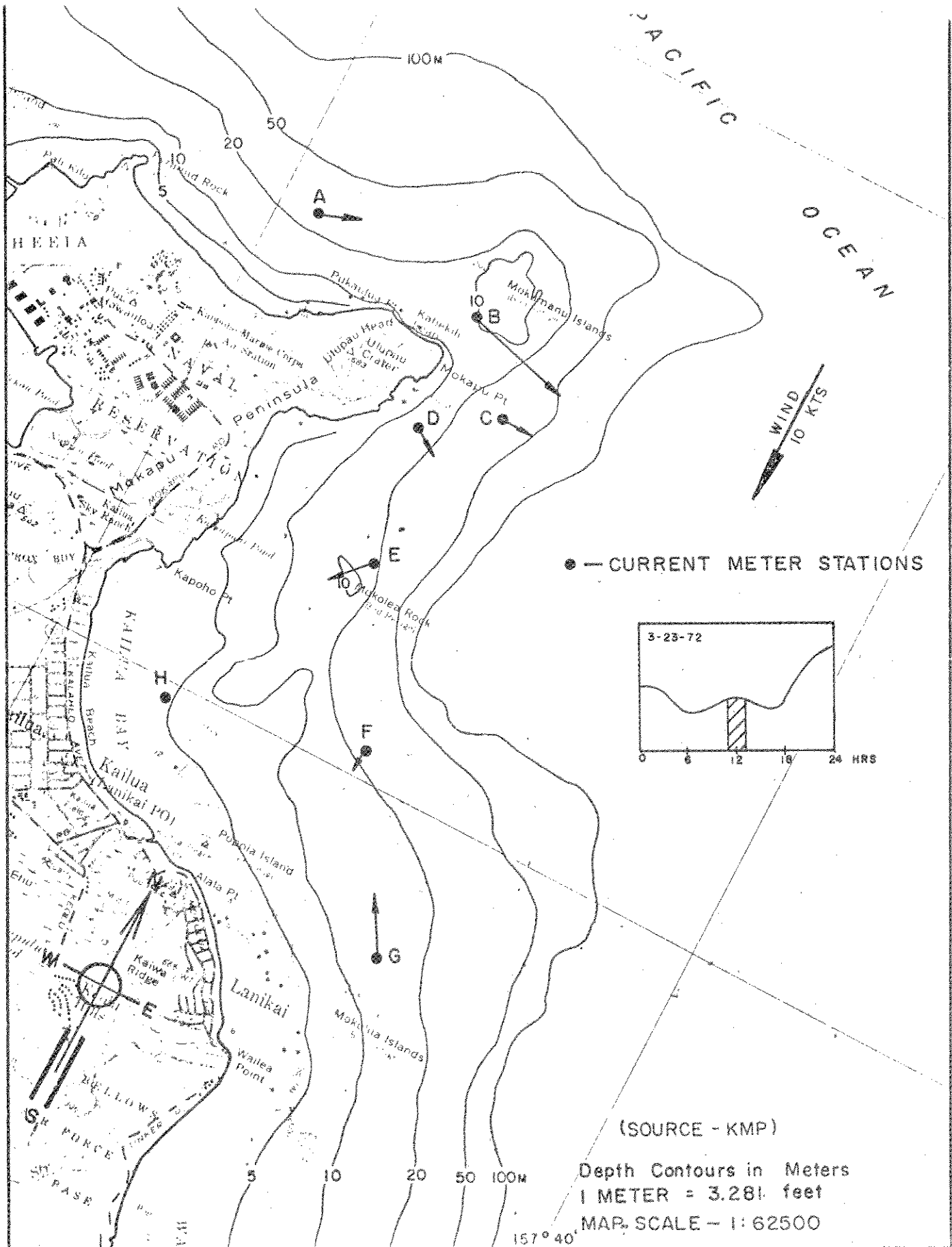
Reviewing the data in the Figures shows that the current velocities observed at current meter station B through E ranged from 0 to 1.7 feet per second (fps). However, ranges of 0.33 fps to 1.3 fps at the 23 to 33-foot depths and 0.16 to 0.83 fps at the 82-foot depth are characteristic. In the subsurface waters, 23 to 182 feet below the surface, the current directions are seasonally consistent and quite different from the surface circulation discussed previously. During the months of September through February the resultant daily transport at Station C (outfall terminus), D and E was consistently to the south or southeast. At Station B off Mokapu Point, strong tidal currents confined by the bathymetry of the channel and weak winds during October, caused the daily reversing flows to be orientated east-west. During May the resultant transport at the outfall terminus at the 23-foot depth was west-northwest and in June the resultant transport changed to the southwest. In contrast, the resultant transport at the 82-foot depth at the outfall during May was consistently to the southeast, although this transport was weak.

The results of all current meter stations show

that the current direction at all stations changed diurnally with each passing tide. Diagrams showing the effects of semi-diurnal and diurnal tides at the various stations indicate that the daily changes in direction were essentially always accomplished in a shoreward direction.

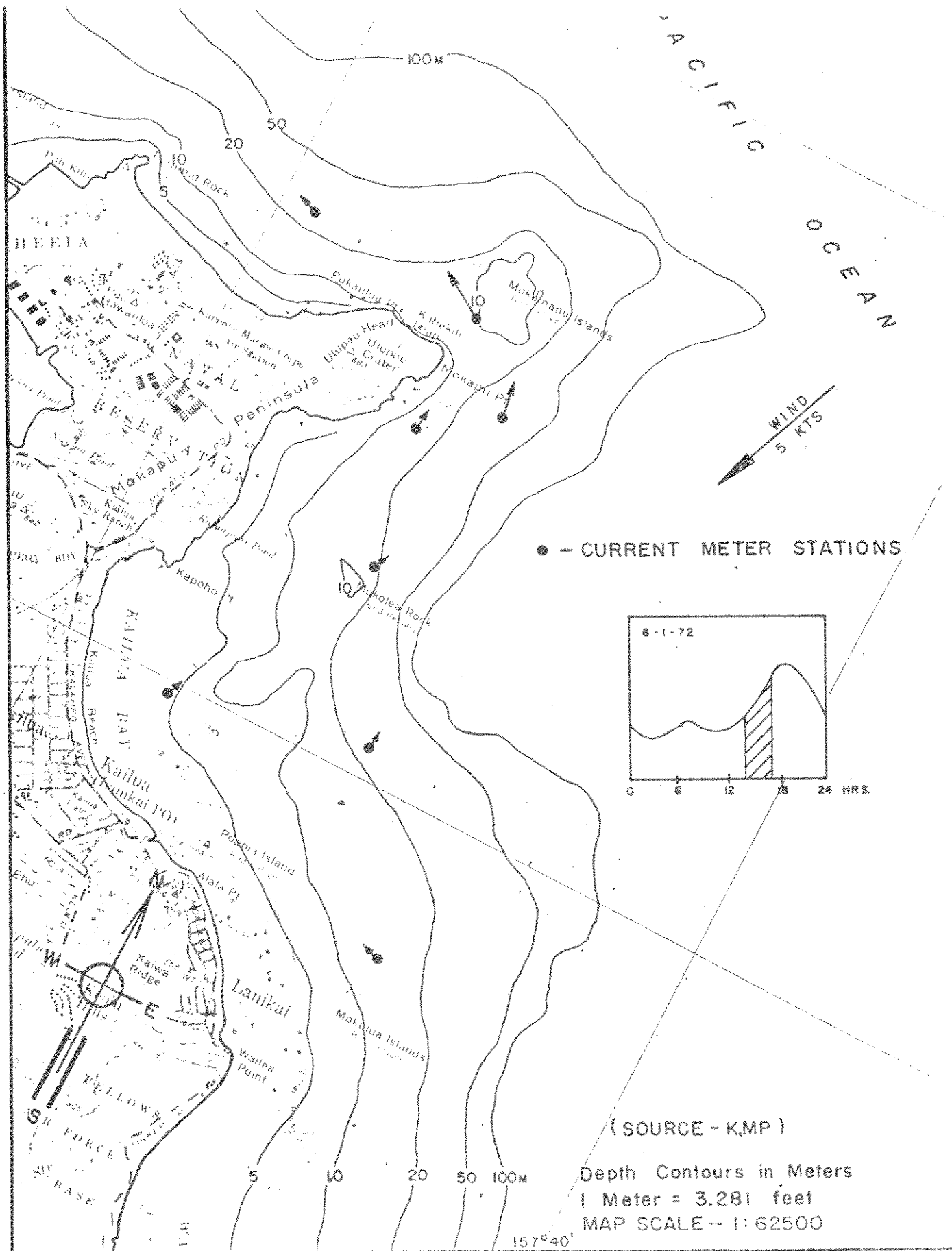
Current meter data were taken at Station A through G in March and Station A through H in June 1972 during strong ebbing and flooding tides respectively. In each case these data were taken over approximately a 2½ hour period at the mid-water depth for each station. The intent was to determine the general ebb and flood circulation patterns in Kailua Bay. Figures I-39 and I-40 show the resultant current vectors of approximately five minutes of data taken at each station. The results show a general eastward (at Mokapu Point) to southeastward (in Kailua Bay) flow during an ebbing tide and a northward (in Kailua Bay) to northwestward (at Mokapu Point) flow during a flooding tide.

Two types of vertical profiles of the currents off windward Oahu were obtained during KMP. The



CURRENT METER RESULTS, KAILUA BAY - MARCH 23, 1972  
STATIONS A-G, DURING EBB TIDE

FIGURE  
I-39



CURRENT METER RESULTS, KAILUA BAY - JUNE 1, 1972  
 STATIONS A-H, DURING FLOOD TIDE

FIGURE  
 I-40



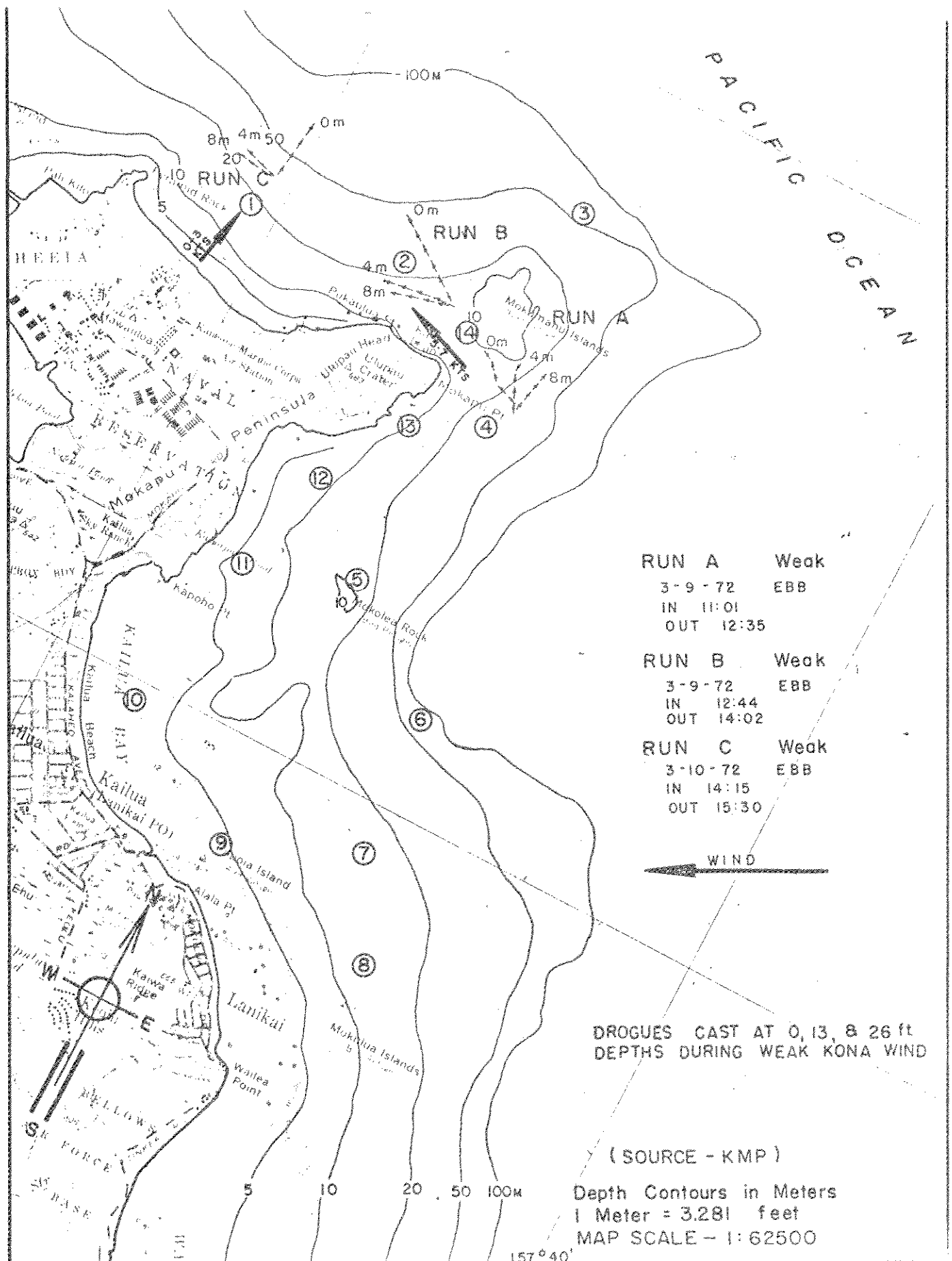
first involved placing a meter sequentially at depths of 3, 33, 66, 99, 132, and 165 feet in 198 feet of water off Waimanalo Bay during November and December for 16 to 35 hours at each of the six depths. The second type of vertical profile of the currents was obtained by lowering a current meter at 10-foot intervals from the surface to the 177-foot depth at a location 820 feet east of Station C on December 1, 1971 during an ebbing tide.

Data from the first vertical profile off Waimanalo show that the transport of surface waters was to the south-southwest. The resultant transport at 33, 66, 99, and 132 depths generally remained to the south or southwest. At the 165-foot depth, the resultant transport during November 30 to December 1, 1971 was offshore to the southeast, closely paralleling the 198 depth contour. The average current velocity computed for each 33-foot decreased from 0.43 fps, 3 feet below the surface to 0.02 fps at the 165-foot depth.

Data from the second vertical profile adjacent to the proposed outfall terminus (Station C) on December 1, 1971 decreased from 0.86 fps at the

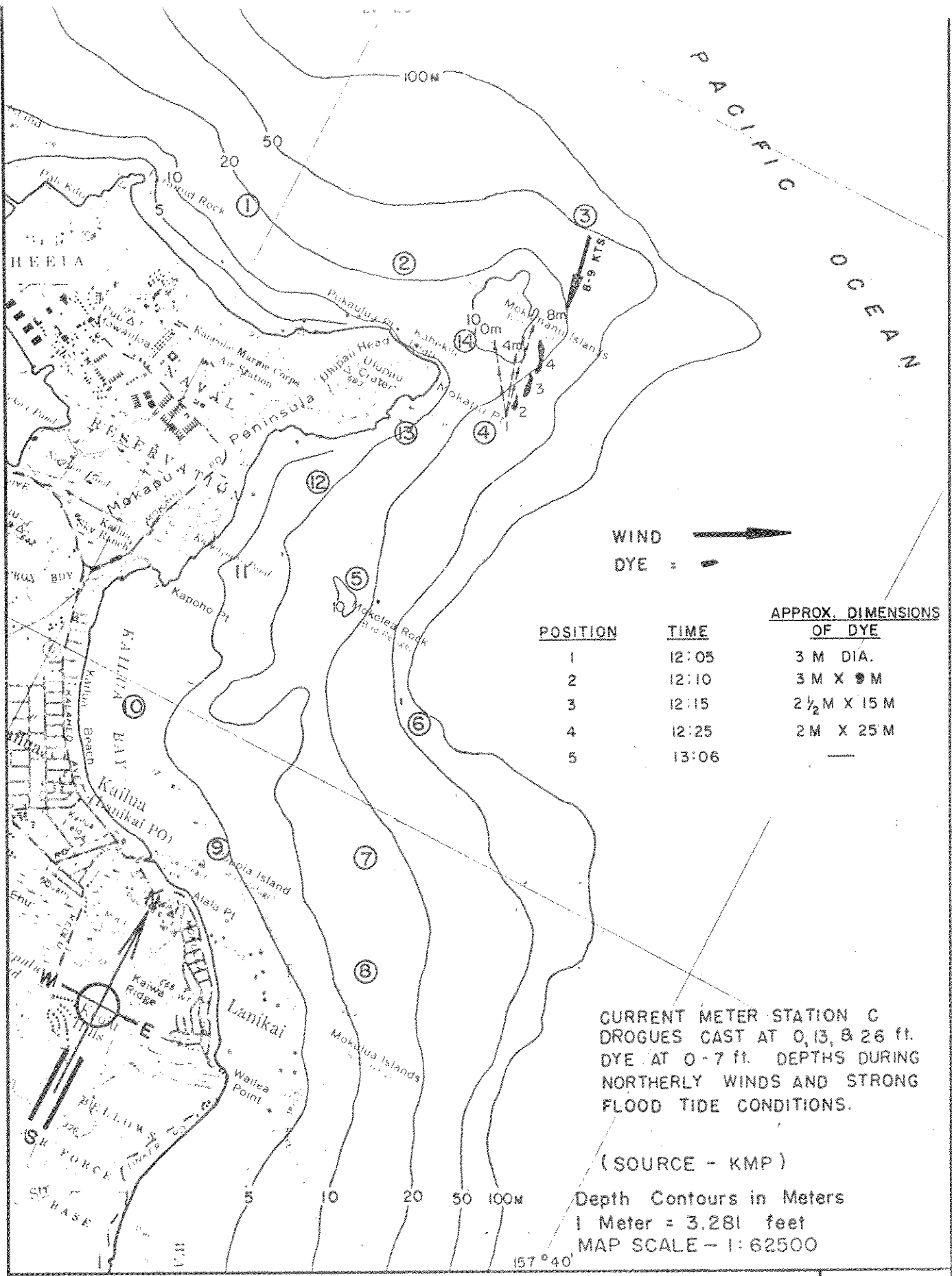
surface to 0.26 fps on the bottom at 177 feet. This is equivalent to approximately a 0.033 fps decrease per 10 feet increase in depth. The current direction at the surface was to the south. The direction was progressively deflected further toward the east with increasing depth. In contrast to the Waimanalo Bay data the flow at the bottom was orthogonal to and moving seaward from the 177-foot contour. As noted earlier, the tidal flow thought to predominate at this location during ebbing tides, is to the southeast. However, tradewinds of 9 to 17 mph (8 to 15 knots) on December 1, 1971, were probably responsible for deflecting the flow at the surface southward ( $170^{\circ}$ ). This influence decreased with depth. At 20-feet below the surface, the flow was east-southeast ( $135^{\circ}$ ). This general direction remained until approximately the 130-foot depth ( $120^{\circ}$ ). Below this depth a weak offshore flow ( $90^{\circ}$  to  $75^{\circ}$ ) was taking place. As noted previously this type of offshore flow, close to the bottom during tradewinds conditions, has been observed in the past.

Figure I-41 through I-44 show current drogue, dye and drift card results obtained during March and



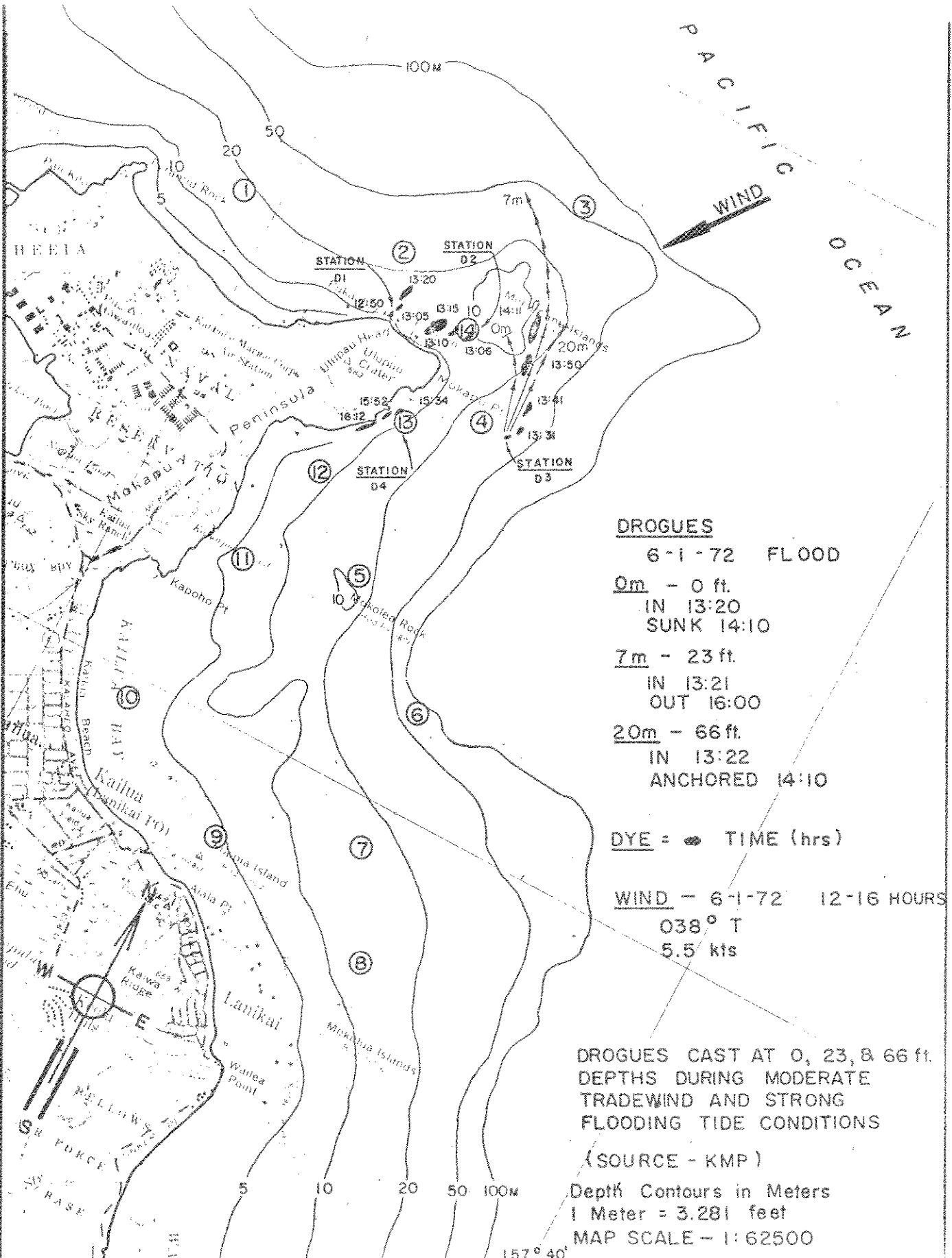
DROGUE RESULTS OFF MOKAPU PENINSULA  
MARCH 9 & 10, 1972

FIGURE  
I-41



DYE AND DROGUE RESULTS OFF MOKAPU PENINSULA  
MARCH 16, 1972

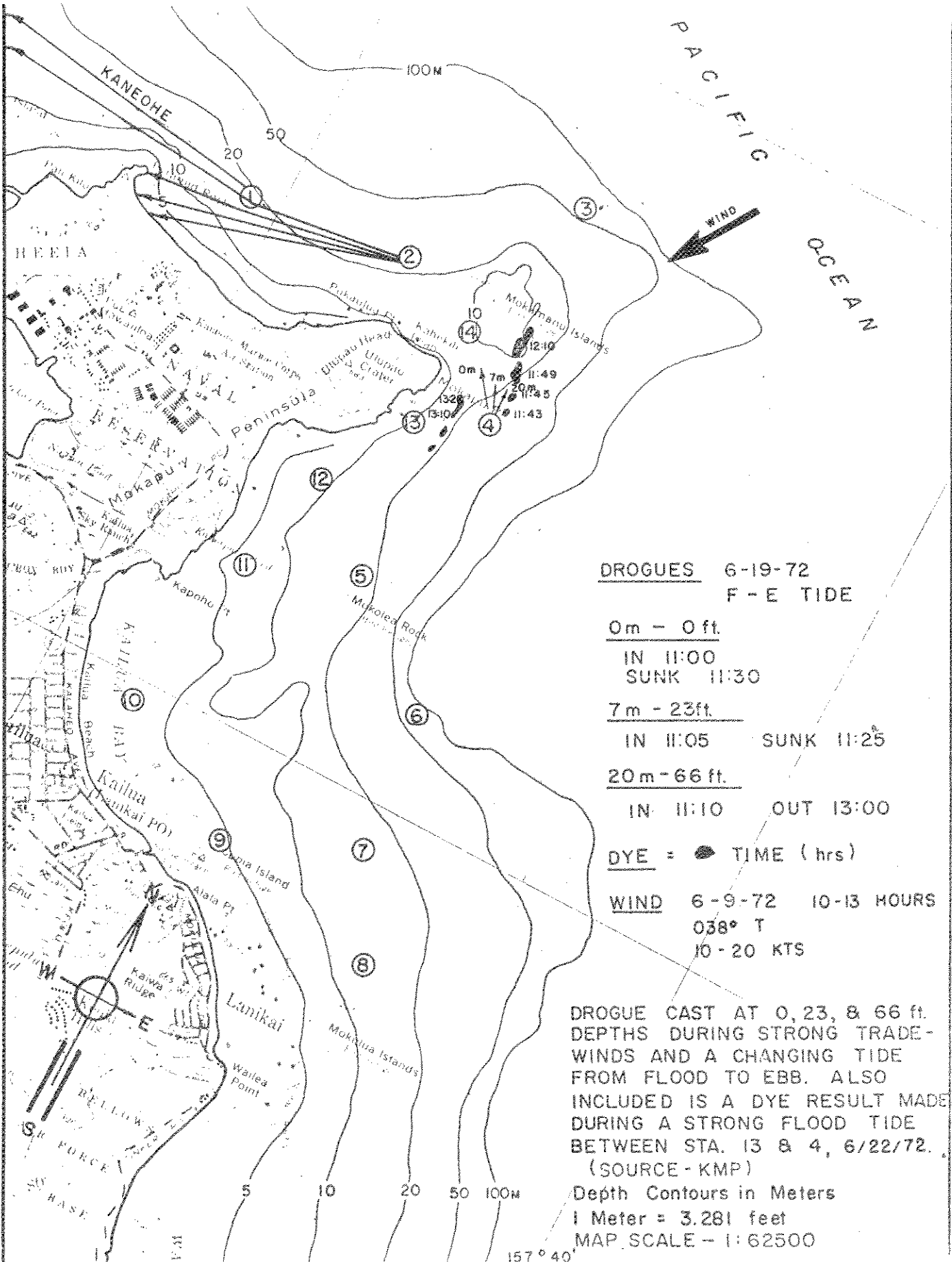
FIGURE  
I-42



DYE AND DROGUE RESULTS OFF MOKAPU PENINSULA

JUNE 1972

FIGURE  
1-43



DROGUES 6-19-72  
F - E TIDE

0m - 0 ft.  
IN 11:00  
SUNK 11:30

7m - 23ft.  
IN 11:05 SUNK 11:25

20m - 66 ft.  
IN 11:10 OUT 13:00

DYE = ● TIME ( hrs )

WIND 6-9-72 10-13 HOURS  
038° T  
10-20 KTS

DROGUE CAST AT 0, 23, & 66 ft. DEPTHS DURING STRONG TRADE-WINDS AND A CHANGING TIDE FROM FLOOD TO EBB. ALSO INCLUDED IS A DYE RESULT MADE DURING A STRONG FLOOD TIDE BETWEEN STA. 13 & 4, 6/22/72. (SOURCE - KMP)

Depth Contours in Meters  
1 Meter = 3.281 feet  
MAP SCALE - 1:62500

DYE, DRIFT CARD AND DROGUE RESULTS  
OFF MOKAPU PENINSULA  
JUNE 1972

FIGURE  
I-44

June 1972 principally off Mokapu Point. The drogue results show a steady northward drift from Station 4 during both strong flooding tides, even when opposed by north-northeasterly winds, and during weak ebbing tides when aided by easterly winds. The drogues at the surface were mostly influenced by the winds, moving first northward, later turning westward toward the channel between Mokapu Point and Mokumanu Island. Subsurface drogues at the 13, 23, 26, and 66-foot depths moved northward closely followed the bathymetric contours around Mokapu Point. Their paths in each case appear to be toward Station 3, around the shoal area of Mokumanu Island.

The dye results shown in Figures I-42 through I-44 show a similar northward movement from Station 4 during all experiments. In each case, the dye patches remained in the surface to 7-foot layer and quickly dispersed. Estimates made during the March 16, 1972 tests indicate the dye patch released at Station 4 increased from approximately 8.5 square yards (sy) to 60 sy in 20 minutes. Assuming the dye remained confined in the surface 3 feet, this is indicative of a dye dilution of approximately 7:1 in the first twenty minutes.

Dye released at Station 14, 4, 13 and Pukaulua Point on June 1, 1972 during a strong flooding tide show a northward movement away from the bay at Station 4, a westward movement through the channel at Station 14, a southwest movement into the bay at Station 13 and a northward movement away from the shoreline at Pukualua Point. These results indicate that the surface waters around Mokapu Point were moving away from Kailua Bay, flowing northward and westward under the influence of a strong flooding tide. An exception was in the area east of and close to Mokapu Peninsula (Station 13). Here the dye moved shoreward, apparently influenced by the presence of northeasterly tradewinds.

Summarizing, the results of circulation observations show flood tide currents move water in a northerly direction while ebb tide currents move in a south-southeasterly direction. The strongest current velocities in Kailua Bay, up to 1 knot (1.69 fps), are found around Mokapu Point. A shoreward surface layer drift was found to occur through most of the bay most of the year. An exception was variable drift patterns found around Mokapu Point; the prevailing pattern de-



pending upon the strength and direction of the winds and the character and strength of the tides. Subsurface daily resultant transports were found to be to the southwest during the fall, winter and early spring months of September to March and to the northwest during the late spring and summer months of April to August. Evidence was gathered supporting a past result that a weak transport moving away from the shoreline and remaining within 33 to 49 feet of the bottom can be found leaving the bay.

#### E. Density Stratification

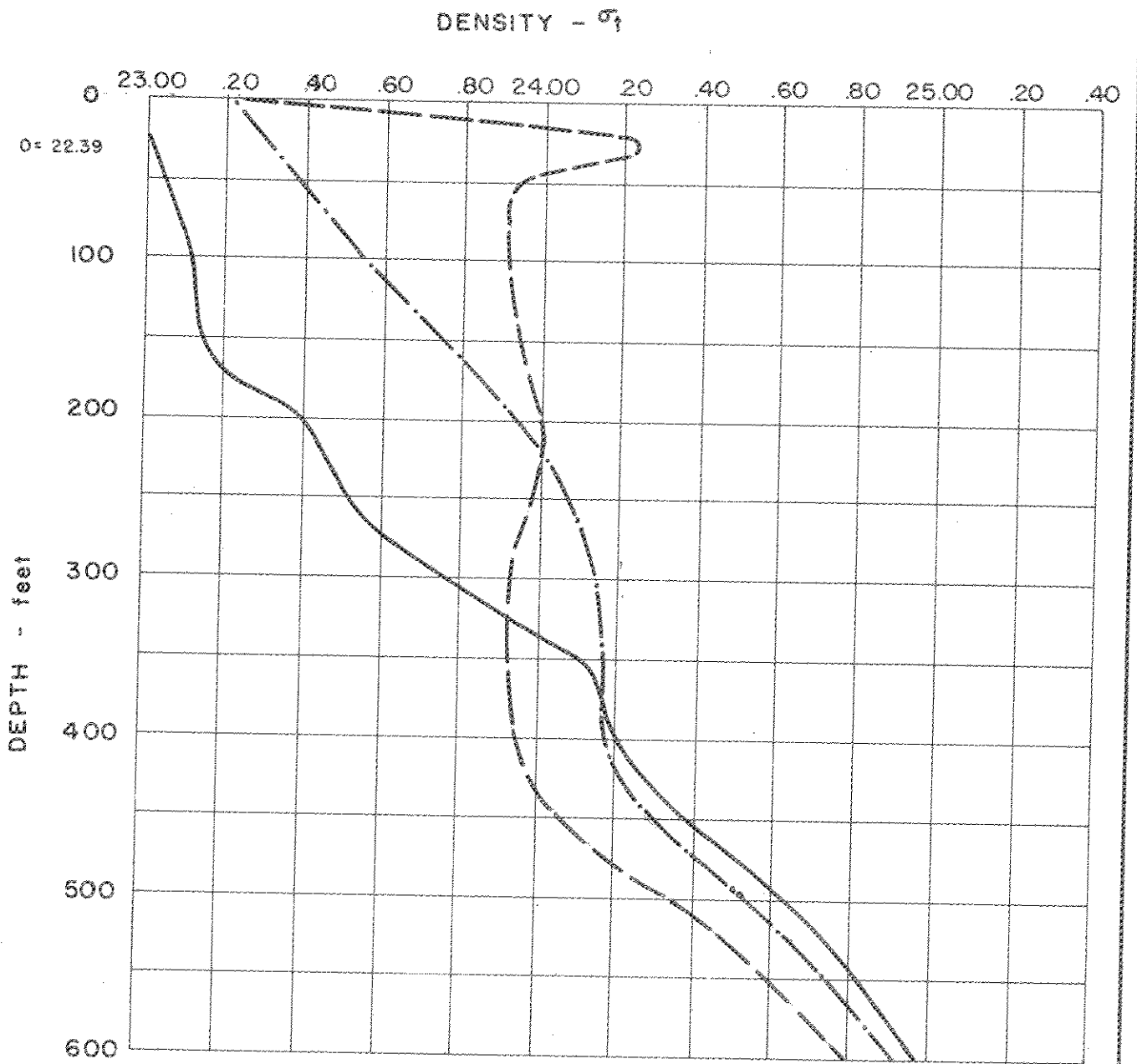
The variation of water density with depth is an important characteristic when considering marine wastewater discharges. It determines to a large extent whether or not the discharge will remain submerged. If there is no density stratification at the disposal site between the depth of the diffuser section and the surface, the wastewater effluent will rise to the surface of the receiving waters regardless of the length of the diffuser used.

Temperature profiles in the deep ocean bordering the Hawaiian Islands compiled by the Naval Oceano-

graphic Data Center (Reference 12) show the approximate annual regime of temperature stratification in the general area. Since these data are approximate and annual in the general area, they are not useful for design purposes. However, the data show that the minimum stratification probably occurs in February, the maximum stratification occurs probably in July through October, and the stratification in July through October is virtually identical.

Temperature and salinity determine the density of seawater. Hence, temperature and salinity data were taken from the surface to the 600-foot depth in Kailua Bay during WQPO. These data were collected at Station R during November 1970, and January and February 1971, the period where the density stratification can be expected to be minimal. The seasonal minimum is of interest of the engineers in the design of outfalls.

At Station R in Kailua Bay, the vertical isothermal layer extended from the surface to the 400-foot depth (Figure I-45). Between the 400-foot to 600-foot depths, the temperature varied as much as 2° centigrade (500-foot depth) over a 24-hour period. The



LEGEND:

- 11-16-70 1315 HRS
- 1-7-71 1500 HRS
- . - . - . 2-5-71 1800 HRS

(SOURCE - WQPO)

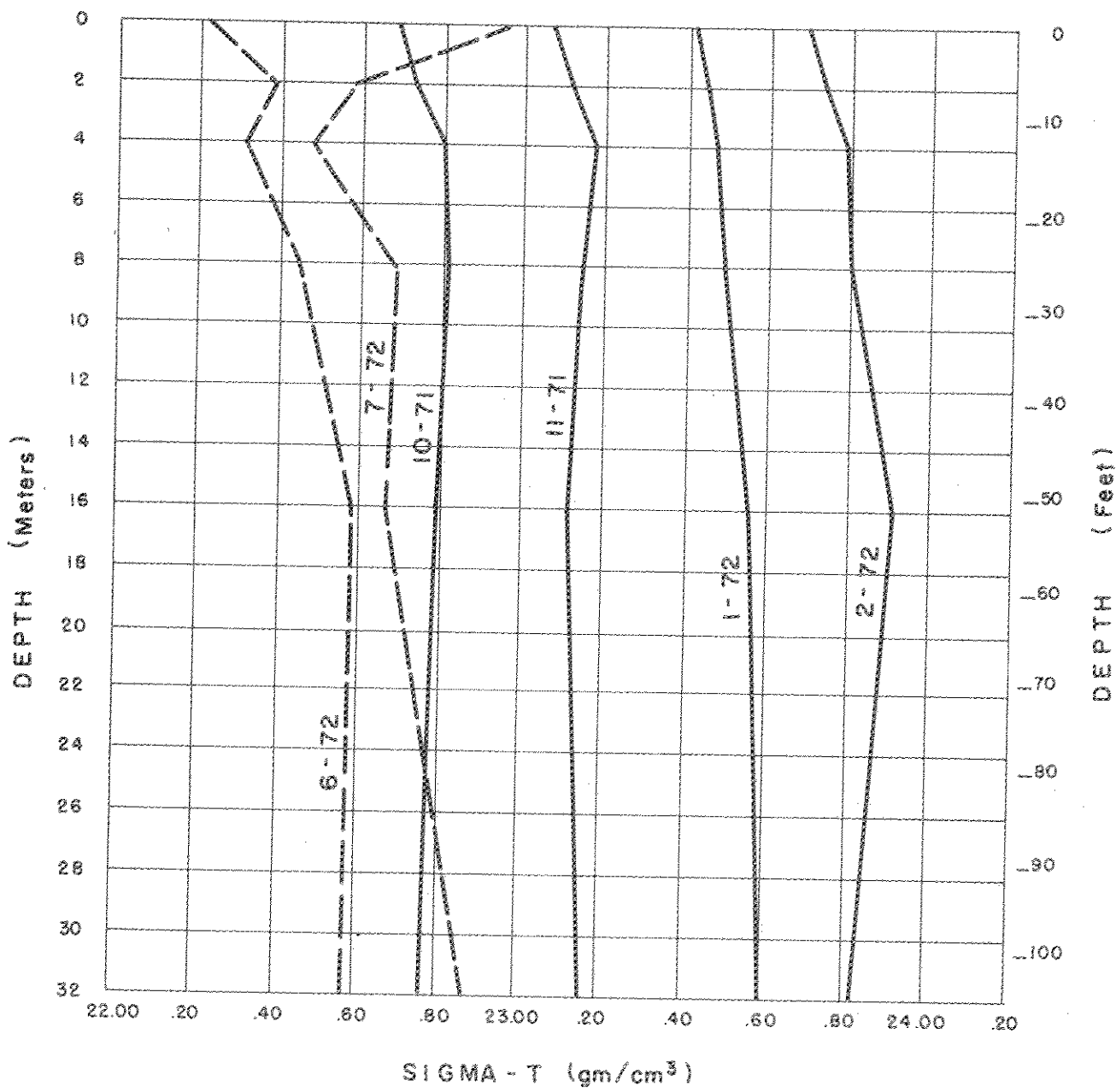
DENSITY vs DEPTH PROFILES - KAILUA BAY  
 Station R, November 1970, January and February 1971

FIGURE  
 I-45

difference in densities at minimum stratification in Kailua Bay was determined during WQPO to be 0.0009 for 0-300 feet and 0.0088 (gms/cm<sup>3</sup>) for 0-600 feet. From a practical standpoint, it is not possible to construct an ocean outfall to depths greater than 300 feet.

Temperature-salinity measurements were taken over an entire year at various depths during the Kailua Monitoring Program (KMP). According to KMP, the water density throughout Kailua Bay varied between 1.0222 to 1.0243 (grams per cubic centimeter) a range of 0.0021. At Station 4 located at the outfall terminus, the density ranged from 1.0222 to 1.0238 from the surface to the 32 meter depth (bottom) (Figure 1-46). The temperature-salinity at the station indicated an unstable weak characteristic for about fifty percent of the year. Only during March 1971 and June 1972 were they stable and strong, however, the 16 meter and 32 meter depths had similar densities.

Overall, Kailua Bay was weakly stratified during the late spring, summer and early months of March through October. By October, this weak stratification disappeared at most stations. Generally, the



LEGEND:  
 ————— WINTER  
 - - - - - SUMMER

(DATA FROM - KMP)

STRATIFICATION PROFILES  
 STATION 4 - KAILUA BAY

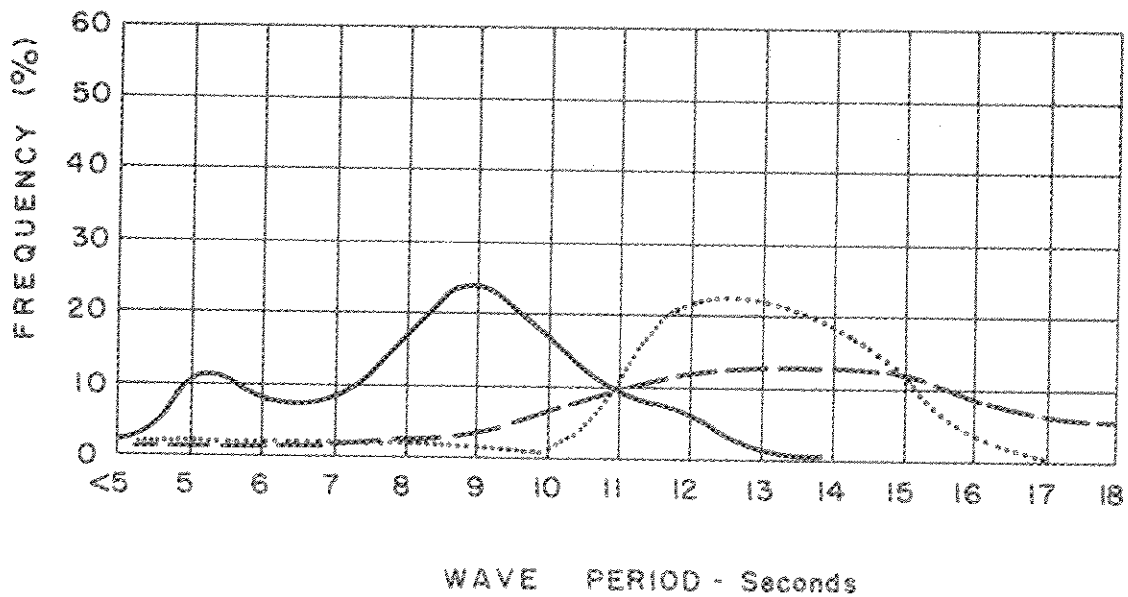
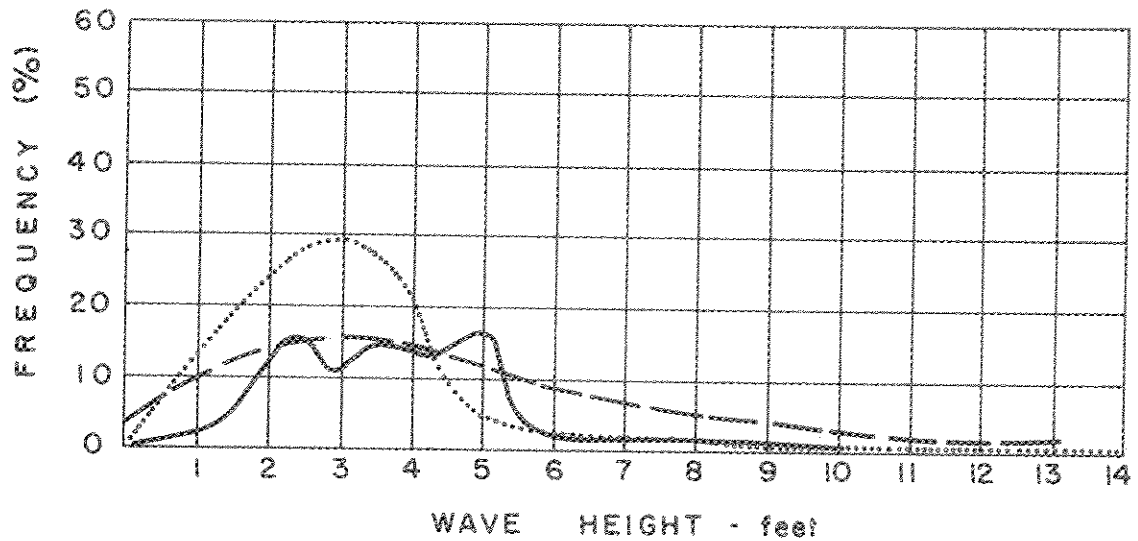
FIGURE  
 I-46

highest water density was reached at each station during January, February or March. Minimum densities were recorded in the bay at most stations and depths during the summer (June).

#### F. Wave Conditions

Recordings for wave heights and wave periods were made in Kailua Bay during WQPO at Station Q. The recordings were made using a wave in-situ recording gauge and included tidal height, significant wave height and significant wave period (average height of the highest one-third of all waves in a given train). Figure I-47 presents frequency diagrams of the significant wave heights and wave periods recorded during 1970 as well as past seasonal spectra statistics. The significant wave heights ranged 1 to 13 feet during the winter but only 2 to 5½ feet during the winter of 1970. The significant wave period varied from 5 to 18 seconds. Again, the results in 1970 showed smaller variation (7 to 12 seconds), indicating that the long period swells normally present in Kailua Bay during the year were not predominant during late 1970.

The difference in the 1970 data and the past data were due to effects of land masses and shoals and



LEGEND:

- OBSERVED 1970 RESULTS
- ..... TYPICAL SUMMER SPECTRUM (APR. - NOV.)
- - - - - TYPICAL WINTER SPECTRUM (DEC. - MAR.)

(SOURCE - WQPO)

WAVE HEIGHT AND PERIOD FREQUENCY DIAGRAMS-KAILUA BAY  
Station Q, 11-16-71 to 11-28-71

size of the sector and direction open to waves at each location. The winter data for Kailua were different from Leeward Oahu because the longer wave periods are more likely to occur on the windward side, however, wave periods during the summer were more similar on both sides of the island.

Two types of waves are important in the design of an ocean outfall sewer. The first is the maximum wave height which will be present during the placement of the pipe, while the other is the maximum possible wave which the outfall sewer will be exposed to after construction. For the latter, the outfall is designed for waves that accompany a maximum predicted hurricane in the area. In the case of the proposed Mokapu Outfall, a moving hurricane developing the same wave characteristics as Hurricane Nina (December 1957) was used for the design of the structural stability of the pipe.

#### G. Bathymetry and Bottom Configuration

Bathymetry and bottom configuration are important to engineers for design consideration, hence, during WQPO, observations of the ocean bottom were



conducted for the water area off Kapoho Point and Mokapu Point for the best alignment of a potential ocean outfall based on engineering and biological impact principles. Using a closed-circuit television, rigged for underwater use, characteristics of the bottom were recorded along a 70-degree magnetic course beginning about 600 yards offshore. In addition, three bathymetric profiles were recorded on an 80-degree (magnetic), 55-degree and 30-degree courses with the point of origin off-setted from Mokolea Rock. The depths at the point of origin were 36, 30 and 44 feet respectively and the distance of the off-set ranged from 750 to 880 yards from Mokolea Rock. The location of the origin and the ship track for the bathymetric profiles and video tapes are shown in Figure I-48.

Although the observations taken during WQPO are not along the present alignment of the proposed outfall, they represent the general condition of the ocean bottom in that area, and are important for that reason. According to the closed-circuit videotapes, the bottom is flat beginning from the origin and consists almost entirely of coral, scattered short growths of algae and widely

scattered viable coral heads, some extending up to 4 feet from the bottom. The flat coral bottom continues seaward and ends abruptly in 195 feet of water at about a 10 to 15-foot coral ledge dropping to a sand bottom. Sand was observed to continue from this depth out to at least the 410-foot depth.

The bottom configuration does not present any difficulties in the design of the outfall, however, the final alignment must be selected with care, after the more intensely current studies were to be completed, in order to avoid destroying viable corals and other benthic communities.

#### H. Biological Observation

##### 1. General

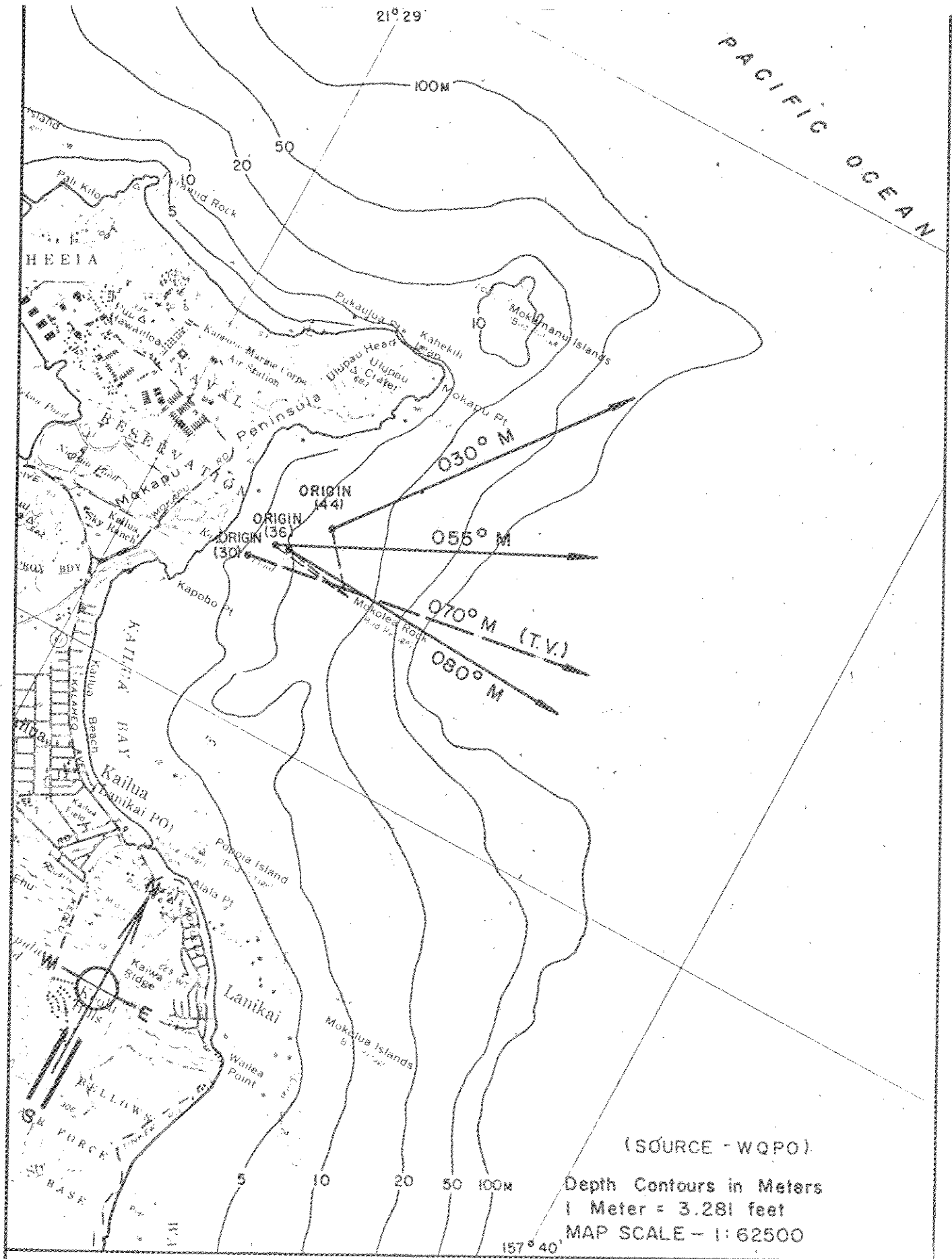
The collection, enumeration, and identification of marine fauna are among the more difficult and time-consuming tasks of monitoring programs for water quality and ecosystem evaluation. Because of limited financial resources, it was felt during WQPO that studies be directed toward the assessment of biological responses to pollution rather than mere enu-

meration of standing crops. Biological observation of Kailua Bay included a TV video tape of the bottom of Kailua Bay from the 30-foot depth out to the 450-foot depth (See Figure I-48); sediment samples from Stations 11, 13, and 4; biological observation made by divers during surveys; a benthic study of Kailua Bay by the Water Resources Research Center of the University of Hawaii (Reference 13) and studies on periphyton.

## 2. Coral

Observations of the spatial distribution of viable and dead coral around the Island of Oahu show that in approximately 33 percent of the nearshore area (less than 100-foot depth) abundant growths of viable coral can be found. These "healthy" areas include the Waianae Coast (with local exceptions) extending from Barbers Point around Kaena Point to Mokuleia, from Kahuku Point to Punaluu, and from Manana Island to Hanauma Bay.

In approximately 13 percent of the total nearshore area, dead coral that has been partially or totally covered with silt can



(SOURCE - WQPO)

Depth Contours in Meters  
 1 Meter = 3.281 feet  
 MAP SCALE - 1:62500

ALIGNMENTS OF BATHYMETRIC PROFILES  
 & TV VIDEO TAPE - KAILUA BAY

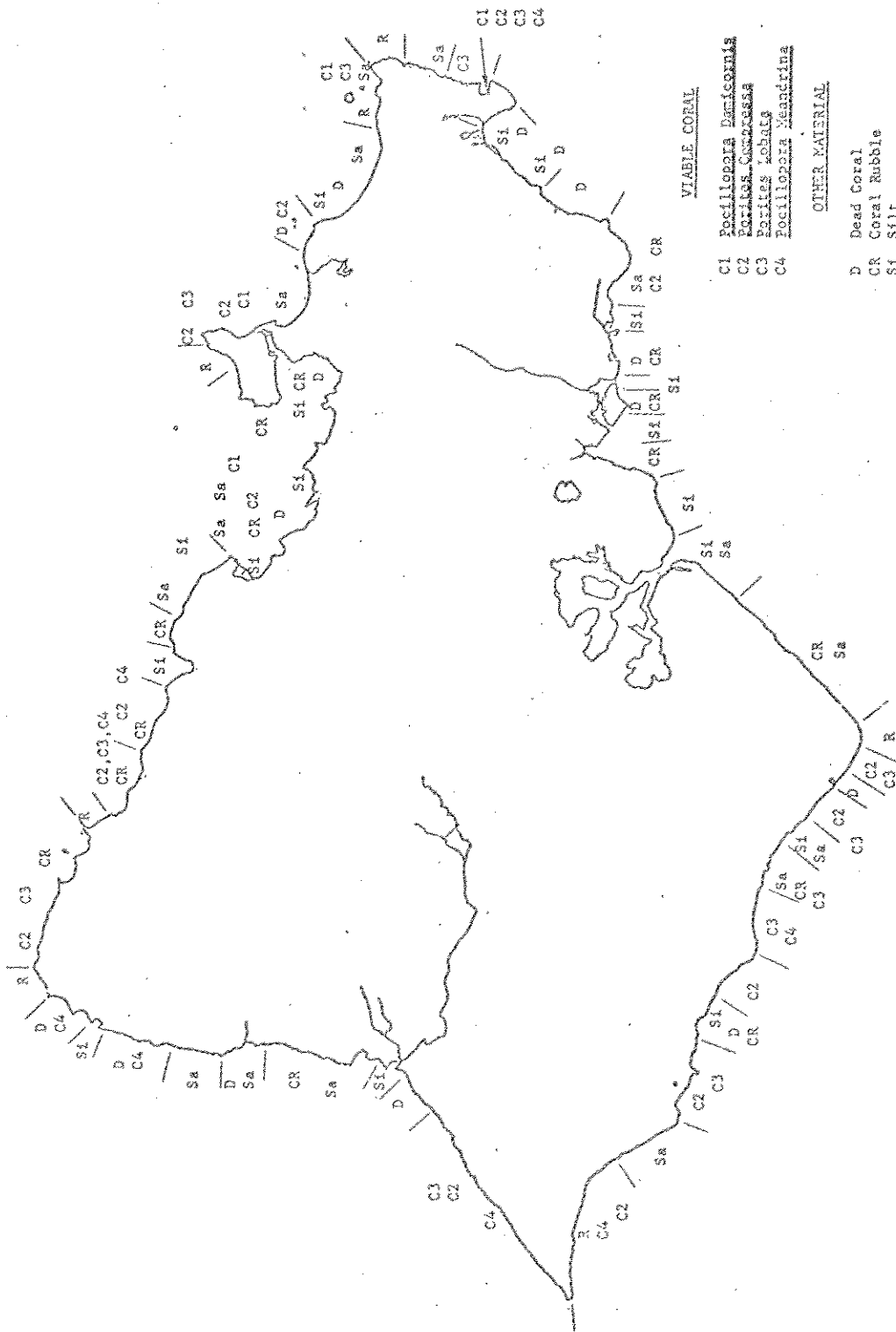
FIGURE  
 I-48

be found. In general, these areas include southeast Kaneohe Bay, Waimanalo Bay, Maunalua Bay, Mamala Bay, Campbell Estate Harbor, off Kaneilio Point, Makaha, Kaiaka Bay, Waimea Bay, Kawela Bay and Kahana Bay.

Scattered areas of viable coral can be found in the remaining areas: central Kaneohe Bay and seaward, Kupikipikio Point to Waikiki, Ewa Beach to Barbers Point, and Puaena Point to Kahuku Point.

A flat and continuous coral bottom with widely scattered coral head extending to 4 feet of the bottom exists in Kailua Bay out to approximately the 220-foot depth. Most of the coral bottom and the coral heads are viable and the widely scattered coral heads contain small colonies of indigenous reef fish. At the 220-foot depths the coral ends abruptly in a 10-foot ledge dropping to a flat sand bottom that continued out to the extent of the observations (450-foot depth). Pinna colonies, coelenterates, crustaceans, and brachiopods were the predominant inhabitants of this area.

Figures I-49 and I-50 show maps of the composite of biological observations made during WQPO. Figure I-49 shows the distribution of the vi-



VIABLE CORAL

C1 *Pocillopora damicornis*  
C2 *Pocillopora damicornis*  
C3 *Seriatopora lobata*  
C4 *Pocillopora meandrina*

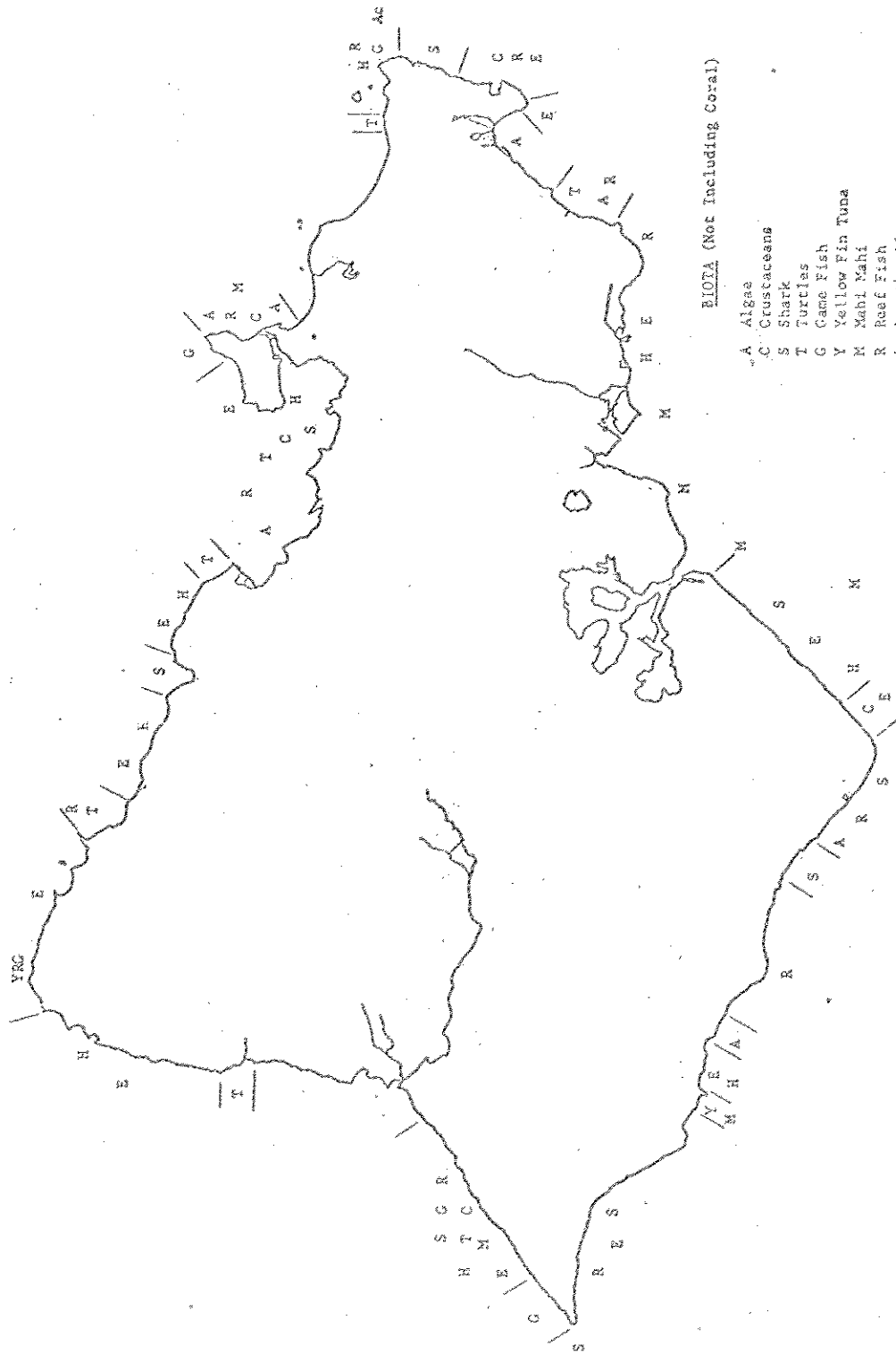
OTHER MATERIAL

D Dead Coral  
CR Coral Rubble  
S1 Silt  
Sa Sand  
R Rock

(SOURCE - WQPO)

DISTRIBUTION OF VIABLE CORAL AND OTHER BOTTOM MATERIAL  
AROUND OAHU, HAWAII - MARCH 1971

FIGURE  
I-49



BIOTA (Not Including Coral)

- A Algae
- C Crustaceans
- S Shark
- T Turtles
- G Game Fish
- Y Yellow Fin Tuna
- M Mahi Mahi
- R Reef Fish
- Ac Acanthurids
- E Echinoderms
- M Molluscs
- H Holothuridians

(SOURCE - WQPD)

BIOTA OBSERVED AROUND OAHU DURING DIVING SURVEYS  
OFF THE COAST OF OAHU - JUNE 1970 to MARCH 1971

FIGURE  
I-50

able coral, dead coral, coral rubble, silt, sand, and rock around Oahu. The shoreline map of Oahu is marked at the approximate points of extent of each kind of bottom. Just the most abundant types of corals that were found in each area are listed. Additional types of less abundant coral are scattered throughout each area.

Comparing the distribution of viable coral and silt indicates that the areas having suffered the most degradation are in and at the entrance to most of the bays around Oahu. At these locations the predominance of silt and lack of viable coral is particularly evident. Areas such as Waimea Bay, Kawela Bay, Kahana Bay, along the shore in Kaneohe Bay, off Waimanalo Beach, along the shore in Maunalua Bay, adjacent to Hawaii Kai, off the entrance to Ala Wai Harbor, Honolulu Harbor, Keehi Lagoon and Pearl Harbor show the greatest deterioration.

Visual observations along the proposed alignment of the Mokapu outfall were made by the City's consultant from the shore to a depth of 75 feet. (Reference 14). The area to



the north of the outfall entry into the ocean was typified by continual wave breaking, indicative of shoaling conditions. This area was examined and a coral reef jutting from a depth of 6 to 8 feet almost to the water surface was found. Hence, a water entry to the south of the Flyers' Monument was selected where no shoaling exists.

The general bottom surficial sedimentology is characterized by a definite lack of any major sand supply. Small sand pockets exist interstitially between the bottom coral formations and the sand size is generally very coarse.

The bottom surficial lithology is characterized by coral formations showing distinctive features as a function of depth. From the water entry zone to a depth of about 35 to 40 feet extensive live coral formations are evident, existing upon a base of dead coral. This zone exhibits many coral heads and localized ledges up to 5 or 6 feet in height. Examples of these conditions have been photographed.

From the 40-foot depth, a definite demarka-

tion was noticed by the absence of live coral growths. The bottom is composed of dead coral exhibiting an unusually flat altitude. This dead coral structure is a highly conglomerated mass, fused together with very few interstitial holes. Proceeding into deeper water at about 65-foot depth and continuing deeper, the bottom becomes more undulatory with smooth ridges and hills rising up to 5 feet from the bottom surface. In the local depression between rises, there exists fill composed of a very loose conglomerate of coarse sand, small pieces of rock and broken coral (about 2 to 4 inches average size). This rubble material seems to fill any depressed area of the zone from 65 to 100 feet possibly due to a previous lower standing sea level.

Observation of corals and bottom conditions at Station 11, 13, and 4 off Mokapu Peninsula was made on May 25-26, 1973 by Dr. Arthur Reed, WRRC U.H., a City consultant. His observation at the three stations are as follows. Station 11 is located at the present Kailua outfall in 15-foot waters. The bottom there is quite flat and slopes gently seaward.

The bottom was predominately hard, limestone rock of coral and coralline algae origin. Small heads of living coral very sparsely (estimated to be less than 5 percent) covered the rock substrate. Most common corals seen were Pocillopora meandrina, and Porites lobata.

The bottom at Station 13, midpoint of the proposed outfall is remarkable in its flat, almost pavement smooth appearance. Water depth was 45 feet. Dominant benthic organisms were heads of the coral Pocillopora meandrina, distributed rather evenly and widely separated. Coral cover was estimated to be less than 1 percent. This observation confirms the findings made earlier by the City's engineering consultants.

At Station 4, at a depth of 100 feet, near the outfall terminus, the bottom consisted of a gently rolling hard limestone substrate with wide, shallow grooves containing sand up to 6 inches in depth. Only sparse patches of coral were observed at the sediment sample site and these consist of the species Pocillopora meandrina, Porites lobata and Porites

compressa. A 100-foot mound was observed approximately 50 feet away to the north. This mound rose some 10 feet above the surrounding bottom and was covered with large and apparently healthy growing heads of coral, predominantly Porites compressa and Porites lobata, with some Montipora verrucosa and Pocillopora meandrina. Live coral cover was estimated to be between 80 and 90 percent on the mound. Additional data on coral were obtained by Reed (Reference 11) at Stations 7, 8, 9, 12 and near 11 and 10. A summary of the survey is shown in Table I-IX-2.

Most of the coral reefs in Kaneohe are composed of living coral. Banner (Reference 15) has surveyed the coral and associated fauna in the southern part of the bay following an extremely heavy rain (32 inches in ten days). Large areas of shallow depth coral were killed by the silt loads and volume of fresh water. Since the flooding in 1965, many of the colonies have been re-established but later reports showed that coral mortalities are in the range of 86 to 99 percent. In areas where

TABLE I-IX-2

Summary of Abundance of Dominant Benthic Organisms  
at Six Stations in Kailua Bay.

Station	Organisms Measured	Dominant Species	Total Abundance or Area Covered	Total Distance or Area Sampled	Method of Measurement
1 (8)	algae	<u>Dictyopteris sp.</u> (31.5%)	45.577 g/m <sup>2</sup>	5 m <sup>2</sup>	dry weight
	coral	<u>Porites lobata</u>	<5%	20 m <sup>2</sup>	photographic transect
		<u>Pocillopora meandrina</u>			
2 (11)	algae	<u>Dictyopteris sp.</u> (58.5%)	55.062 g/m <sup>2</sup>	5 m <sup>2</sup>	dry weight
	coral	<u>Porites lobata</u>	<2%	20 m <sup>2</sup>	photographic transect
		<u>Pocillopora meandrina</u>			
3 (10)	coral	<u>Pocillopora meandrina</u>	2.6%	-----	joint point nearest neighbor
4 (9)	algae	<u>Halimeda discoidea</u> (26.8%)	63.148 g/m <sup>2</sup>	5 m <sup>2</sup>	dry weight
5 (7)	coral	<u>Porites lobata</u> (5.4%)	13.5%	60 m <sup>2</sup>	linear transect
sea urchin		<u>Tripneustes gratilla</u>	1.5/m <sup>2</sup>	30 m <sup>2</sup>	m <sup>2</sup> quadrat transect
6 (8)	coral	<u>Porites lobata</u>	<1%	60 m <sup>2</sup>	linear transect
sea urchin		<u>Tripneustes gratilla</u>	1.4/m <sup>2</sup>	30 m <sup>2</sup>	m <sup>2</sup> quadrat transect

Note: The number in ( ) indicates the equivalent KMP station (Reference Figure I-13)

(Source: Reed 1973)

silt loads are continuously seen deposited colonies will not be able to re-establish themselves.

According to Moberly and Campbell (Reference 16), in the inshore area, the bottom sediments are mainly coral rubble, gray coral mud, and fine coral sands. Near the stream mouths, fine brown silts and clays occur. Fringing reefs nearshore are covered with a poorly sorted, sandy, gravelly mud. In the offshore area, the central reef is composed of live coral, coral rubble, coarse coral sand, and volcanic rock. Sand is fed into both channels from the reef. In the southeast basin, sediments vary from coral sands and rubble in the deep center, to fine brown sands and clays deposited at the shoreline from the stream mouths. The basin area near the two sewer outfall has fine grey clays and coral sands.

In summary, the fringing coral reefs of Oahu are an important natural resource. These reefs provide a certain amount of physical protection for beaches and shores and pro-

vide the necessary habitats for a great many aquatic organisms. Coral reefs are probably the most biologically productive of all natural communities whether they be marine or terrestrial. The corals, even though they do not appear to account for the major fraction of reef community biomass, provide suitable habitats for thousands of other kinds of plants and animals which would die or migrate from the area should the corals be selectively killed. Thus it appears imperative that corals receive the maximum protection possible to ensure their continued existence as well as the existence of many other desired marine organisms.

Of the many factors which have the potential of killing or damaging corals, the most important ones probably are exposure to waters with a high sediment load and waters of low salinity. Investigations in Kaneohe Bay have shown that the abundance and distribution of corals have been reduced significantly in the past few years because of sedimentation and exposure to waters of low salinity (Reference 35).

### 3. Periphyton

Communities of microorganisms growing on submerged surfaces are greatly influenced by water quality. These groups of organisms, designated periphyton, were collected on artificial substrates left submerged for a minimum period of one month during WQPO.

The attached growths were analyzed for dry weight and chlorophyll content. Biomass accumulation in terms of dry weight and chlorophyll production was significantly higher in the surface waters above the Sand Island outfall, southeast basin of Kaneohe Bay, and at the entrance to Pearl Harbor. The biomass accumulation in the surface waters off Waikiki Beach, off Sandy Beach, and in Kailua Bay were lower by an order of magnitude. The reason for the greater productivity at the 60-foot depth as compared to the surface in Kailua Bay is not known.

The results of the WQPO studies are shown in Table I-IX-3. The results illustrates the high amount of biomass amounting to 340 grams per square meter ( $\text{gm}/\text{m}^2$ ) and chlorophyll



TABLE I-IX-3

CHLOROPHYLL a, b, c, AND DRY WEIGHT AT EIGHT  
LOCATIONS AROUND OAHU

Location	Depth (ft.)	Chlorophyll a (mg/m <sup>2</sup> )	Chlorophyll b (mg/m <sup>2</sup> )	Chlorophyll c (mg/m <sup>2</sup> )	Dry Weight (gms/m <sup>2</sup> )
Keehi Lagoon	Surf	2.44	0.00	1.95	52
Kapalama Canal	Surf	2.38	0.23	1.77	48
Pearl Harbor (East Loch)	Surf	3.79	1.21	4.85	160
Pearl Harbor Ent. (Bishop Point)	Surf	14.68	2.36	13.14	216
Pearl Harbor Ent. (Keahi Point)	Surf	23.46	1.05	15.06	283
	30	8.67	0.15	4.76	97
	60	0.70	0.12	0.00	6
Sand Is. Outfall	Surf	70.48	5.25	66.84	340
	30	4.20	0.83	4.13	166
Waikiki	Surf	6.95	0.00	4.33	21
Kailua Bay	Surf	4.30	0.80	5.60	19
	30	2.07	0.14	1.64	51
	60	6.88	1.03	5.80	55

TABLE I-IX-3 (cont'd.)

Location	Depth (ft.)	Chlorophyll a (mg/m <sup>2</sup> )	Chlorophyll b (mg/m <sup>2</sup> )	Chlorophyll c (mg/m <sup>2</sup> )	Dry Weight (gms/m <sup>2</sup> )
Kaneohe Bay	Surf	20.90	1.02	18.00	285
Sandy Beach	Surf	3.22	0.00	1.57	47
	30	1.47	0.00	1.30	31

(SOURCE - WQPO)

CHLOROPHYLL a, b, c, AND DRY WEIGHT AT EIGHT  
LOCATIONS AROUND OAHU

type a, b, and c found at the surface waters off the Sand Island outfall compared to Kailua Bay ( $19 \text{ gm/m}^2$ ) indicating that the latter is a near pristine bay. In other areas of suspected high productivity, both the biomass and amounts of chlorophyll were found to be high. These include the surface waters in the southeast basin of Kaneohe Bay (biomass of  $285 \text{ gm/m}^2$ ) and at the entrance of Pearl Harbor (Bishop Point, biomass of  $216 \text{ gm/m}^2$ ) and Keahi Point (biomass of  $283 \text{ gm/m}^2$ ).

#### 4. Others

The biota indicated in Figure I-50 represents those that were recognized during diving surveys. Most of the organisms listed are pelagic, but it is assumed that these organisms such as reef fish, crustaceans, echinoderms and holothuroidians, generally inhabited in the area in which they were found. Other organisms such as game fish may be transient to the area diurnally or seasonally. Hammerhead sharks have been found in abundant numbers in Kaneohe and Kailua Bays.

Four plankton tow samples were taken around

Oahu during WQPO. Table I-IX-4 includes the results of examining two of the 16 biosubstata samples taken. Phytoplankton, found around Oahu in the past have been listed in Table I-IX-5. The Sandy Beach plankton sample was taken approximately one mile offshore to represent the pristine conditions off Oahu.

The predominant phytoplankton and zooplankton organisms found off Sandy Beach were diatoms, copepods and benthic invertebrate larvae. The most abundant meroplankton found were gastropod and bivalve mollusk larvae. In Kailua Bay, diatoms, copepods and benthic invertebrate larvae are common. The presence of organisms as ctenophores and their absence off Sandy Beach is indicative that Kailua Bay is less than pristine. The absence of both zooplankton and phytoplankton at the Sand Island outfall does not mean these organisms do not or cannot inhabit this area. In oligotrophic conditions this may occur. The particulate materials gathered by the plankton net at this site made identification difficult.

The examination of the biosubstrata showed that filamentous green algae predominated on

TABLE I-IX-4  
RESULTS OF THE PLANKTON SAMPLING AND THE  
EXAMINATION OF THE GROWTH ON ARTIFICIAL BIOSTRATA

Location	Date (Time)	Sample (Depth)	Phytoplankton	Zooplankton	Remarks
Sand Island Outfall (Station A)	1-9-71 (1530 hours)	Plankton (3 feet)	None found	None found	Sample contained an abundance of live coliform bacteria 75 $\mu$ net; 16,680 liters filtered
Diamond Head (Station 1)	1-8-71 (1830 hours)	Plankton (3 feet)	Blue-Green Algae <u>Diatoms--Navicula</u>	Pelecypod larvae (2376) Ostracoda (32) Gastropod larvae (536) Copepod nauplii (352) Cirripedia larvae (200) Shrimp larvae (96) Chaetognath larvae (57) Tunicates (40) Radiolarians (16) Foraminiferida (16) Crustacean larvae (84) Copepods (578)	4318 Zooplankton Approximately 157 were $\geq$ 300 $\mu$ Majority were $\geq$ 50 $\mu$ 75 $\mu$ net; 10,800 liters filtered
Sandy Beach (1 mile offshore)	1-8-71 (1715 hours)	Plankton (3 feet)	<u>Diatoms--Licmophora</u> Ctenophore (1)	Copepods (1817) Benthic Inv. larvae (174) Crustacea larvae (121) Gastropod larvae (108)	2250 Zooplankton 75 $\mu$ net; 16,620 liters filtered

TABLE I-IX-4 (cont'd.)

Location	Date (Time)	Sample (Depth)	Phytoplankton	Zooplankton	Remarks
Kailua Bay (Station Q)	1-8-71 (1240 hours)	Plankton (3 feet)	Diatoms-- <u>Nitzschia</u> (most) <u>Licmophora</u> <u>Cymbella</u> <u>Strepto-</u> <u>theca</u> (least)	Bivalve larvae (56) Polychaete (7) Echinoderm (1) Siphonophores (38) Tunicates (52) Chaetognaths (40)  Copepods (138) Cyclopoida (40) Harpacticoid (1) Calanoids (97) Benthic Inv. larvae (148) Gastropod larvae (48) Decapod larvae (60) Echinoderm larvae (39) Polychaete larvae (2) Ctenophores (82) Siphonophores (82) Radiolarian (82)	368 Zooplankton  75 $\mu$ net; 6,960 liters filtered
Kailua Bay (Station Q)	Jan. 1971 (30 days)	Substrata (Surf)	Filamentous Green Algae Diatoms-- <u>Nitzschia</u> (most) <u>Cymbella</u> <u>Licmophora</u> <u>Strepto-</u> <u>theca</u> (least)	Cirripeds-- <u>Lepas</u> (5) Polychaete worms (12) Round worm (1) Copepods Harpacticoids (3) Calanoid (1) ( <u>N. gracilis</u> )	Gooseneck barnacles From 0.7 to 8.0 long  2 are residences of Kaneohe Bay

TABLE I-IX-4 (cont'd.)

Location	Date (Time)	Sample (Depth)	Phytoplankton	Zooplankton	Remarks
Kailua Bay (Station Q)	Jan. 1971 (30 days)	Substrata (Surf)	Filamentous Green Algae Phaeophyta Diatoms-- <u>Licmophora</u> (most) <u>Thalassio-</u> <u>thrix</u> <u>Naviculla</u> <u>Nitzschia</u> (least) Ctenophore (1)	Pele cypod larvae (approx. 100) Gastropod Veligera (approx. 20) Copepods Harpacticoid (1) Cyclopoid (1) ( <u>Corycaeus</u> ) Copepod <u>Liauphilus</u> (few)	Bivalve mollusk valigers

(SOURCE - WQPO)

RESULTS OF THE PLANKTON SAMPLING AND THE EXAMINATION OF THE GROWTH ON ARTIFICIAL BIOSTRATA

TABLE I-IX-5

SOME PHYTOPLANKTON FOUND AROUND OAHU PRIOR TO 1970

<u>Location</u>	<u>Organism</u>
Kaneohe Bay	<u>Nitzschia longissima</u>
Kaneohe Bay	<u>Pleurosigma delicatulum</u>
Kaneohe Bay	<u>S. costatum</u>
Kaneohe Bay	<u>Navicula bacillum</u>
Kaneohe Bay	<u>Navicula radiosa</u>
Kaneohe Bay	<u>Navicula salinarum</u>
Kaneohe Bay	<u>Navicula exsul</u>
Kaneohe Streams	<u>Cymatopleura solea</u>
Waihole Stream	<u>Cocconeis</u>
Waihole Stream	<u>Meridion circulare</u>
East Oahu	<u>Biddulphia</u>
East Oahu	<u>Coscinosira polychorda</u>
East Oahu	<u>Pseudoeuntotia doliolus</u>
Waianae Coast	<u>Katagnymene spiralis</u>
Ala Wai Canal	<u>Oscillatoria animalis</u>
Ala Wai Canal	<u>Phormidium luridum</u>
Waianae Coast (Makaha Beach)	<u>Melosira moniliformis</u>
Waianae Coast (Makaha Beach)	<u>Navicula salva</u>
Waianae Coast (Makaha Beach)	<u>Vorticella convallaria</u>
Waianae Coast (Makaha Beach)	<u>Nitzschia closterium</u>
Waianae Coast (Makaha Beach)	<u>Amphiproa</u>

(SOURCE - WQPO)



the substrata with some phytoplankton organisms intermixed in the marine plant growth. Diatoms, pelecypod larvae, gastropod larvae, polychaete worms and cirripeds were present in the Kailua Bay samples.

To supplement baseline data in Kailua Bay gathered by WQPO, KMP, and the Mokapu Outfall Baseline Study (Western, in preparation) a survey of the benthic biota in the bay was made in the summer of 1973 (Reference 13). The UH WRRRC with S. Arthur Reed as chief investigator, was contracted to perform the work. The survey included (1) a general description of the benthic conditions, (2) a determination of the dominant benthic flora and fauna, (3) fish species and abundance and (4) analysis of micromolluscs at six locations in the bay. The benthic biota stations numbering from 1 to 6, corresponded to KMP Stations 12, 11, 10, 9, 7, and 8 respectively. Stations 1 (12), 2 (11), 3 (10) and 4 (9) are shallow water areas ranging in depth from 10 to 20 feet. Two deeper stations, 5 (7) and 6 (8) were located in 45 feet waters. Station 2 (11) is located about 200 feet from the existing

Kailua outfall at a depth of 20 feet.

Benthic algae were found in sufficient quantities to warrant measurements and definition at Stations 1 (12), 2 (11) and 4 (9). Dry weight and species identification were made within five 1 meter square ( $m^2$ ) quadrants and averaged. Average dry weight for Stations 1 (12), 2 (11) and 4 (9) were 45.577 grams/ $m^2$  ( $g/m^2$ ), 55.062  $g/m^2$  and 63.148  $g/m^2$  respectively. Fourteen algae species were identified at Stations 1 (12) and 2 (11) and 17 at Station 4 (9). Dic-tyopteris sp. was the dominant specie at Stations 1 (12) and 2 (11). At Station 4 (9) it was Halimeda discordia. At Station 2 (11) off the existing outfall, Ulva fasciata was found in abundance indicating a source of increased nutrient and fresh water. Findings of the benthic survey conducted by Reed are presented in Table I-IX-6 to I-IX-8.

A fish survey was also made in Kailua Bay as part of the baseline survey of benthic biota (Reference 13, Appendix A). Data on fish abundance and species diversity were determined using a technique modified from Brock. Species diversity indices were calculated using the techniques de-

TABLE I-IX-6  
 DRY WEIGHT OF BENTHIC ALGAE  
 AT STATION I (12), KAILUA BAY, OAHU

Species	QUADRATS (one meter <sup>2</sup> )					TOTAL (gm)	%
	IA	IB	IC (g/m <sup>2</sup> )	ID	IE		
<u>Dictyopteris sp.</u>	14.218	19.816	7.633	12.303	17.804	71.774	31.5
<u>Galaxaura sp.</u>	9.906	13.162	10.964	14.627	8.078	55.927	24.5
Red alga, unident.	4.923	1.333		10.854	3.630	20.740	9.1
Red alga, unident.	1.743	2.991				4.734	2.1
<u>Microdictyon sp.</u>	0.521	2.024		1.065		3.610	1.6
<u>Trichogloea sp.</u>	1.692			0.106	0.552	2.350	1.0
<u>Halimeda discoidea</u>		0.541	1.168		0.621	2.330	1.0
<u>Dictyota acutiloba</u>	2.047					2.047	0.9
<u>Laurencia sp.</u>				1.441		1.441	0.6
<u>Dictyosphaeria cavernosa</u>	0.027		1.075			1.102	0.5
<u>Codium edule</u>	0.525		0.202			.726	0.3
<u>Turbinaria sp.</u>	0.120				0.486	.606	0.3
<u>Codium arabicum</u>				0.450		.450	0.2
<u>Padina japonica</u>	0.338					.338	0.2
Mixed species	7.632	5.103	10.155	19.684	17.135	59.709	26.2
TOTAL	42.882	43.637	32.529	60.530	43.306	227.884	100

(Source: Reed 1973)

Average dry weight = 45.577 g/m<sup>2</sup>

Note: The number in ( ) indicates the equivalent KMP station (Reference Fig. I-13)

TABLE I-IX - 7  
 DRY WEIGHT OF BENTHIC ALGAE  
 AT STATION 2 (II), KAILUA BAY, OAHU

Species	QUADRATS (one meter <sup>2</sup> )					TOTAL (gm)	%
	2A	2B (g/m <sup>2</sup> )	2C	2D	2E		
<u>Dictyopteris sp.</u>	56.790	27.922	39.061	26.730	10.563	161.066	58.5
<u>Codium arabicum</u>		10.729	8.972	3.358		23.059	8.4
<u>Ulva fasciata</u>	2.152	4.037	2.060	1.702	2.627	12.578	4.6
<u>Galaxaura sp.</u>	.188	6.072	1.281	3.014		10.555	3.8
<u>Dasya sp.</u>					8.336	8.336	3.0
<u>Asparagopsis sp.</u>				8.086		8.086	2.9
<u>Jania sp.</u>	3.060	2.580				5.640	2.1
<u>Halimeda discoidea</u>		1.276		1.296	2.615	5.187	1.9
Red alga, unident.				4.754	0.155	4.909	1.8
<u>Gracilaria sp.</u>	4.142					4.142	1.5
<u>Trichogloea sp.</u>	0.390	0.616		2.660	0.238	3.904	1.4
<u>Chondrococcus sp.</u>	0.082		0.464		0.088	0.634	0.2
<u>Dictyosphaeria sp.</u>		0.177				0.177	0.1
<u>Dictyota sp.</u>			0.050			0.050	0.0
Mixed species						23.938	9.4
TOTAL	66.804	53.409	52.386	51.600	25.173	275.310	100

Note: The number in ( ) indicates the equivalent KMP station (Reference Fig. I-13)  
 Average dry weight = 55.062 g/m<sup>2</sup>

TABLE I-IX-8  
 DRY WEIGHT OF BENTHIC ALGAE  
 AT STATION 4 (9), KAILUA BAY, OAHU

Species	QUADRATS (one meter <sup>2</sup> )					TOTAL (gm)	%
	4A	4B	4C (g/m <sup>2</sup> )	4D	4E		
<u>Halimeda discoidea</u>	22.276	16.699	5.983	11.132	28.547	84.637	26.8
<u>Sargassum sp.</u>	9.867	3.365		16.460	3.969	33.661	10.7
<u>Trichogloea sp.</u>	10.370	3.459	8.351		4.593	26.773	8.5
<u>Dictyopteris sp.</u>	2.017	3.990	5.837	6.460	1.673	19.977	6.3
<u>Dictyota acutiloba</u>	0.156	1.859	0.076	8.770		10.861	3.4
<u>Galaxaura sp.</u>		8.865		1.056		9.921	3.1
<u>Hypnea sp.</u>	1.847	0.183	0.521	2.061	1.762	6.374	2.0
<u>Padina japonica</u>	0.095	1.373	1.463	2.116		5.047	1.6
<u>Laurencia sp.</u>	1.937	0.506			2.018	4.461	1.4
<u>Dictyosphaeria sp.</u>	0.540	0.399	0.989	0.050	0.389	2.367	0.8
Red Alga, unident.		1.604				1.604	0.5
<u>Sciara sp.</u>					1.397	1.397	0.4
<u>Asparagopsis sp.</u>				0.952		0.952	0.3
<u>Codium arabicum</u>		0.303			0.364	0.667	0.2
<u>Colpomenia sp.</u>			0.259			0.259	0.1
<u>Acanthophora sp.</u>	0.138					0.138	0.0
<u>Bornatella sp.</u>		0.022				0.022	0.0
Mixed species	12.278	26.199	10.471	35.485	22.190	106.623	33.8
TOTAL	61.521	68.826	33.950	84.542	66.902	315.741	100

Average dry weight = 63.148 g/m<sup>2</sup>

Note: The number in ( ) indicates the equivalent KMP station (Reference Fig. I-13).

(Source: Reed 1973)

veloped by Shannon and Weaver, and Brilliouin, and fish abundance was determined using the species constant values for weight-length relationships available from the State Division of Fish and Game. The results of the fish transect runs in number of individuals, total weight in pounds, weight density and diversity indices are shown in Table I-IX-9. The transect runs were taken on July 23-24, 1973. The number of individual fishes ranged from 38 at Station 4(9) to 315 at Station 2(11) which is the location of the existing outfall. The greatest abundance in terms of total weight and weight per acre was registered at Station 6(8) located in 45 feet waters and the lowest at Station 4(9).

Reed attributed the extremely low abundance and diversity of fish at Station 4(9) to its shallowness (10 feet), exposure to strong surge, and its uniform bottom cover of sand and closely cropped algae. These conditions provide a relatively inhospitable environment for a large and diverse fish population. The relative abundance of Station 6(8) over Station 5(7) was attributed to a great number of Acanthurus sandvicensis at that station and **its complete** absence at Station 5(7). Otherwise, the two stations would be identical or very similar. Abundance of fish at Station 2(11) at the existing

TABLE I-IX-9

FISH SURVEY IN KAILUA BAY

(July 1973)

Station	# Families	# Species	# individuals in size classes		Total Pounds	Pounds/acre	Diversity Index	
			<6"	6-1" >10"			B	SW
1(12)	12	25	258 (200+)	9	51.01(139.01) <sup>1</sup>	444.4(1211.1) <sup>1</sup>	3.591	3.804
2(11)	9	19	311	4	23.00	200.4	3.099	3.242
3(10)	7	17	264	3	22.59	196.8	3.107	3.265
4(9)	6	9	38		3.61	31.5	2.501	2.935
5(7)	13	26	154	32	32.91	286.7	3.464	3.830
6(8)	10	26	140	66	64.99	566.2	3.391	3.672

Notes:

1. Number in parenthesis include a wandering school of goatfish.
2. B denotes Brillouin Diversity Index.
3. SW denotes Shannon, Weaver Diversity Index.
4. The number in ( ) indicates the equivalent KMP station (Reference Figure I-13).

(Source: Reed, 1973)

outfall is less than half of that at Station 1(12), where the characteristics are similar in terms of depth, exposure to surge, bottom configuration, algae and coral cover. The diversity index at Station 2(11) is also less. It is suspected that chlorine in the effluent and the low dilution provided (about 10 to 1) are the causative agents for conditions at the existing outfall. A similar situation has been observed at Wahiawa Reservoir where chlorinated effluent from the Wahiawa municipal plant is discharged.

A survey of micromolluscan assemblages was included as part of the Kailua Bay benthic study. Professor E. Alison Kay was in charge of this work. Samples were obtained from the six stations where algae and fish surveys were conducted during June-July 1973. Micromollusks considered in this survey were mollusks with shells less than 10 millimeters (about 3/8 inches) in greatest dimension. The survey in Kailua Bay included species composition, species diversity, trophic structure and standing crop. Species diversity was determined using a formula developed by Pielow<sup>U</sup>. Standing crops were estimated by dividing the number of shells obtained from a station by the volume of sediment analyzed. Trophic structure was determined by calcu-



lating the number of individuals associated with a particular feeding habit and dividing by the total number of individuals in the sample. The species of the families Phasianellidae, Rissoidae, and Cerithiidae were dominant at all six stations. The highest standing crop and the largest number of species were found at the existing Kailua outfall (Station 2(11)), however, the species diversity was next to the lowest. Results of the survey are shown in Table I-IX-10 and in Reference 13, Appendix B.

According to Kay, species composition, species diversity, trophic structure and standing crop of the micromollusks of the six stations in Kailua Bay are comparable with the patterns which emerge at other areas of similar depth and substrate around Oahu. The highest standing crop was recorded at Station 2(11) at the existing outfall which makes it tempting to speculate that it reflects the high nutrient concentrations and hence higher productivity at this station. The very low standing crop at Station 6(8) may be due to the surge conditions at that station.

## I. Distribution of Water Properties

### 1. General

A total of 6,356 measurements of the water quality around Oahu were obtained during WQPO.

TABLE I-IX-10

MICROMOLLUSCAN ASSEMBLAGES SURVEY IN KAILUA BAY

(June-July 1973)

Station	1(12)	2(11)	3(10)	4(9)	5(7)	6(8)
No. shells	239	542	290	398	180	69
No/cm <sup>3</sup>	9.6	21.7	11.6	15.2	7.2	2.8
No. species	29	40	38	28	39	21
Species diversity (H')	3.9	3.7	4.3	2.6	4.2	3.9
Relative proportions of dominants						
Tricolia	11%	28%	17%	47%	20%	20%
Cerithidae	18%	14%	8%	26%	5%	10%
Rissoidea	40%	26%	20%	12%	40%	33%
Merelina spp.*	11%	12%	12%	84%	9%	13%
Rissoina spp.*	85%	60%	74%	4%	59%	52%
Vitricithna*	1%	18%	12%	11%	7%	---
Hipponix spp.	---	---	11%	2%	1%	---
Bivalves	---	1%	8%	4%	---	---
Trophic Structure						
Herbivores	81%	92%	87%	97%	75%	74%
Crazing	81%	90%	83%	92%	75%	74%
Suspension feeding	---	2%	4%	5%	---	---
Carnivores	18%	89%	13%	2%	25%	26%
Active predators	5%	1%	6%	---	10%	16%
Faunal grazers	11%	4%	6%	1%	12%	10%
Parasites	2%	3%	1%	1%	3%	---

Notes:

\*Percentages calculated on basis of total number of Rissoidea.

The number in ( ) indicates the equivalent KMP station (Reference Figure I-13)

(Source: Kay 1973)

Even though the data were substantial and covered nine months of data for Mamala Bay, the coverage for Windward Oahu was limited to 4 to 6 months of data. Because of the need to establish variations which may occur over an annual cycle, additional water quality data were obtained during the Kailua Monitoring Program (KMP) during September 1971 - September 1972. The KMP survey alone included 3250 observations from about 1900 water quality samples. Location of WQPO and KMP stations are shown in Figure I-13.

Actually, many years of data are required to determine an annual average and range of water quality data, however, because of the limitation of time, and the lack of basic water quality information by the regulatory agencies, the data obtained by the City represents the best available information.

The first extensive water quality survey of Kailua Bay was undertaken by the City from July 1957 to September 1959. Water quality parameters collected were limited to specific gravity, salinity, dissolved oxygen (DO), bio-

chemical oxygen demand (BOD), and total and suspended solids from 11 offshore stations between Kapoho Point to Alala Point and from shore stations along Kailua Beach. These parameters reflected the capability of the City's laboratory at that time. Additional information on Kailua Bay waters was obtained by the City's consultant, Holmes and Narver, Inc., from October 1958 to September 1959. The consultant's water quality data included temperature, density, pH, chlorinity, DO, BOD, total and suspended solids, phosphate as phosphorus, and nitrate as nitrogen.

Depending on the station depth, samples were obtained at the surface, 1 meter (m), 2m, 4m, 8m, 16m and 32m during KMP. Water quality parameters collected included temperature, salinity, reactive and total phosphorus, nitrate and nitrite nitrogen and turbidity (secchi disc depth). The WQPO data included total phosphorus, total nitrogen, pH, salinity, temperature, turbidity (secchi disc depth and light attenuation), DO, BOD, and fecal and total coliform bacteria from the surface and the 50-foot depth. Methods of collection,

analyses, and measurements for the data are prescribed in Standard Methods (Reference 17) and by Strickland and Parsons (Reference 18).

Data during KMP were collected from 14 offshore stations located from Mokulua Island to North Beach. The WQPO survey included two nearshore stations and two offshore stations, one near Mokulua Island and the other over the existing Kailua Outfall.

## 2. Water Properties, Kaneohe Bay

Total phosphorus concentrations in Kaneohe Bay have been reported as averaging 0.003 to 0.005 mg/l (milligram per liter) with higher values (0.10 mg/l) over the Kaneohe MCAS and Kaneohe STP outfalls and in the streams. The streams forming the Kahaluu Stream averaged 0.10, 0.04, and 0.12 mg/l. No samples were collected during WQPO over the two outfalls. Near the outfalls, the average concentrations of total phosphorus were 0.060 and 0.048 mg/l. Off the Kaneohe Fishing Pier, the average concentration was 0.039 mg/l and at Kahaluu, 0.086 mg/l.

Total nitrogen concentrations over the outfalls have been reported as averaging about 0.6 mg/l with the rest of the bay averaging 0.15 to 0.20 mg/l. The three streams forming the Kahaluu Stream averaged 0.41, 0.34, and 0.24 mg/l. Results of averages obtained during WQPO were 0.345 and 0.311 mg/l near the outfalls and 0.325 mg/l at Kahaluu. Total nitrogen and total phosphorus concentrations grossly exceeded the State Water Standards (Class AA) of 0.100 mg/l and 0.035 mg/l respectively.

Dissolved oxygen levels in 1968 and 1969 generally exceeded 6.0 mg/l in most of the bay. The average concentrations over the outfalls were 6.1 and 5.9 mg/l but with lows of 4.5 and 2.3 mg/l being recorded. The streams were usually supersaturated, all the values exceeded 5.0 to 6.0 mg/l. Comparable values during WQPO indicate averages of 5.2 and 6.3 mg/l near the outfalls with recorded lows of 2.8 and 2.5 mg/l.

Temperatures reported in 1968-1969 at the outfall stations ranged from a low of 20°

Centigrade (C) in January to a high of 28.6° C in July. The three streams described previously had temperatures ranging from 19.5° C to 26.0° C. During the WQPO, temperatures near the outfalls ranged from 23.5 to 27.8° C, and the shoreline station at the mouth of the Kahaluu Stream had a temperature range of 21.1 to 27.6° C.

### 3. Water Properties, Kailua Bay

Water quality properties collected during WQPO in Kailua Bay were not significantly different from those observed by Holmes and Narver prior to the construction of the outfall. Inorganic phosphates were higher (0.003 vs. 0.013 mg p/l) but nitrates were lower (0.072 vs. 0.031 mg n/l). Only inorganic phosphates and nitrates could be compared with past data.

Total phosphorus concentrations ranged from 0.019 to 0.540 mg/l and 0.036 to 0.290 mg/l during WQPO for the offshore stations and beach stations respectively. The highest concentration (.540 mg/l) was observed at Station 40, near the existing Kailua outfall. The

maximum value recorded near Mokulua Island (Station 38) was 0.209 mg/l. During KMP, total phosphorus values ranged from 0 (Stations 11, 12, and 13) to 0.130 mg/l (Station 8, @ 8m depth). Largest variation was 0.1118 mg/l for surface waters at Stations 11 and 14. The reasons for the wide difference in maximum concentration values between the KMP and WQPO values are not known.

WQPO values for nitrogen were given in terms of nitrate, nitrites, ammonia and total nitrogen while KMP data included only nitrate and nitrites. Total nitrogen values varied from 0.054 to 0.498 mg/l and averaged 0.208 mg/l during WQPO. The average over the outfall was 0.234 mg/l. Maximum nitrates and nitrites concentrations during KMP were 0.0205 and 0.0185 mg/l respectively and the minimum recorded was 0 for both parameters.

The maximum temperature range for surface waters was 4.82° C over the outfall during WQPO, minimum and maximum values being 22.88° C and 27.70° C respectively for the bay. The maximum and minimum temperatures recorded



during KMP were 27.59° C and 22.55° C for all stations. Dissolved oxygen (DO) levels recorded during WQPO included minimum and maximum values of 5.60 and 7.50 mg/l. The average DO concentration over the outfall was 6.48 mg/l.

A summary of WQPO and KMP water quality data is shown in Tables I-IX-11 and I-IX-14. (complete discussions are listed in References 1 and 11)

TABLE I-IX-II  
WATER QUALITY DATA, KANEOHE BAY  
 1970-1971

DEPTH IS 0 FEET

	MIN.	AVE.	MAX.	RANGE	STD. DEV.
<b>STATION 41</b>					
TEMPERATURE (DEG C)	21.91	(24.91)	25.60	* 1.99*	( 0.811)
SALINITY (0/00)	26.58	(32.18)	34.68	* 6.09*	( 2.611)
OXYGEN (MG/L)	2.80	( 5.16)	7.70	* 4.90*	( 2.003)
TOTAL NITROGEN (MG/L X 0.001)	172.0	(344.0)	477.4	*305.4*	( 8.109)
TOTAL PHOSPHORUS (MG/L X 0.001)	4.9	( 8.5)	181.0	*176.1*	( 0.071)
SECCHI DEPTH (FT)	0.	( 0.0)	80.	* 78.0*	( 37.000)
PH	8.0	( 8.0)	0.0	* 0.0*	( 0.000)
BOD (MG/L)	1.6	( 4.0)	7.1	* 5.5*	( 2.072)
TOTAL COLIFORM (COLONIES/100ML)	1.1	( 6.1)	17.0	* 11.0*	( 4.49)
( 6 MONTHS OF DATA)					
<b>STATION 42</b>					
TEMPERATURE (DEG C)	23.45	(25.25)	27.80	* 4.35*	( 1.433)
SALINITY (0/00)	31.05	(31.29)	35.00	* 3.95*	( 1.474)
OXYGEN (MG/L)	2.50	( 6.31)	8.50	* 6.00*	( 2.013)
TOTAL NITROGEN (MG/L X 0.001)	107.3	(310.9)	567.0	*459.7*	( 0.161)
TOTAL PHOSPHORUS (MG/L X 0.001)	23.0	( 48.3)	123.0	*100.0*	( 0.034)
SECCHI DEPTH (FT)	3.	( 5.0)	8.	* 5.0*	( 1.870)
PH	8.9	( 8.9)	8.9	* 0.0*	( 0.000)
BOD (MG/L)	1.7	( 3.4)	4.9	* 3.2*	( 1.264)
TOTAL COLIFORM (COLONIES/100ML)	26.1	(24.1)	600.0	* 576.0*	( 207.45)
( 6 MONTHS OF DATA)					
<b>STATION 43</b>					
TEMPERATURE (DEG C)	22.65	(25.47)	28.36	* 5.71*	( 1.820)
SALINITY (0/00)	28.29	(32.67)	34.78	* 6.48*	( 2.373)
OXYGEN (MG/L)	2.80	( 5.62)	7.25	* 4.45*	( 1.376)
TOTAL NITROGEN (MG/L X 0.001)*	91.0	(255.1)	477.7	*386.7*	( 0.120)
TOTAL PHOSPHORUS (MG/L X 0.001)	15.1	( 38.7)	109.0	* 93.9*	( 0.035)
SECCHI DEPTH (FT)	2.	( 6.2)	10.	* 8.0*	( 2.861)
PH	8.9	( 8.9)	8.9	* 0.0*	( 0.000)
BOD (MG/L)	1.1	( 3.0)	5.6	* 4.5*	( 1.562)
TOTAL COLIFORM (COLONIES/100ML)	1.1	( 34.)	100.0	* 99.0*	( 46.43)
( 6 MONTHS OF DATA)					
<b>STATION 60</b>					
TEMPERATURE (DEG C)	21.06	(24.23)	27.57	* 6.51*	( 2.558)
SALINITY (0/00)	3.72	(18.21)	34.12	*30.39*	( 14.466)
OXYGEN (MG/L)	3.70	( 5.50)	7.20	* 3.50*	( 1.506)
TOTAL NITROGEN (MG/L X 0.001)	205.0	(325.2)	461.0	*256.0*	( 0.090)
TOTAL PHOSPHORUS (MG/L X 0.001)	15.0	( 86.3)	131.9	*116.9*	( 0.051)
SECCHI DEPTH (FT)	3.	( 3.0)	5.	* 2.0*	( 0.942)
PH	9.0	( 0.0)	0.0	* 0.0*	( 0.000)
BOD (MG/L)	0.9	( 2.1)	4.0	* 3.1*	( 1.138)
TOTAL COLIFORM (COLONIES/100ML)	3800.1	(36700.1)	110000.0	* 106700.0*	( 42883.21)
( 5 MONTHS OF DATA)					

DEPTH IS 25 FEET

	MIN.	AVE.	MAX.	RANGE	STD. DEV.
<b>STATION 41</b>					
TEMPERATURE (DEG C)	25.35	(29.35)	25.35	* 0.00*	( 0.000)
SALINITY (0/00)	33.54	(33.54)	33.54	* 0.00*	( 0.000)
OXYGEN (MG/L)	2.70	( 2.70)	2.70	* 0.00*	( 0.000)
TOTAL NITROGEN (MG/L X 0.001)	196.0	(196.0)	196.0	* 0.00*	( 0.000)
TOTAL PHOSPHORUS (MG/L X 0.001)	27.5	( 27.5)	27.5	* 0.00*	( 0.000)
SECCHI DEPTH (FT)	0.	( 0.0)	0.	* 0.0*	( 0.000)
PH	0.0	( 0.0)	0.0	* 0.0*	( 0.000)
BOD (MG/L)	0.0	( 0.0)	0.0	* 0.0*	( 0.000)
TOTAL COLIFORM (COLONIES/100ML)	0.0	( 0.0)	0.0	* 0.0*	( 0.000)
( 1 MONTHS OF DATA)					

TABLE I-IX-12  
WATER QUALITY DATA, KAILUA BAY  
 1970 - 1971

DEPTH IS 0 FEET

	MIN.	AVE.	MAX.	RANGE	STD. DEV.
<b>STATION 38</b>					
TEMPERATURE (DEG C)	23.91	(25.86)	27.28	* 3.36*	( 1.235)
SALINITY (0/00)	0.45	(27.70)	34.84	*34.39*	( 13.633)
OXYGEN (MG/L)	5.60	( 6.22)	7.30	* 1.70*	( 0.657)
TOTAL NITROGEN (MG/L X 0.001)	68.2	(184.5)	275.0	*706.8*	( 0.300)
TOTAL PHOSPHORUS (MG/L X 0.001)	19.0	( 97.1)	209.0	*170.0*	( 0.072)
SECCHI DEPTH (FT)	25.	( 36.1)	50.	* 25.*	( 8.926)
PH	0.0	( 0.0)	0.0	* 0.0*	( 0.000)
BOD (MG/L)	0.2	( 0.6)	1.2	* 1.0*	( 0.499)
TOTAL COLIFORM (COLONIES/100ML)	0.1	( 0.1)	0. *	* 0.*	( 0.001)
					( 5 MONTHS OF DATA)
<b>STATION 39</b>					
TEMPERATURE (DEG C)	22.63	(26.33)	30.82	* 8.19*	( 2.496)
SALINITY (0/00)	23.16	(28.82)	37.00	* 9.86*	( 3.637)
OXYGEN (MG/L)	3.50	( 6.45)	9.00	* 5.50*	( 1.754)
TOTAL NITROGEN (MG/L X 0.001)	120.0	(394.1)	635.2	*515.2*	( 0.178)
TOTAL PHOSPHORUS (MG/L X 0.001)	36.0	(144.1)	290.0	*254.0*	( 0.103)
SECCHI DEPTH (FT)	2.	( 2.1)	3.	* 1.*	( 0.500)
PH	8.6	( 8.8)	8.8	* 0.0*	( 0.000)
BOD (MG/L)	0.2	( 3.2)	5.8	* 5.6*	( 2.987)
TOTAL COLIFORM (COLONIES/100ML)	1.1	(0.1)	240. *	*239.*	(106.45)
					( 6 MONTHS OF DATA)
<b>STATION 40</b>					
TEMPERATURE (DEG C)	22.88	(25.82)	27.70	* 4.81*	( 1.597)
SALINITY (0/00)	33.16	(34.23)	34.75	* 1.59*	( 0.550)
OXYGEN (MG/L)	5.60	( 6.68)	7.50	* 1.90*	( 0.605)
TOTAL NITROGEN (MG/L X 0.001)	54.3	(244.2)	498.0	*441.7*	( 0.160)
TOTAL PHOSPHORUS (MG/L X 0.001)	28.0	(209.9)	540.0	*411.9*	( 0.200)
SECCHI DEPTH (FT)	10.	( 17.1)	25.	* 15.0	( 5.571)
PH	6.0	( 0.0)	0.0	* 0.0*	( 0.000)
BOD (MG/L)	0.5	( 1.1)	1.7	* 1.2*	( 0.422)
TOTAL COLIFORM (COLONIES/100ML)	5.1	(0.1)	1400. *	*1395.*	( 697.50)
					( 5 MONTHS OF DATA)
<b>STATION 59</b>					
TEMPERATURE (DEG C)	25.89	(26.98)	29.24	* 3.54*	( 1.343)
SALINITY (0/00)	9.33	(22.35)	34.01	*24.68*	( 8.776)
OXYGEN (MG/L)	1.40	( 4.14)	6.20	* 4.80*	( 1.742)
TOTAL NITROGEN (MG/L X 0.001)	290.0	(372.2)	425.6	*135.6*	( 0.058)
TOTAL PHOSPHORUS (MG/L X 0.001)	50.2	(137.9)	255.0	*204.8*	( 0.086)
SECCHI DEPTH (FT)	1.	( 7.1)	3.	* 2.*	( 0.942)
PH	0.0	( 0.0)	0.0	* 0.0*	( 0.000)
BOD (MG/L)	0.6	( 2.8)	4.6	* 4.0*	( 1.663)
TOTAL COLIFORM (COLONIES/100ML)	100.1	( 1633.1)	2700. *	*2600.*	(1111.55)
					( 4 MONTHS OF DATA)

DEPTH IS 50 FEET

	MIN.	AVE.	MAX.	RANGE	STD. DEV.
<b>STATION 40</b>					
TEMPERATURE (DEG C)	22.89	(22.89)	22.89	* 0.00*	( 0.000)
SALINITY (0/00)	33.14	(33.14)	33.14	* 0.00*	( 0.000)
OXYGEN (MG/L)	6.80	( 6.80)	6.80	* 0.00*	( 0.000)
TOTAL NITROGEN (MG/L X 0.001)	177.0	(177.0)	177.0	* 0.00*	( 0.000)
TOTAL PHOSPHORUS (MG/L X 0.001)	23.0	( 23.0)	23.0	* 0.00*	( 0.000)
SECCHI DEPTH (FT)	0.	( 0.1)	0.	* 0.0*	( 0.000)
PH	0.0	( 0.0)	0.0	* 0.0*	( 0.000)
BOD (MG/L)	0.0	( 0.0)	0.0	* 0.0*	( 0.000)
TOTAL COLIFORM (COLONIES/100ML)	0.1	( 0.1)	0. *	* 0.*	( 0.001)
					( 1 MONTHS OF DATA)

TABLE I-IX-13  
ANNUAL RANGE OF WATER QUALITY, KAILUA BAY, OAHU  
SEPT. 1971 - JUL. 1972

DEPTH(m) (station)	TEMPERATURE °C		SALINITY ‰		REACTIVE PHOSPHORUS mg/lx10 <sup>-3</sup>		TOTAL PHOSPHORUS mg/lx10 <sup>-3</sup>		NITRATE mg/lx10 <sup>-3</sup>		NITRITE mg/lx10 <sup>-3</sup>	
	max	min	max	min	max	min	max	min	max	min	max	min
0 (station)	27.59 (11)	22.55 (1,2)	35.31 (11)	33.80 (3)	55.9 (11)	0.5 (2)	119.6 (14)	5.8 (1)	19.3 (11)	0.3 (6,8, 9,11)	6.5 (11)	0.3 (1-4,6, 8-11,13)
1	26.62 (11)	25.61 (1)	34.69 (10)	34.29 (3)	325.0 (6)	0 (7,11, 12,13)	77.0 (7)	0 (11, 12,13)	6.5 (2)	0 (11, 12,13)	2.9 (1)	0 (11,12,13)
2	27.54 (11)	22.48 (2)	35.54 (9)	33.96 (1)	55.9 (11)	0.5 (4)	101.4 (8)	14.3 (4)	20.5 (11)	0.3 (8,13)	4.9 (11)	0.1 (9)
4	26.86 (13)	20.06 (12)	34.52 (11)	34.11 (2)	23.4 (14)	0 (10,11)	87.1 (1)	0 (10,11)	11.5 (5)	0 (10,11)	3.9 (1)	0 (10,11)
8	26.29 (3)	22.39 (1,8)	35.29 (4)	34.02 (2)	14.3 (7)	0.6 (1,6)	130.0 (8)	16.9 (2,14)	7.3 (14)	0.3 (6,8)	3.1 (3,7)	0.3 (1,2,3,4, 6,7,14)
16	26.14 (6)	22.33 (2)	35.24 (5,7)	34.03 (1)	22.1 (5)	1.3 (1)	85.8 (2,6)	18.2 (7)	18.5 (5)	0.3 (2,6)	18.5 (5)	0.2 (5)
32	25.84 (6)	22.36 (6)	35.21 (4)	34.19 (3)	10.4 (3,6)	1.3 (6)	85.8 (4)	16.9 (4)	7.5 (3)	0.5 (6)	3.9 (4)	0.3 (6)

NOTE: Values underlined indicate the maximum and minimum for each property considering all depths. The number in ( ) indicate the station (reference Figure 1-13). Values from all stations.

(SOURCE - KMP)

TABLE I-IX-14  
ANNUAL AVERAGE OF WATER QUALITY, KAILUA BAY, OAHU  
SEPT. 1971 - JUL. 1972

DEPTH(m)	TEMPERATURE °C		SALINITY ‰		REACTIVE PHOSPHORUS mg/lx10 <sup>-3</sup>		TOTAL PHOSPHORUS mg/lx10 <sup>-3</sup>		NITRATE mg/lx10 <sup>-3</sup>		NITRITE mg/lx10 <sup>-3</sup>	
	warmest	coldest	highest	lowest	greatest	least	greatest	least	greatest	least	greatest	least
0	25.19 (11)	24.27 (2)	34.71 (11)	34.49 (1)	12.9 (11)	5.0 (1)	46.0 (12)	37.1 (5)	4.4 (11)	2.7 (2,10)	1.7 (11)	0.7 (10)
1	26.62 (11)	25.76 (4)	34.69 (10)	34.29 (3)	325.0 (6)	0 (11,12,13)	77.0 (2)	0 (11,12,13)	6.5 (2)	0 (11,12,13)	2.1 (5,9)	0 (11,12,13)
2	24.93 (11)	24.07 (14)	34.80 (9)	34.50 (1)	12.0 (11)	4.1 (4)	49.6 (11)	32.1 (14)	5.4 (2,11)	2.6 (6,13)	2.2 (2)	0.4 (7)
4	26.64 (11)	23.75 (12)	34.76 (8)	34.52 (11)	8.0 (12)	0 (10,11)	44.9 (2)	0 (10,11)	5.5 (9)	0 (10,11)	1.2 (1,2)	0 (10,11)
8	25.38 (13)	23.47 (12)	34.82 (13)	34.60 (1)	7.9 (8)	3.9 (12)	65.0 (12)	36.9 (5)	6.7 (12)	2.3 (8)	1.5 (12)	0.8 (2,4)
16	24.84 (13)	23.97 (3)	34.75 (7)	34.55 (13)	13.0 (8,13)	4.3 (7)	66.3 (8)	35.1 (7)	6.5 (13)	2.9 (2)	3.1 (5)	0.3 (8,13)
32	25.13 (1)	23.87 (3)	34.72 (4,6)	34.37 (1)	10.4 (1)	4.9 (4)	62.7 (1)	35.2 (6)	4.4 (3)	2.2 (6)	2.1 (1)	0.7 (6)

NOTE: Values underlined indicate the maximum and minimum for each property considering all depths. The number in ( ) indicate the station (reference Figure 1-13). Values from all stations.

(SOURCE - KMP)

## X. DEVELOPMENT OF MARINE DISPOSAL PARAMETERS

### A. General

The discharge of wastes into receiving waters may affect the ecology in various ways. Almost all waste discharges contain some biostimulatory as well as inhibitory substances. Biostimulatory substances include nitrogen, phosphorus, carbon, iron, vitamins, and growth factors; inhibitory substances include pesticides, metals, phenols, cyanides, and hydrocarbons. Nutrients present in waste discharges can be utilized by phytoplankton through photosynthesis. With zooplankton serving as links, they in turn affect other trophic levels such as the carnivorous nektonic organisms. These changes may not be desirable in some receiving waters because they can cause excessive algae growth in bays, estuaries, etc., but may be beneficial in others; i.e., nutrients deficient waters.

Inhibitory substances in waste discharges can kill some organisms immediately, or they can stifle growth in others. Desirable organisms may be replaced by less desirable organisms, resulting in a different and less desirable aquatic ecosystem. Other undesirable aspects of waste discharges are turbidity,

which can affect aquatic ecosystems by changing the optical properties of receiving waters, and floatable materials that affect the aesthetic quality of a water. Liquid floatables (oil and petroleum products) are also often toxic to marine organisms.

Fish and other marine life depend on light directly in the search of food as well as indirectly since light serves as a source of energy for the production of their food by the photosynthesis process. Light also acts as stimuli affecting the grazing habits of zooplankton.

Floatable materials removal by waste treatment systems is extremely important since floatables affect the aesthetics of receiving waters. Materials that are not removed by a treatment plant can appear on the water surface and will be subjected to wind-induced currents, often toward shore.

Marine disposal parameters were developed with the help of special studies, conducted during the WQPO to predict and evaluate wastewater discharges on the ecology and aesthetics of coastal receiving waters. These special studies included work on biostimulation, benthic communities, color and turbidity, floatables, odor, settleables, and toxicity. Studies on biostimulation and toxicity were conducted at Coconut Island by scientists of the

Hawaii Institute of Marine Biology.

The specific objectives of the special studies were--

1. to determine criteria with which to judge the toxic effects of various waste discharges upon aquatic biota and to determine the relative toxicity of effluent from different waste treatment processes,
2. to evaluate and quantify the effect of a waste discharge on the benthic communities of the receiving waters,
3. to determine through laboratory analyses the biostimulatory effects of waste discharge on algae production in receiving waters,
4. to determine the required removal of floatable materials from waste streams prior to discharge such that the aesthetic qualities of the receiving waters are not impaired,
5. to evaluate the effects of waste discharges on the color and turbidity of receiving waters,
6. to determine the concentrations of settleable materials being discharged into coastal receiving waters and to evaluate the effect of these materials upon the marine biota, and
7. to evaluate the effect of waste discharges on the odor of receiving waters and to determine the



usefulness of odor as a criterion for the protection of aesthetic uses.

Detailed procedures and techniques employed in the special studies are shown in the Work Area Study Report of WQPO (Reference 1). Only a summary and conclusions are given here.

#### B. Toxicity

1. The toxicity of a given wastewater discharge was found to be characteristic of the discharge and was not predictable on the basis of treatment. For instance, Kaneohe WWTP effluent (secondary) was more toxic than Pearl City WWTP effluent (primary) which in turn was more toxic than the Sand Island discharge (raw).
2. Of the three principal test organisms, coral planulae were the most sensitive to the wastewaters assayed, followed by damsel fish and tilapia.
3. The toxicity of a waste was not predictable from its BOD, phosphorus, or ammonia concentrations. Ammonia appeared to have been one of the more important toxic components of the wastewaters although there was insufficient evidence to warrant specific treatment for its removal from effluents to reduce toxicity.

4. Secondary treatment appeared to reduce the toxicity of the wastewaters. For example, both Kaneohe and Kailua influents were more toxic than the effluents.
5. Recommended "safe" dilutions for effluent were determined to be as follows:

Indigenous fish	1 : 45 dilution
Coral planulae (in estuary)	1 : 420 dilution

C. Benthic Communities

1. Benthic organisms are particularly well suited for evaluating effects of wastewater discharges because of their lack of mobility and their subjection to the longer term integrated effects of discharges.
2. Sediment BOD, bicarbonate extractable phosphorus, and total nitrogen (ammonia plus organic) concentrations in excess of 0.5, 0.05, and 0.6 mg/gm (dry weight) respectively were consistent with immature or unstable open ocean benthic communities.
3. The settleable component of waste discharges apparently causes most of the changes in nearby benthic communities.
4. Benthic animal communities outside a 300-acre area around the Sand Island raw sewage discharge

were not measurably affected by the discharge.

5. Sewage treatment designed to substantially reduce the settleable materials fraction should reduce significantly the bottom area affected by municipal discharges.

#### D. Biostimulation

1. Nitrogen appears to be the limiting nutrient in the coastal waters of Oahu.
2. Restraints on assimilation and growth of tested alga species were removed when inorganic nitrogen concentrations were in excess of 0.007 mg N/l (milligram nitrogen per liter).
3. The near shore coastal waters of Oahu generally exceed this value (0.007 mg N/l), hence removal of nitrogen by treatment may not prevent or limit alga growth.
4. Wastewater discharges should be diverted from estuaries and bays into open ocean waters to obtain maximum dilution and prevent excessive concentrations of biostimulatory substances.

#### E. Floatables

1. Existing primary and secondary (trickling filter) plants remove about 55 and 65 percent respectively of the influent floatable materials.
2. Floatables concentrations below 1.5 mg/m<sup>2</sup> (mil-

ligram per square meter dry weight) in the receiving waters do not appear to be objectionable.

3. Removal of a total of 60 percent of the floatable materials in the influent wastewater by appropriate treatment should prevent aesthetic degradation in the receiving waters. The 60 percent total includes a removal efficiency of 95 percent of large persistent particles, 65 percent of small persistent particles, and 0 percent of non-persistent particles.

#### F. Settleables

1. (See notation 3 under Benthic Communities).
2. Where municipal wastewater discharges of predominantly domestic sewage are concerned, chlorinated hydrocarbons and heavy metals deposition in bottom sediments of marine waters are relatively minor.

#### G. Color and Turbidity

1. The suspended solid content of municipal wastewater controls the amount of light absorbed.
2. Secondary (trickling filter) treatment can remove significant amounts of light absorbing substances.

## H. Odors

To eliminate odors in the discharge areas, the following dilutions are required (without chlorination):

Raw sewage (Sand Island)	1 : 130
Primary treatment (Pearl City)	1 : 28
Secondary treatment (Kaneohe)	1 : 13

## I. Water Quality Control Systems

Consideration of the water quality objectives, the results of the oceanographic surveys, special studies made during the WQPO, and the evaluation of a variety of alternative systems led to the formulation of general design objectives for a "best" system. The objectives are summarized as follows:

1. Provide for the immediate alleviation of the most serious existing water quality problem areas; viz, Mamala Bay, Kaneohe Bay and Pearl Harbor.
2. Utilize to an appropriate degree the dilution capabilities of the open coastal waters of Oahu.
3. Design all physical facilities for maximum flexibility.
4. Provide for wastewater reclamation wherever feasible.

5. Provide for the maximum realization of the beneficial uses of the waters of Oahu.

Based on the design objectives, the following alternative water quality control systems were evaluated for the Kaneohe-Kailua district:

1. Advanced primary treatment with ocean disposal at depths to maintain a submerged field.
2. Secondary treatment with ocean disposal to depths of 80-100 feet.
3. Secondary treatment within estuarine or fresh-water disposal.
4. Secondary treatment with reuse of the effluent.
5. Secondary treatment with ground (subsurface) injection.
6. Tertiary (advanced) treatment.

Further discussions on the foregoing water quality control systems are presented under Part II.

## XI. OCEAN OUTFALL DESIGN

### A. General

The present engineering practice of disposing of wastewater effluent into the ocean is to utilize a long series of ports along a straight diffuser pipe. The resulting discharge is in a form of a rising plume. If the initial discharge is small, there will be good jet mixing resulting in high initial dilution. In addition, if the ocean is sufficiently stratified in density, the plume may not rise to the surface of the ocean but will be suspended below at an intermediate level. A large plume is formed when the flow is discharged from the end of a large open pipe such as the existing Kailua outfall sewer regardless of density stratification.

The major factors which influence the design of an ocean outfall are ocean currents, density stratification, winds, tides, bacterial decay-rate, height and period of waves, water quality standards, degree of treatment, benthic community, bathymetry and hydraulic consideration. These factors have been discussed elsewhere in this statement; however, some elaboration will be presented here.

## B. Ocean Currents

General offshore and nearshore ocean circulations and the determination of baseline water quality for the island of Oahu were made during WQPO. The main thrust of the investigation was concentrated in Mamala Bay off Sand Island and Barbers Point, and Kailua Bay off Mokapu Peninsula. A substantial amount of additional data were collected during KMP.

Ocean current data collected in-situ during WQPO included 1213 hourly measurements during January - February 1971 at Station "X" and "Q" at the water layer of 30 feet in 70-foot depth. Fourteen hourly measurements (frequency of occurrences, 1.15 percent) were recorded in the  $180^{\circ}$  -  $209^{\circ}$  magnetic sector but none in the  $210^{\circ}$  -  $359^{\circ}$  magnetic sector which would be directly onshore based on the location of stations. The maximum current recorded in the  $180^{\circ}$  -  $209^{\circ}$  magnetic sector was 0.73 knots at  $200^{\circ}$  magnetic at Station X. A current of this magnitude would require over two hours of transport time to shore from this station. The net transport at Station X was generally east-southeast (offshore) at  $117$  magnetic at 0.25 knots. During this period, (February 5-21, 1971) Kona winds prevailed with



some period of light trade winds. When the winds shifted to strong trade winds, the net transport was to the north. Net transport and velocity at Station "Q" between January 8-30, 1971 and February 5-16, 1971 were  $128^{\circ}$  magnetic at 0.45 knots and  $136^{\circ}$  magnetic at 0.65 knots respectively.

Data observed at Station C, the outfall terminus taken during KMP during 1971 and 1972 included 1289 hourly observation at the 75-foot layer, and 1352 for the 23-foot layer. Bottom depth was 105 feet. Currents directions between  $210^{\circ}$  -  $289^{\circ}$  magnetic, between Kapoho Point and Mokapu Point occurred 18.2 percent of the time at the 23-foot water layer and 10.2 percent at the 75-foot layer. Currents directly onshore between  $240^{\circ}$  -  $289^{\circ}$  magnetic were 10.5 percent at the 23-foot layer and 2.7 percent at the 75-foot layer.

Since the effluent field would rise toward the surface immediately after leaving the discharge ports, the upper layer currents would play the dominant role in the diffusion of the field. Combining WQPO and KMP data for the 23-30-foot layer, the frequencies of occurrence of the currents in the  $210^{\circ}$ - $239^{\circ}$ ,  $240^{\circ}$ - $269^{\circ}$ , and  $270^{\circ}$ - $289^{\circ}$  mag. sectors were 4.0 percent,

3.2 percent, and 2.4 percent respectively. The 50 percent (average) and 90 percent velocities of the onshore current between Kapoho Point to Mokapu Point was 0.2 knots and 0.4 knots respectively. The average and 90 percent velocities of the direct onshore currents between the base of the outfall and Mokapu Point varied from 0.3 knots to 0.4 knots respectively.

Nearshore currents at the 23 feet layer at the midpoint of the proposed outfall (Station D) indicated a frequency of 27.9 percent in the direction between Kapoho Point to Mokapu Point. This is about three times the frequency of occurrence in deeper waters (9.6%). The average and 90 percent velocities at Station D were 0.4 knots and 0.5 knots respectively. For design purposes, a maximum onshore current of 0.80 knots was used.

### C. Waves

To protect the structural stability of the ocean outfall during construction and after its placement, the maximum possible waves that it would be exposed to were determined. Using data on operational wave heights, periods, and percent of time of occurrence, collected by Marine Advisers (Reference 19) and

calculations by Koh (Reference 20) on the two worst hurricanes on record to affect the Oahu area (NINA - 1957, and DOT - 1959), the following wave characteristics were developed for the design of the outfall sewer.

	<u>Stationary Hurricane</u>	<u>Moving Hurricane</u>	<u>Hurricane NINA Dec. 1957</u>
$V_f$ , Knots	0	23.5	
$H_s$ , Feet	20.4	29	26
$H_{max}$ , Feet	41	48	
$T_s$ , Seconds	9.6	11.4	12

Based on these characteristics, the recommended design deep water wave for the outfall was obtained. The results are listed below.

	<u>Perpendicular to Pipeline</u>	<u>Parallel to Pipeline</u>
Significant wave height (ft.)	27.0	25.0
Significant wave period (sec.)	11.7	11.4
Maximum wave height (ft.)	46.0	43.0

The zone of breaking for the design wave is situated at about the 55-foot water depth. To protect the pipeline, rock ballast of approximately 36-inches in diameter would be required. Since the ballast size is too large to be practical, the City's con-

sultants recommended that the line be buried through the surf zone to a water depth of about 80 feet.

#### D. Density Stratification

Density profiles in Figure I-45 show the results of three observations in Kailua Bay at Station R during November, 1970, January 1971 and February 1971. The density gradient at Kailua was not well defined from the surface to the 600-foot depth. The isothermal layer was estimated at 400 feet at minimum stratification compared with 250 feet at Sand Island in Mamala Bay. At a discharge depth of about 300 feet, the field at Kailua would surface while it would be submerged throughout most of the year at Sand Island.

From a practical construction standpoint, it is presently not feasible to construct an outfall beyond the 300-foot depth to obtain the benefits of field submergence. Hence, secondary treatment and a discharge depth of 100 feet was the recommended treatment and disposal scheme for the Mokapu Outfall.

#### E. Winds

The influence of winds on current circulation has been described in classical literature on oceanography. The average annual wind frequency diagrams for Windward Oahu are shown in Figure II-12. The modal value of wind speeds is about 12 to 14 knots. Trade winds predominate with frequencies exceeding 90 percent. Kona winds can occur throughout the year but are generally prevalent during October to April.

During most of the year, the winds blow onshore on the windward side. The effects of wind direction on currents and floatable materials in an ocean discharge are of great interest to engineers. During WQPO, it was determined that surface currents to the 20-foot layer are greatly influenced by the onshore winds in the bay especially as it nears the proximity to the shoreline. In deeper waters, wind effects on net transport diminishes. Current observations at the 30-foot depth in 60 to 70 feet of water (Station X) during mixed tradewind and Kona winds in January and February 1971 show that the transport was parallel to the coastline at the 30-foot depth. During periods of strong tradewinds, the surface to 50-foot layer may move more to the shore. During these conditions

(late spring, summer, and early fall) the off-shore (greater than 100-foot depth) net transport has been observed to move northward, away from Kailua Bay toward Mokapu Point.

#### F. Bacteria Decay Rate

To determine the probable bacterial concentration at the disposal site, a T-90 value of 1.0 hour was used in the design of the outfall. This is a conservative value, considering that field studies off Sand Island indicate that for Oahu's oceanic waters, the T-90 value for the summer varied between 9 to 18 minutes and for the winter it was 15 minutes. An earlier experiment in Kailua Bay showed that approximately 99 percent of the bacterial population were killed during the first 10 minutes of exposure to the bay waters.

#### G. Diffuser Design

The diffuser system of the proposed outfall would consist of 80 side ports and 2 end ports on a 963-foot section at the end of 4093 feet sewer for a total length of about a mile. Depth of the diffuser section would vary from 90 feet to 105 feet. The average port depth will be 98 feet. The side ports

are spaced 12 feet on center, alternating along the springline (middle) of the pipe with port diameters ranging from 5½ inches to 4 inches. The size and location of the ports are arranged to yield a uniform discharge along the entire length of the diffuser section at different flow conditions. To accomplish uniformity of discharge, a hydraulic characteristic, the smaller 4-inch ports are located at the shoreward end of the diffuser since port discharge is influenced by depth and hydraulic losses.

Assuming calm water conditions, the diffuser design will provide for an initial dilution of 200 to 1 under average flow conditions. The initial dilution for peak wet weather flows will be 100 to 1. Peak wet weather flows will occur about 5 percent of the time.

## XII. VIRUS HAZARD

### A. General

In addition to bacteria and other pathogenic agents, large quantities of viruses of human origin are found in sewage and sewage effluent. Compared with the number of bacteria excreted from humans, the amount of viruses are small; however, their importance lies not in their numerical number but their ability to produce infection in man. Because of this capability, there is sufficient justification for seeking the total removal of viruses from any water which man might consume. Potable water supplies should be entirely devoid of viruses.

The combined effluent of the Kailua, Kaneohe, KMCAS, and proposed plant at Kahaluu will undoubtedly contain viruses which will be discharged offshore of Mokapu Peninsula. The process of virus isolation and identification is now underway for the Mililani and Wahiawa treatment plants. Because of the limited laboratory capability of the virus laboratory at the University of Hawaii, the examination of the effluent for number and kinds of viruses at the three existing Windward



plants has not been possible. From the public health aspect, there is insufficient epidemiological evidence at this time to seek complete or partial removal of all viruses for ocean discharges.

The average enteric virus density has been calculated by Clarke, et al. (Reference 21) to be about 500 virus units per 100 ml in domestic sewage and one virus unit per 100 ml in polluted surface (fresh) water. Coliform-virus ratios in sewage has been estimated to be 92,000 to 1 and 50,000 to 1 in polluted surface water.

These ratios may not be necessarily applicable to the Mokapu Peninsula discharge. However, on the basis of these aforementioned ratios, coliform bacteria are by far the better indicator of pollution (in terms of numbers) than are enteric viruses.

Shuval and his co-workers (Reference 22) reported virus concentrations in raw sewage average 664 plaque-forming units per liter (PFU/l) and concentrations as high as 60 PFU/l in highly contaminated seawater off Tel Aviv. Using values of median coliform concentrations found in his

report, the coliform-virus ratio for raw sewage and highly polluted seawater was 7,000,000 to 1 and 400,000 to 1 respectively. Shuval also reported enteriophages in samples where the mean coliform MPN was 460/100 ml. This means that coliform bacteria counts of 2400/100 ml, considered acceptable for swimming, may still contain enteriophages.

#### B. Pollution Indicator Index

Bacteriologists have used indicator organisms of the coliform group rather than pathogens to ascertain the sanitary quality of water for dietetic, domestic, or recreational uses for more than 70 years. Indicator organisms are used for this role because of their occurrence with disease-producing agents, ease of detection and enumeration, and their prolonged survival rate (in fresh water). The coliform group remains the principal indicant of contaminated water although *Aeromonas*, *Pseudomonas*, *Candida* and *Staphylococci* microorganisms are also suitable indicator organisms.

The microbiological requirements of the State's water quality standards (Reference 23) do not specify the "safe" number of viruses in the re-

may be present. Absence of coliform, however, may not mean that virus is absent. The coliform index, therefore, while a good laboratory tool is not a reliable index for viruses."

### C. Sampling Procedures

Sampling and detection procedures for viruses in water were inadequate at the commencement of the WQPO (April 1970) and KMP (September 1971). The ASCE report (Reference 24) stated that the prior method of sampling for viruses in water was the suspension of a pad of gauze into a flowing stream. The grab sample technique was also used but allowed only small volume samples. Using these sampling methods, highly contaminated waters, including sewage, frequently failed to yield viruses by the detection procedures available. The present procedures (1970) includes (1) passing water through a Millipore filter and (2) "Phase Separation Method" developed by Shuval and his co-workers. These procedures are being modified for work in the field.

The WQPO report as well as current monitoring studies by the City do not provide any data on viruses in sewage discharges because of the pre-

sent state of the art. The Department of Public Works and the Board of Water Supply recently (1972) established a virus laboratory at the University of Hawaii. The laboratory was established to monitor percolates as part of the study on the recycling of sewage for cane irrigation. The study is in its second year. Refinement of present practices is continuing which will permit the City to include the analysis of viruses in sewage effluents and in receiving waters in other areas. It is hoped that routine virus analysis can be made at the University of Hawaii within three years. Funding for the virology laboratory beyond the recycling study at the University should be made by the State.

D. Sewage Treatment Removal

Conventional wastewater treatment plants are not designed to remove viruses and complete removal does not occur. Primary settling removes little viruses (0-3 percent removal in 3 hours). Removal efficiencies of secondary activated sludge process are up to 90 percent. No data of trickling filter process removal are available in the literature, however, efficiencies will be sub-

stantially less than activated sludge process. A virus-free effluent can be obtained from activated sludge effluent by terminal disinfection by chlorine.

There is no information on the removal efficiencies of viruses at the existing trickling filter plants at Kaneohe, Kailua, and KMCAS but it is fairly certain that viruses are present in the effluent after treatment. Chlorination facilities are available at all three plants for disinfection of the effluent. The Department of Health regulation provides for a total chlorine residual of 0.5 mg/l with a detention time of 15 minutes for the disinfection of sewage effluent. Actual practice at the two city's plants indicate a total chlorine residual of 0.5 to 1.0 mg/l with a detention time in excess of 30 minutes, greatly exceeding the State's requirements. It is not likely that breakpoint chlorination will be practiced at these plants even after the trickling filter plants are converted to activated sludge plants because of the constraints of costs and the lack of an apparent need with respect to potential health hazards from viruses.

#### E. Virus Decay Rate

The earliest known work on decay rate of viruses in seawater was reported in Nice in 1961. This process has been observed and reported on the Atlantic Ocean, North Sea, Baltic Sea, Mediterranean Sea and Red Sea. The finding of Shuval, et al. (Reference 22) reported marine anti-viral activity (MAVA) average coefficient of inactivation of polluted and unpolluted waters from the Mediterranean and Red Sea of 4.1 and 2.7 respectively. Shuval reported that enterioviruses are more resistant to inactivation in seawater than coliform bacteria, the classical pollution indicator organism, and the T-90 value of poliovirus in seawater appears to be about 48 hours at 15 degree C.

Since there are wide variations in the T-90 values of coliform bacteria in seawater (3 hours off Southern California versus a T-99 rate of decay of 10 minutes at Kailua Bay as an example), there is also the likelihood that the T-90 values of viruses vary at different locations. To apply the T-90 value off Tel Aviv to waters off Mokapu Peninsula is not logical. Since virus T-90 values

in seawater have not been reported elsewhere, we are not in a position to determine hypothetically the effects of viral decay rates off Mokapu Peninsula on the bathing beaches off Kailua Bay. Field studies must be delayed pending the availability of a facility and personnel for detecting viruses in the State.

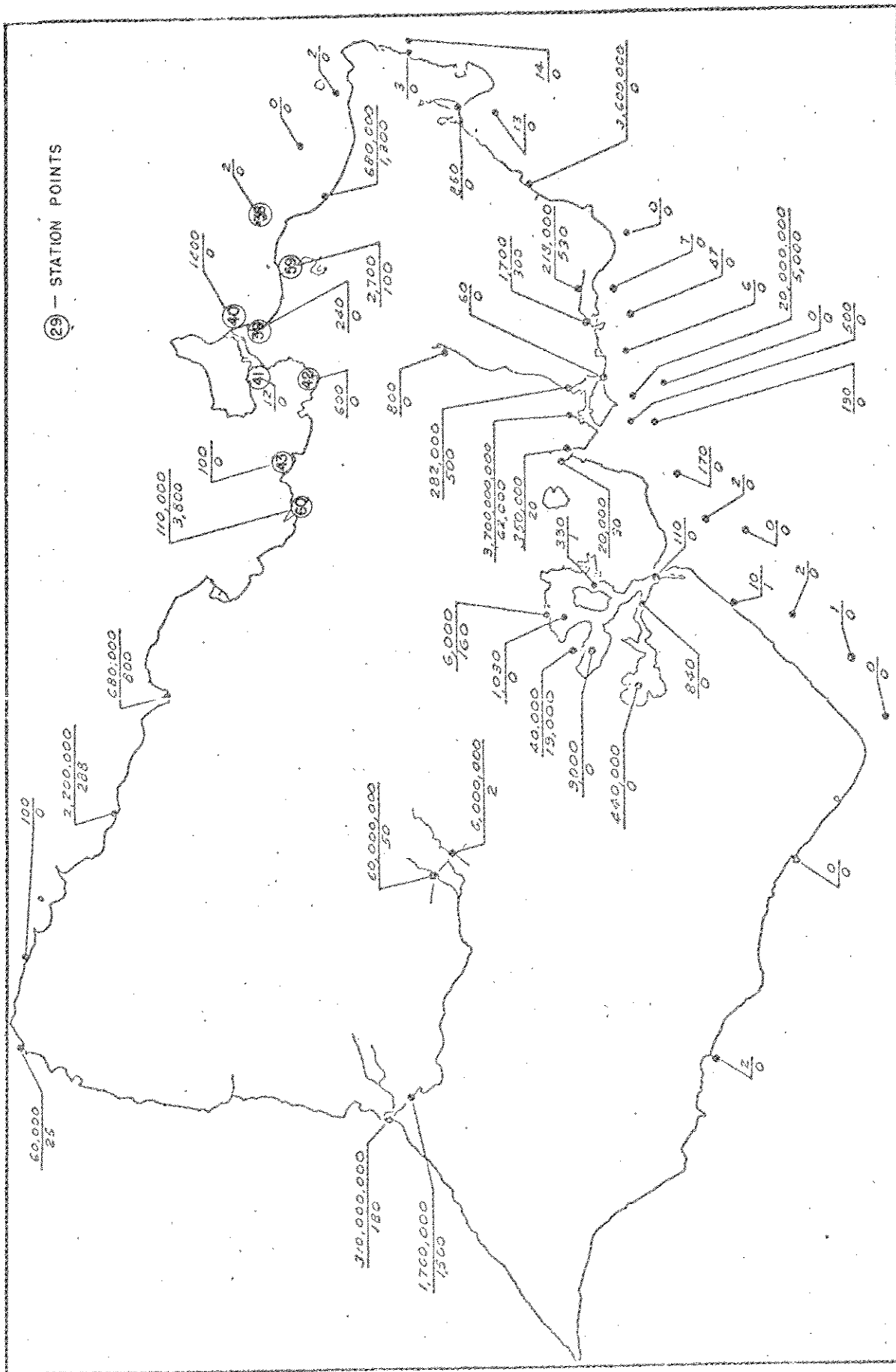
Relative survival of viruses and bacteria in water is very difficult to assess from the data available (Reference 24). Viruses survive longer in seawater (Reference 22), but coliforms have been shown to survive longer than certain enteric viruses in other waters. Before useful generalization and assessment on relative survival time of viruses off Mokapu Peninsula can be made, additional data, including field sampling are needed.

### XIII. BACTERIOLOGY

#### A. General

The coliform group which includes the predominant Escherichia Coli and Aerobacter Aerogenes has been used as bacteria indicators for pollution for the past seventy years. Coliform bacteria are generally non-pathogenic to humans and are found abundantly in soils, vegetation, water and milk and the intestinal tract of humans and animals. E. coli strains are usually, but not always, of fecal origin and A. aerogenes strains are usually, but not always of soil, vegetable, or other non-fecal origin. Total coliform determination includes both fecal and non-fecal strains. Standard methods developed for their detection include the multiple tube and membrane filter methods. Results of the multiple-tube method are expressed in terms of the most probable number (MPN) per 100 milliliters (ml). Membrane filter results are given in number of bacteria per 100 ml. Details for these tests are found in Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971 (Reference 17).





Maximum and Minimum Total Coliform Count/100 ml Observed - June 1970 to February 1971 around Oahu at 60 Ocean, Shoreline, and Fresh Water Stations.

Figure I-51

The former was located near Mokulua Islands and the latter over the existing Kailua outfall sewer. The Kaneohe Bay's stations included 41 at the KMCAS Pier, 42 at the Kokokahi Pier, 43 at Heeia Marina and 60 at the mouth of the Kahaluu Stream at the bridge.

The data collected during WQPO indicate that the microbiological requirements of the offshore stations are being met, including Stations 38 and 40 (See Table I-XIII-1). Surprisingly, results from shoreline stations indicated good sanitary quality waters except for the Kahaluu Stream where the mean total coliform was 17,610 per 100 ml. The remainder of the stations' mean total coliform counts were below 1000/100 ml which is the standard in Chapter 37-A, DOH Regulation, Water Quality Standards.

#### C. Kaneohe Bay

In order to determine the sanitary quality of the receiving waters, bacterial analysis was conducted by the City during the summer of 1954, prior to any discharge of effluent from the proposed treatment plant. Studies on the bay consisted of 16 sampling stations, fanning out

from the mouth of the Kaneohe and Kawa Streams to a distance of 2,000 feet and included various stations along the densely populated shoreline areas. Results of the four-month sampling period was significant in that it showed that 1,000 feet offshore, water of good quality could be found. Results of this initial study using the coli-aerogenes group as a pollution indicator with determination made in accordance with Standard Methods indicate that total coliform counts from the 10 offshore stations ranged from 6 MPN/100 ml to 620 MPN/100 ml and averaged 22 MPN/100 ml for the ten stations. Total coliform counts for nearshore stations ranged from 13 to 240,000 MPN/100 ml. The station located at the mouth of the Kaneohe Stream exhibited the highest range, from 2,400 to 240,000 MPN/100 ml. High coliform counts for shore stations indicated that these waters were being affected by cesspool's seepage, drainage from pasture lands, piggeries, and septic tank discharges located on Kawa Stream.

Sampling in Kaneohe Bay was resumed in 1961 during the construction of the Kaneohe treatment plant. The plant was put in operation in 1962. The sampling stations in this survey were re-

arranged to cover a larger area. A total of 11 samples were taken from each of 14 stations over a two-year period. Total coliform counts from most of the shore stations showed water of poor quality reflecting the influence of surface storm waters. Among the offshore stations, only on one occasion was total coliform counts greater than 2400 MPN/100 ml at two stations indicating that the waters met Class A waters bacteriological standards at that time.

A bacteriological study of the Bay for the State Department of Health was performed by Gundersen and Stroupe (Reference 25) from June to August 1967. With the exception of the nearshore middle section between Kahaluu and Molii, the Bay was not heavily polluted with material of fecal origin. The southeast waters had heavy concentrations of fecal streptococci. The bacteria population in nearshore waters ranged between 100,000 to several million per 100 ml. Sediment samples in the area of the municipal plant were also analyzed for bacteria counts. Total coliform count per gram of sediment ranged from 22,000 to a high of 3,190,000.

The State Department of Health (DOH) maintains three shore sampling stations in the southern part of Kaneohe Bay and collects samples twice a month. The stations are located at Kaneohe Beach Park, Kokokahi Pier, and Mikiola Drive. Results of the DOH data from March 1972 to the present time (May 1973) are shown in Table I-XIII-2, and indicate deteriorating water quality with respect to bacteriological standards for Class AA waters.

D. Kailua Bay

During the course of the City's water quality survey of Kailua Bay from July 1957 to September 1959 bacteriological analyses for total coliforms were made along Kailua Beach. These studies were supplemented by Holmes and Narver (H & N), the City's engineering consultant. In addition to the beach, the H & N studies included total coliform and fecal streptococci counts of Kawainui Canal Swamp and Kaelepula Stream and Pond. Total coliform counts from these data along the beach were very low and ranged from less than 6 MPN/100 ml to 620 MPN/100 ml. Fecal streptococci counts ranged from 0/100 ml to 360/100 ml. Beach stations showed

little evidence of pollution during the sampling periods.

The coliform bacteria found were probably from three sources: (1) surface and subsurface drainage from the Coconut Grove and Lanikai; (2) drainage from Kawainui Canal; and (3) swimmers. Coliform and fecal streptococci counts for the Kawainui Canal and Kaelepulu tributaries were considerably higher and ranged from 15 MPN/100 ml to 4600 MPN/100 ml for total coliform and 110/100 ml to 6030/100 ml for fecal streptococci. Highest counts were located at the headworks of the Kawainui Canal. The principal sources of the high counts were probably leachates from cesspools from Coconut Grove, grazing pastures in the swamp, and chlorinated effluent discharged from the Pohakapu treatment plant.

Coliform densities were extremely low for the Kailua beach station during 1958-1959 (6 MPN/100 ml) as compared to a mean (log.) of 8/100 ml during WQPO. The principal source of bacteria today is probably from swimmers.

TABLE I-XIII-1

BACTERIOLOGICAL SURVEY DURING WQPO OF KAILUA BAY AND KANEOHE BAY

(June 1970 - Feb. 1971)

Station	Bay	Location	Water Classification	Number of Samples	Range (MF/100ml)	Mean (MF/100ml)
38	Kailua	Mokulua Islands	A	4	0 - 2	1
39	Kailua	Kailua Beach	A	5	0 - 240	14
40	Kailua	Outfall	A	4	0 - 1,400	9
59	Kailua	Kaelepuli Stream	A	3	100 - 2,700	828
41	Kaneohe	KMCAS Pier	B	4	0 - 12	3
42	Kaneohe	Kokokahi Pier	AA	5	0 - 600	63
43	Kaneohe	Heeia Marina	B	4	0 - 100	4
60	Kaneohe	Kahaluu Stream	AA	4	3,800 - 110,000	17,610

TABLE I-XIII-2

BI-MONTHLY BACTERIOLOGICAL DATA, KANEHOE AND KAILUA BAYS

(Source: State Department of Health)

MARCH 1972 - APRIL 1973

Sta.	Bay	Location	Water Class.	No. of Samples	Total Coliform (MPN/100ml)		Fecal Coliform (MPN/100ml)			
					Range	Mean	Range	Mean		
						% Negative	% Negative	% Negative		
193	Kailua	Beach Park	A	27	0 - 240	6	41	0 - 240	4	52
194	Kailua	Lanikai Beach	A	26	0 - 930	8	38	0 - 240	5	42
206	Kailua	Outfall	A	27	0 - 2400	7	44	0 - 1100	4	59
207	Kailua	Outfall	A	27	0 - 430	7	41	0 - 93	4	44
190	Kaneohe	Beach Park	AA	26	23 - 24000	700	0	0 - 4300	153	12
191	Kaneohe	Kokokahi Pier	AA	26	4 - 46000	358	0	3 - 46000	123	0
192	Kaneohe	Mikiola Drive	AA	26	0 - 2400	134	5	0 - 24000	24	19



## PART II

### ENVIRONMENTAL IMPACT OF THE KANEOHE-KAILUA SEWER SYSTEM

#### I. GENERAL

The project resulted from recommendations submitted to the City and County of Honolulu by a group of scientists and experts from three engineering firms, collectively referred to as the Oahu Water Quality Program who were given the task of formulating a wastewater management program for the island of Oahu. Their 18-month studies began in April 1970 and covered all aspects of wastewater management including oceanography, ecology, demography, sanitary engineering, etc. The objective of the WQPO was to develop optimum overall wastewater management systems which will protect and enhance the water quality on land and in the surrounding sea, on which the present and future life of Hawaii depends so completely.

Bimonthly meetings were held by the City and retained five-member Board of Advisors during the course of the WQPO. These meetings were attended by representatives of the State Department of Health, the local water quality office of the Environmental Protection Agency, the Water Resources Research Center, University of Hawaii, Board of Water Supply and other invited participants. The following agencies were contacted during

the course of the study and valuable contributions were obtained:

A. State of Hawaii

1. Department of Health, Environmental Health Division
2. Department of Planning and Economic Development
3. Department of Agriculture
4. Department of Transportation, Harbors Division
5. Department of Land and Natural Resources
6. a. Division of Fish and Game  
b. Division of Water and Land Development
7. Environmental Quality Control Office

B. University of Hawaii

1. Hawaii Institute of Marine Biology
2. Water Resources Research Center
3. Department of Oceanography
4. Department of Geosciences
5. Hawaii Institute of Geophysics
6. Department of Agricultural Biochemistry
7. Land Study Bureau

C. Federal Government

1. Environmental Protection Agency
2. U.S. Navy

3. U.S. Army Corps of Engineers
4. U.S. Air Force
5. U.S. Coast Guard
6. U.S. Geological Survey
7. U.S. Weather Bureau
8. U.S. Bureau of Sports Fisheries

D. Industry

1. Oahu Sugar Company
2. Waialua Sugar Company
3. Hawaiian Sugar Planters' Association
4. Dole Company
5. Del Monte Corporation
6. Hawaiian Electric Company

E. Numerous private consultants

## II. BRIEF DESCRIPTION OF PROJECT

### A. Introduction

The Kaneohe-Kailua sewer system includes the tributary subdistricts of the present Kailua, Kaneohe, and Kahaluu (Ahuimanu) and KMCAS sewer systems. At the present time, each is served by their separate treatment and disposal systems. Three plants, Ahuimanu, Kaneohe, and KMCAS discharge their effluents into Kaneohe Bay or its tributaries; the other, Kailua, discharges into Kailua Bay. The tributary area of the Kaneohe-Kailua sewer system encompasses those areas between Keolu Hills in the southeast to Kualoa in the northwest. The area of the District's tributary area is 34,134 acres of which 24,183 acres or 71 percent are presently in conservation or agricultural.

### B. Population

The present (1970) total resident population of the district is 84,419 which includes 7,566 military personnel of the KMCAS. Population increase from 1960 to 1970 in the district was 28,081 or 23.25 percent of Oahu's past total decadal population increase. This increase was second only to the Mamala Bay dis-

district that includes Honolulu, Pearl City, and Hounouliuli. The Kaneohe-Kailua district population is projected to increase to 158,000 in 1990 and 337,000 in 2020 (ultimate). The population which is served by the sewers includes 32,500 in Kailua, 29,000 in Kaneohe, 1,500 in Kahaluu, and 6,500 in KMCAS for a total of 69,500.

#### C. Waste Flows

Studies indicate that the average waste flow per capita from the district's tributary areas amount to 90 gpcd for the Kailua area, 85 gpcd for Kaneohe, and 75 gpcd for the Kahaluu area. It is expected that these quantities will not increase except within the Kahaluu area where it can be expected to increase to 85 gpcd by year 2020.

The studies also indicate that the dry weather infiltration into the sewer system can be expected to amount to 42 gpcd for the Kailua tributaries, and 21 gpcd for the Kaneohe and Kahaluu tributaries.

Based on the above quantities, the estimated wastewater flows to be handled by the Kaneohe-Kailua sewer system are as indicated in Table II-II-1. The present (1970) sewage flows totaled 8.60 mgd and include 4.35 mgd from Kailua, 3.10 mgd from Kaneohe, 0.15 mgd from Kahaluu, and 1.0 mgd from KMCAS. The flows to cesspools include 1.05 mgd in Kailua, 0.10 mgd in Kaneohe, 0.55 mgd in Kahaluu, and none in KMCAS, for a total of 1.70 mgd.

TABLE II-II-1

ESTIMATED WASTEWATER FLOWS

<u>TREATMENT FACILITY</u>	<u>Sewer</u>	<u>Cesspool</u>	<u>1970</u>		<u>1990</u>		<u>2020</u>	
			<u>Average (MGD)</u>	<u>Peak (MGD)</u>	<u>Average (MGD)</u>	<u>Peak (MGD)</u>	<u>Average (MGD)</u>	<u>Peak (MGD)</u>
Kailua	4.35	1.05	5.4	14.9	9.9	24.4	20.4	44.5
Kaneohe	3.10	0.10	3.2	11.7	6.7	19.5	15.1	36.6
Kahaluu	0.15	0.55	0.7	3.1	1.4	5.9	3.7	13.3
KMCAS (based on design average capacity of the existing plant)	1.0	0.0	1.0	5.6	1.4	6.5	2.0	7.9
<b>TOTAL</b>	<b>8.60</b>	<b>+ 1.70</b>	<b>10.3</b>		<b>19.4</b>		<b>41.2</b>	

D. Wastewater Characteristics (Suspended solids and BOD)

The quantity of total suspended solids in sewage flows from these areas can be expected to average 0.16 lbs/capita/day and the estimated BOD load in domestic flows from these areas can average 0.19 lbs/capita/day.

These anticipated loads will be used as the ultimate basis for design for the existing Kailua and Kaneohe treatment facilities and the proposed secondary treatment facility at Kahaluu.

E. Recommended Wastewater System

The recommended wastewater system for the Kailua-

Kaneohe-Kahaluu sewerage district is shown in Figure I-12. Projections indicate that the population for this sewerage district could total 337,000 by year 2020. To accomodate this population, it is assumed that land use designations will change in the future. For example, existing residential areas like Kailua town could become high density apartment-type centers. For purposes of this report, the projected population has been distributed uniformly throughout each Study Area rather than to speculate on any specific area where high density development may occur.

Most of the Kaneohe and Kailua residences are presently sewerred. If densities do not change appreciably, the existing sewers should be adequate until at least 1990. Relief sewers and modifications to existing pumping stations may then become necessary in certain localities depending on the future growth and development of each locality.

The existing Kailua and Kaneohe secondary treatment plants will be expanded as required. A new secondary treatment plant will be constructed at Kahaluu and the existing Ahuimanu plant phased out. The KMCAS plant will be maintained. Each plant will

have an effluent pumping station. Effluent from the Kahaluu plant will be pumped to the effluent pumping station at the Kaneohe plant. This station will then pump the combined flows to the Kailua effluent pumping station, from which effluent will be pumped to the Mokapu ocean outfall sewer for disposal. Effluent from the KMCAS plant will also be pumped to the Kailua effluent pumping station.

The City's Advisory Board concurred with the wastewater system recommended for this district along the following basis:

1. The Kailua and Kaneohe treatment plants will be maintained.
2. Treated effluent from the Kaneohe plant will be conveyed to the Mokapu ocean outfall sewer for disposal.
3. That the KMCAS plant will also be maintained and effluent conveyed to the Mokapu outfall sewer.
4. That the Ahuimanu plant will continue to operate with discharge into Ahuimanu Stream, until such time that a secondary treatment plant is constructed at Kahaluu. The Ahuimanu plant will then be abandoned and flows diverted to the Kahaluu plant for treatment. Effluent from this plant will be conveyed directly to the effluent



- pumping station at the Kaneohe plant, from which the combined effluent flows will be pumped to the Mokapu outfall sewer for disposal.
5. The Mokapu ocean outfall will serve to discharge the combined effluent flows from the three municipal plants and the KMCAS plant.
  6. The Mokapu ocean outfall will be constructed along the shoreline of the Kaneohe Marine Corps Air Station toward Mokapu Point for final disposal of the effluent into a depth of approximately 100 feet.

F. Major Components (Projects) of the System

The major projects of the proposed sewer system which will eliminate all effluent discharges into Kaneohe Bay and a nearshore discharge into Kailua Bay are as follows:

1. Mokapu Outfall
  - a. Ocean Portion (Mokapu Ocean Outfall)
  - b. Land Portion (Kailua Effluent Force Main)
2. Kailua STP Effluent Pump Station (Kailua Effluent Pump Station)
3. Diversion Line from Kaneohe STP to Kailua STP
  - a. Kaneohe Effluent Force Main
  - b. Kaneohe Effluent Pump Station

4. Kahaluu WWTP Effluent Sewer (Kahaluu Effluent Force Main)
5. Kahaluu WWTP
6. Other interceptors and pump stations

The preliminary alignment and locations of the major components of the sewer system are shown in Figures I-12, II-1, II-2, II-3, II-4, and II-5.

The proposed ocean disposal system will discharge biological secondary (trickling filter) treated effluents from the existing Kaneohe, Kailua and KMCAS plants, and the proposed secondary (activated sludge) treatment facility at Kahaluu. These facilities have or will provide the following treatment parameters:

1. Grit removal
2. Biochemical Oxygen Demand: Substantially complete equal to or greater than 85 percent of organic degradable materials. Initially the trickling filter plants may not be able to meet this requirement for design reasons; however, they will be converted to the activated sludge process upon reaching their design capacity.
3. Settleables: Substantially complete, equal to

95 percent of settleable materials.

4. Floatables: Overall removal equal to or greater than 65 percent of floatable materials.
5. Fine Screening: Removal of particulate materials, particularly filter flies in final effluent.
6. Chlorination facilities for effluent disinfection.
7. Sludge Handling: Sand filter beds or mechanically dewatering devices preceded by anaerobic digestion. Sludge disposal to landfill.

Applicable design parameters and descriptions for the sewerage and ocean disposal systems are listed below:

1. Outfall System

- a. Capacity: Ultimate peak wet-weather  $Q = 92.9$  mgd. Present average  $Q = 10.3$  mgd including 1.7 mgd to cesspools and 8.6 mgd to sewers. Present peak wet-weather flow  $Q = 32.2$  mgd (estimate for 3 plants)
- b. Dilution: Initial dilution of 200 to 1 for average flow condition. Greater than 100 to 1 for all flow conditions. Initial dilution is defined as that dilution resulting from the jet action of the outfall diffuser ports prior to and independent of subsequent dilution caused by the ocean currents.

- c. Ocean outfall including diffuser section consists of approximately 0.96 miles of 48-inch pipe beginning from the Flyer's Monument on Mokapu Peninsula. Land portion consists of 2.8 miles of 54-inch pipe laid around the south and east periphery of KMCAS.

2. Kailua EPS

- a. Capacity: Same as outfall system. Capacity provided for the 1990 design peak wet-weather flow of 21,000 gpm. Provisions provided for addition pumping capacity for the 2020 flows.
- b. Station to be located on the site of the existing Kailua treatment plant.

3. Kaneohe Effluent Force Main

- a. Capacity: Ultimate peak wet-weather  $Q = 49.9$  mgd. Present wet-weather  $Q = 14.8$  mgd (est.).
- b. Consists of 3.13 miles of 42-inch pipe from the Kaneohe treatment plant to the Kailua treatment plant, laid under Kaneohe Bay Drive and various easements.

4. Kaneohe Effluent Pump Station

- a. Capacity: Same as effluent force main.  
Capacity provided for the 1990 design peak wet-weather flow of 20,000 gpm. Provisions provided for additional pumping capacity for the 2020 flows.
- b. Station to be located on the site of the existing Kaneohe treatment plant.

5. Kahaluu Effluent Force Main

- a. Capacity: Ultimate peak wet-weather  $Q = 13.3$  mgd.
- b. Consists of 6.0 miles of 24-30-inch pipe from the proposed Kahaluu treatment plant to the Kaneohe treatment plant and laid in and along Kahekili Highway, Keaahala Road, Anoi Road, Paleka Road, Waikalua Road and various easements.

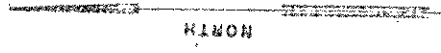
6. Kahaluu WWTP

- a. Capacity: Ultimate average  $Q = 3.7$  mgd.  
Initial design capacity  $Q = 1.85$  mgd.
- b. Proposed improvements to be constructed on DLUM site in Kahaluu.
- c. Design parameters are similar to other

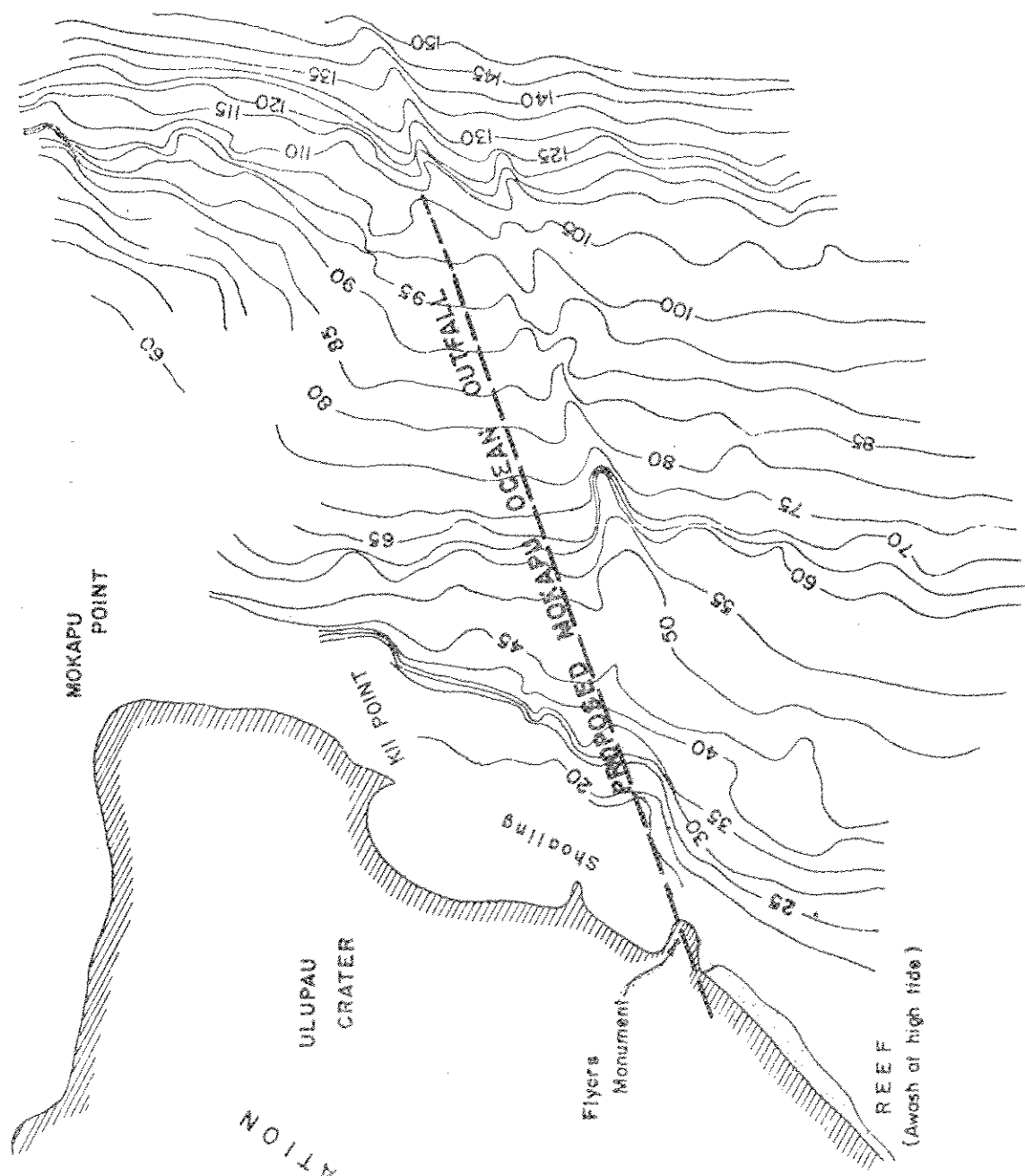
existing treatment plants as given earlier.

7. KMCAS Effluent Pump Station and Force Main

- a. Capacity: Ultimate peak wet-weather Q = 7.9 mgd. Present average Q = 1.0 mgd.
- b. Consists of 0.78 miles of 16-inch pipe constructed within KMCAS.



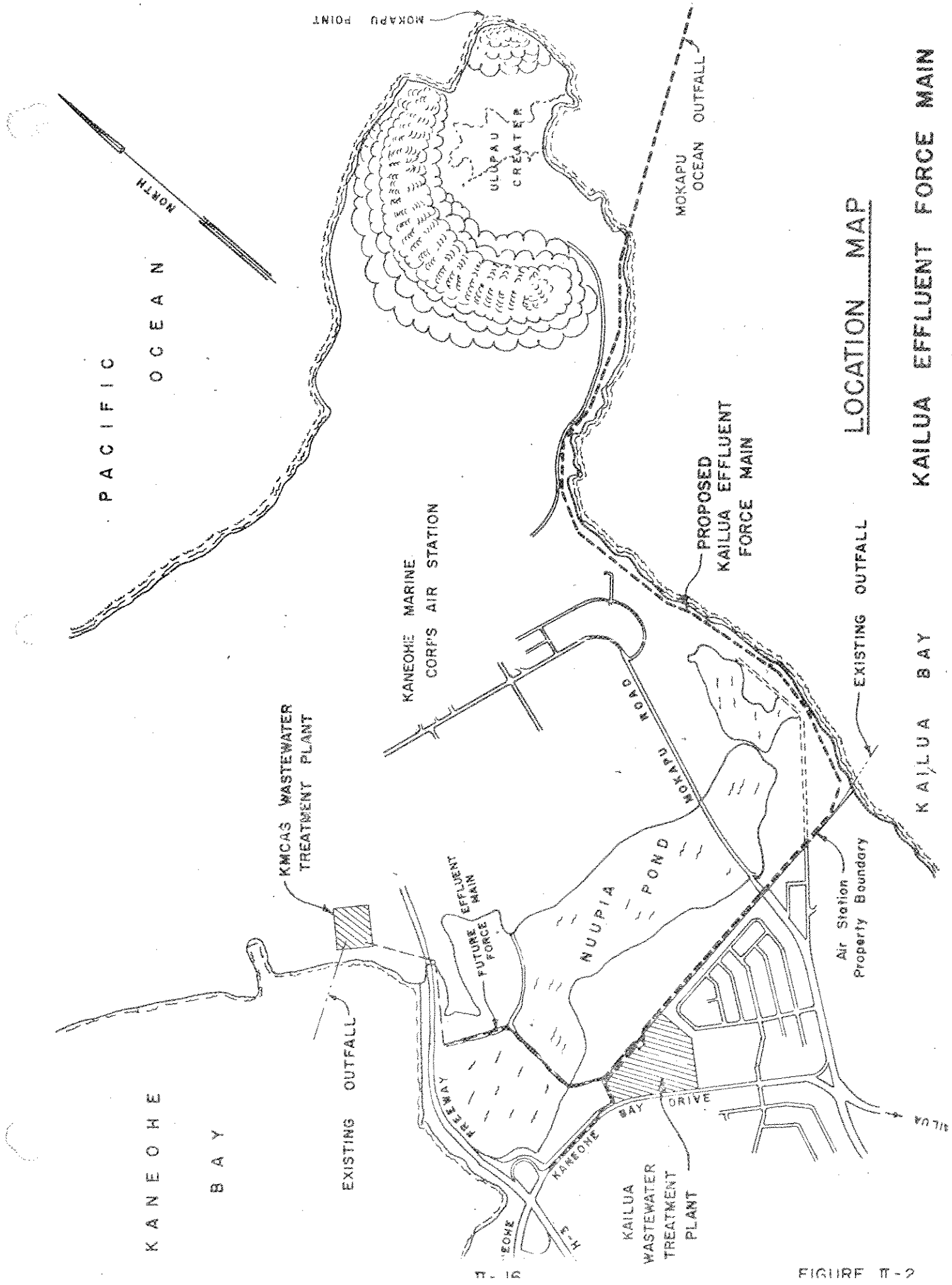
PACIFIC OCEAN



PRELIMINARY PLAN  
MOKAPU OCEAN OUTFALL

FIGURE II-1

KANEOHE  
CORPS  
AIR STATION  
MARINE



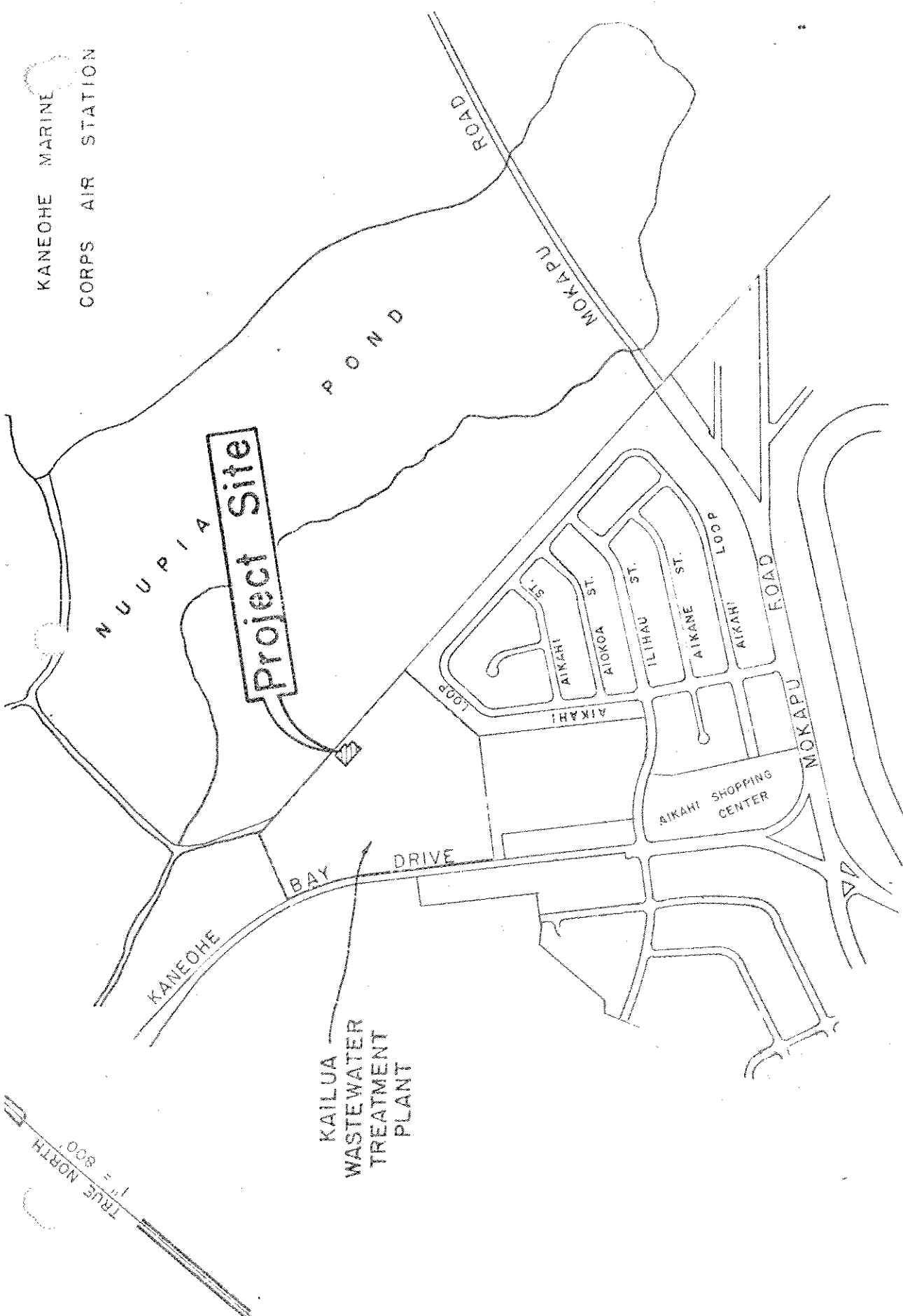
LOCATION MAP

KAILUA EFFLUENT FORCE MAIN

FIGURE II-2

FIGURE II-2





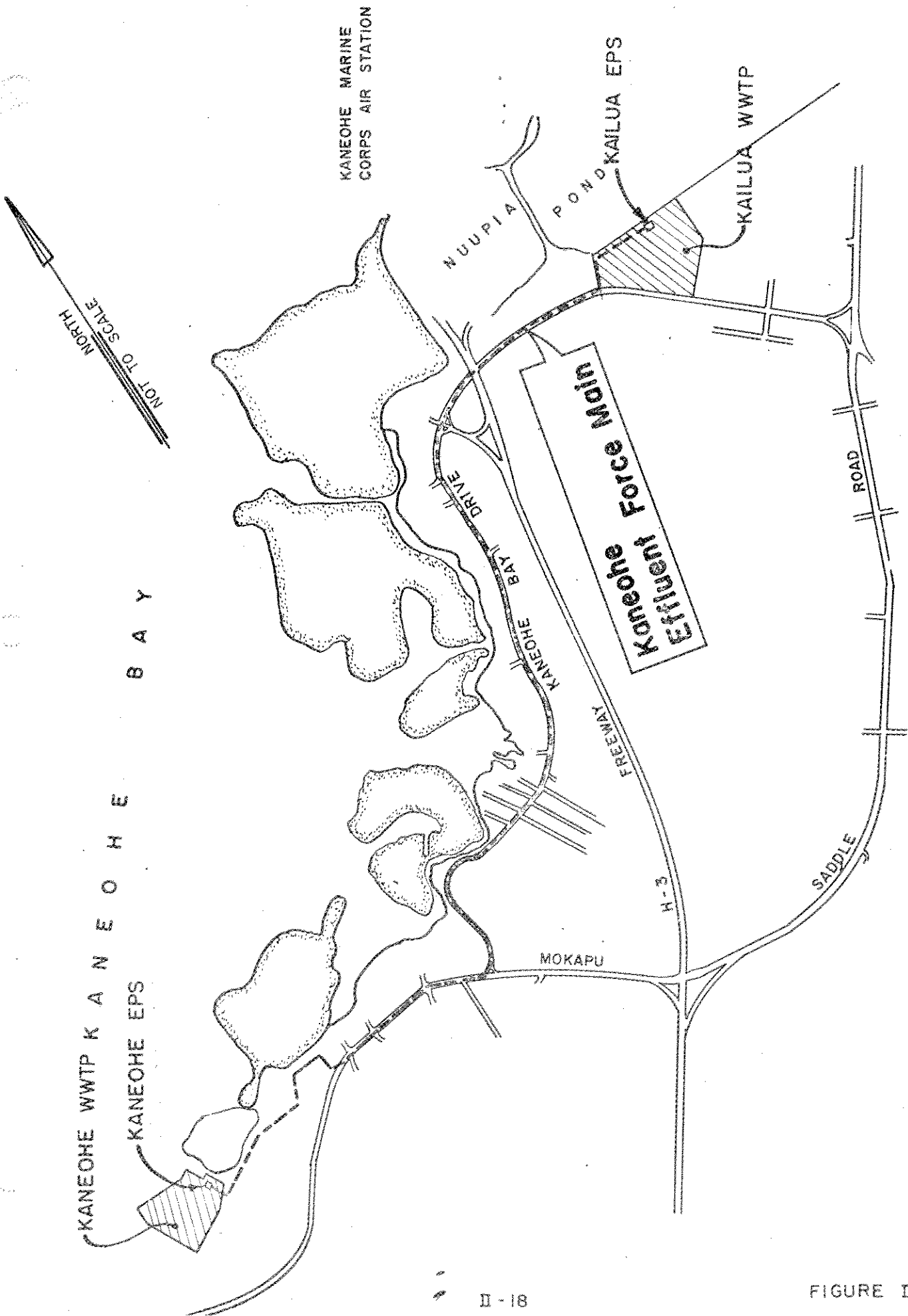
KANEOHE MARINE  
CORPS AIR STATION

KAILUA  
WASTEWATER  
TREATMENT  
PLANT

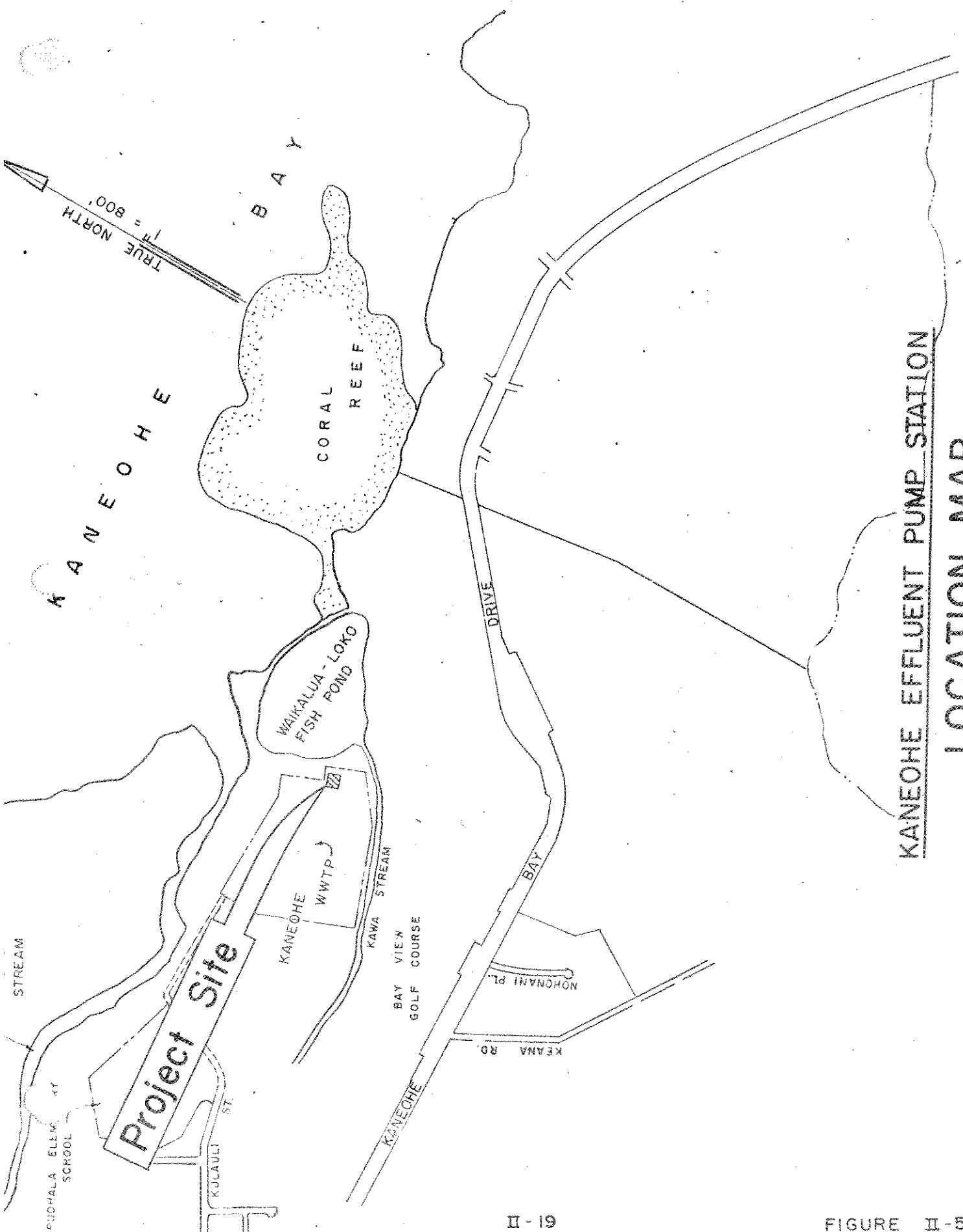
**Project Site**

**KAILUA EFFLUENT PUMP STATION  
LOCATION MAP**

SCALE: 1" = 800'



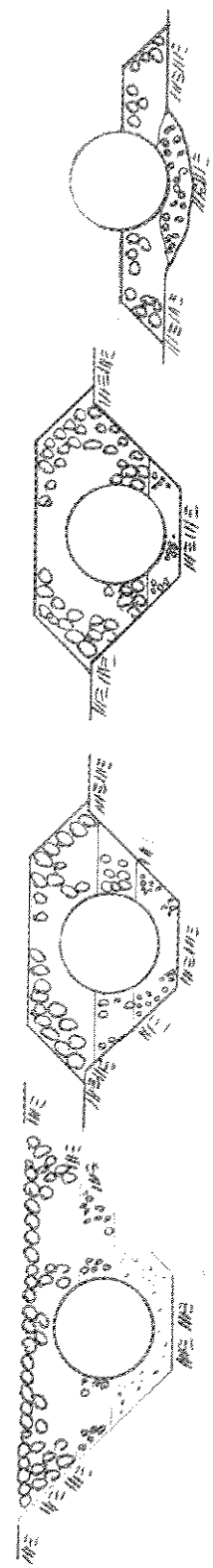
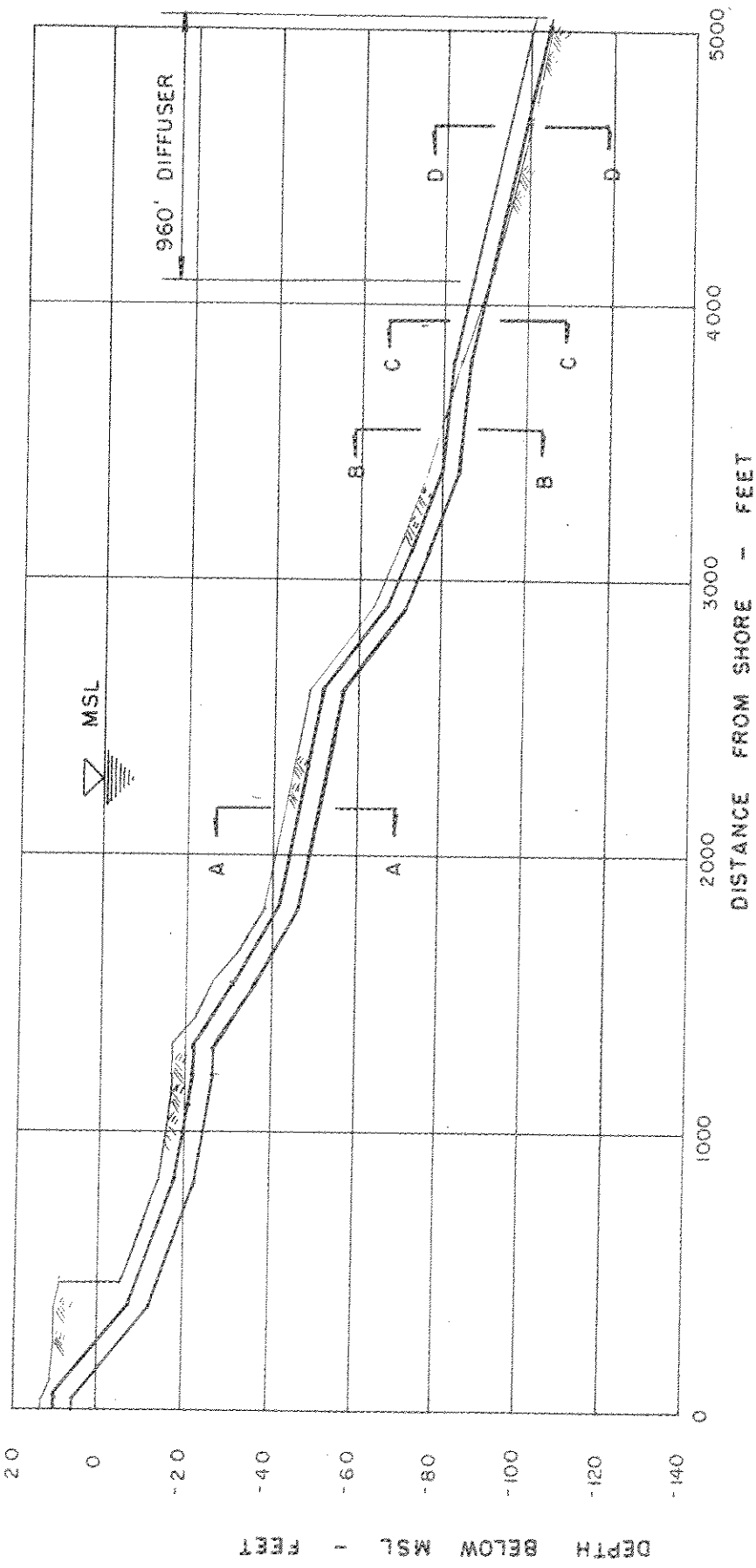
LOCATION MAP



**KANEOHE EFFLUENT PUMP STATION  
LOCATION MAP**

SCALE: 1" = 800'

FIGURE II-5



**PRELIMINARY PROFILE AND SECTIONS**  
**MOKAPU OCEAN OUTFALL**

### III. ENVIRONMENTAL IMPACT OF THE ACTION (PROJECT)

#### A. Environmental Assessment of Wastewater Disposal off Mokapu Peninsula

##### 1. General

This action (project) consists of the construction of an ocean outfall pipe and diffuser system to handle the discharge of secondary treated sewage effluent to a depth of 105 feet off Mokapu Peninsula. The outfall sewer will begin at the Flyers' Monument and extend offshore to a distance of 0.96 miles (Figures II-1 and II-6). The pipe will be buried beneath the bottom of the ocean to about the 80-foot depth. Thereafter, it will be ballasted on both sides of the pipe by rock and other materials.

##### 2. Anticipated Effluent Characteristics

The anticipated effluent characteristics from the combined effluents from the Kaneohe, Kailua, KMCAS and proposed Kahaluu wastewater treatment plants are presented below. The anticipated effluent will meet the Environmental Protection Agency's BOD and suspended solids limitations for secondary treatment. The effluent will have to be chlorinated continuously to meet EPA's requirements on total and fecal coliform bacteria.

<u>Parameters</u>	<u>Anticipated Effluent Characteristics</u>
a. BOD, median	28 mg/l
b. Fecal Coliform, median	6,700/ml (est.)
c. Total Coliform, median	17,000/ml (est.)
d. Floatables	1 ppm
e. pH	6.8 - 7.7
f. Total Nitrogen, average	16 mg/l
g. Total Phosphorus, average	6 mg/l
h. Total Dissolved Solids	2,740 mg/l
i. Settleable Solids	0.05 mg/l
j. Suspended Solids, median	26 mg/l
k. Temperature	77 - 81 Deg. Fah.
l. Turbidity	23 - 27 JTU

The minimum level of effluent quality for secondary treatment promulgated by EPA (Title 40, Part 133, CFR) includes the following:

<u>Parameters</u>	<u>Unit</u>	<u>Monthly Average</u>	<u>Weekly Average</u>
BOD	mg/l	30	45
Suspended Solid	mg/l	30	45
Fecal Coliform Bacteria	#/100 ml	200	400
pH	Unit	6.0	- 9.0

### 3. Effects of Biostimulatory Substances

Biostimulatory effects of the proposed discharge should be minimal. No adverse conditions such as undesirable algae blooms have been noted near the present Sand Island outfall sewer (offshore currents) and the present Kailua outfall; however, the presence of the alga Ulva fasciata at the latter site did indicate a source of increased nutrients and fresh water. The ocean currents are of sufficient magnitude (up to 1.0 knots) and direction (See Table I-IX-1) to prevent excessive accumulation of nutrients which might stimulate undesirable algae blooms. A slight increase in primary productivity may occur, but it is anticipated that this increase will be quickly cycled through to the next trophic level thereby preventing accumulation of plant biomass.

Removal of nutrients from the effluent does not appear to be necessary and warranted now. Studies conducted during the WQPO indicated that nitrogen was growth limiting in Hawaiian oceanic waters. The studies showed that inorganic nitrogen concentrations in excess of 0.007 mg/l removed any growth restraint of three ubiquitous phytoplankton species. Water quality data from Kailua Bay

and other local coastal waters indicate that inorganic nitrogen concentrations frequently exceed 0.007 mg/l.

#### 4. Effects Due to Heavy Metals and Pesticides

Accumulation of heavy metals and pesticides in sediments near the proposed discharge are not expected. In June 1973, sediment samples were taken from Stations 4, 11, and 13, the outfall terminus, existing outfall and midpoint of the proposed outfall respectively. These samples were analyzed by the WRRC UH. The analysis indicated that there were no significant amounts of heavy metals and pesticides in the northern part of Kailua Bay. The results of the test are given below (concentration as ppm dry weight):

Parameter	Location		
	Exist. Outfall	Prop. Outfall Terminus	Midpoint
DDT (ppt) <sup>1</sup>	140	147	215
Lead	20.3	25.8	31.1
Copper	9.3	23.9	4.6
Zinc	45.4	49.0	3.7
Cadmium	1.9	2.8	4.0
Mercury	nd <sup>2</sup>	0.07	nd <sup>2</sup>
Chromium	37.1	26.4	5.2
Nickel	307.4	118.0	42.6
Arsenic	3.4	10.3	1.1

1. parts per trillion  
 2. nd - not detectable



Except for small quantities of DDT (in the range of parts per trillion), no other chlorinated hydrocarbons were detected at the three Kailua Bay stations. Concentrations of DDT are generally considered ubiquitous and have been detected even in sediments and in water samples at Kahana Bay (Reference 32). Wastewater and sludges from the Kailua and Kaneohe plants were analyzed by Myron Nomura (M.S. Thesis). The heavy metals analyzed included Aluminum, Cadmium, Chromium, Copper, Iron, Mercury, Nickel, Lead, and Zinc. The quantities are shown in Tables II-III-1. The figures in the table represent the average of ten samples. The results of Nomura's work indicated heavy metals were being removed by the two plants at widely different efficiencies. Removal efficiencies at the Kailua plant were substantially higher than Kaneohe's. Higher concentrations of heavy metals in the sludge indicated that they were components of the suspended solids fraction of the wastewater. Although there are few data of heavy metals in the literature, the concentrations of metal in the effluent are considered normal for domestic sewage. The heavy metal concentrations in the sediments are probably the results of natural

TABLE II-III-1

HEAVY METAL CONCENTRATIONS

KANEHOE AND KAILUA TREATMENT PLANTS  
(Values in ppm)

Sample	Al	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
Raw Sewage	1.009	.038	.018	.217	2.75	.0007	.0466	.052	.339
Pri. Effl	.359	.017	.014	.032	1.163	.0752	.0166	.024	.223
Final Effl	.229	.017	.011	.016	.526	ND	.026	.060	.16
Outfall	.227	.016	.010	.013	.054	ND	.024	.050	.134
Digested Sludge	284.5	5.36	3.585	16.34	1,014	.274	2.34	14.12	73.59
<b>Kanehoe:</b>									
Sample	Al	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
Raw Sewage	.460	.023	.010	.452	1.59	.0005	.046	.023	.234
Pri. Effl	.328	.0158	.010	.023	1.529	.0003	.108	.023	.104
Final Effl	.194	.024	.006	.012	.798	ND	.028	.050	.165
Outfall	.154	.081	ND	.014	.857	ND	.067	.025	.145
Digested Sludge	265.5	3.725	2.975	14.288	1076.25	.237	2.34	10.413	64.737

Note: Kailua samples taken on 5/22/73; Kaneoche samples taken on 5/25/73. Both further taken on 5/29, 5/31, 6/4, 6/8, 6/12, 6/19, 6/22, 6/26, 6/28. Above figures are averages of ten samples.

(Data from Nomura, 1973)

geologic processes of weathering and leaching and dependent on the parent rock constituent. Heavy metal concentration patterns are not identifiable similar to the condition at Kahana Bay (Reference 32). Based on these investigations, there will be no deleterious effects on the marine environment due to heavy metals and pesticides from the proposed Mokapu outfall.

5. Effects on Beneficial Uses of Area

The proposed discharge will have no significant deleterious effects on the beneficial uses of the area. These uses include boating, fishing, bird refuges and aesthetics. Water contact sports do not generally occur in the discharge area for a number of reasons including the presence of strong, prevailing offshore currents, the absence of a sandy beach and the wilderness characteristics of the area. If water contact sports occur in the area in future years, no health hazards would be anticipated since chlorination facilities which can reduce coliform counts below Class "A" water standards are or will be available at all treatment facilities associated with the system.

The natural clarity of the surface waters should not be significantly changed since the effluent will be practically devoid of suspended and settleable materials. Although the effluent field will surface, the slight increase in turbidity probably would not be noticed by the casual observers. It is anticipated that as the field surfaces, the turbidity (23-27 JTU) would approach sea water immediately. Temperature of the effluent will range from 23 to 27° C (77.5 - 80.8° F.). Since the temperature of the receiving waters ranges from 22.75 to 26.74° C, there will be no temperature variations outside the normal variation.

Odors would not be detectable in the receiving waters. Threshold odor tests conducted during WQPO indicated that for secondary (trickling filter) effluent, a dilution ratio of 13 to 1 would be necessary to eliminate objectionable odors. The design of the diffuser system will provide for a dilution of 200 to 1 under average conditions and 100 to 1 at peak flow conditions, hence there should be no problem.

Although a "zone of mixing" for coliform bacteria is being requested; no significant deviations from the State's Water Quality Standards

are anticipated. To be realistic, the boundaries of the zone of mixing would begin at the ocean bottom and extend upwards to the surface. The initial and subsequent dilution of the effluent should eliminate the necessity for a large zone of mixing. The dimensions of the zone, based on non-continuous chlorination, would be 500 feet wide by 1,460 feet long. With continuous chlorination, the effluent will meet bacterial standards at the treatment plant.

It should be pointed out that meeting the present nutrient standards for these waters may not be possible because even under natural conditions, these waters appear to violate the standards. For example, water quality data taken at Station 38 (off Mokulua Island) during the WQPO indicated average total nitrogen and total phosphorus concentrations of 0.244 mg/l and 0.209 mg/l respectively. Nutrient analysis of water samples during KMP included nitrite, nitrate, total phosphorus and reactive phosphorus. The concentrations are listed in Tables I-IX-13 and I-IX-14. WQPO values are given for total nitrogen and total phosphorus and are listed in Tables I-IX-11 and I-IX-12. Total nitrogen and total phosphorus concentrations

greatly exceed the allowable Class A water standards of 0.15 mg/l and 0.025 mg/l respectively. It should be pointed out that these deviations from allowable limits appear to be purely a natural phenomenon. Water quality analysis from other coastal waters of Oahu yielded similar deviations from the standards.

#### 6. Effects Due to Floatable Materials

No objectionable accumulations of wastewater floatables are expected to occur in Kailua Bay as a result of this outfall. There appears to be a large number of factors involved which govern concentrations of wastewater materials on a receiving water surface. Of importance are quantity, quality and the emission rate of floatables in the discharge, currents, including eddy diffusivity, density stratification of the receiving waters, and wind. Large persistent floatables will probably rise rapidly from the discharge ports to the water surface without being influenced greatly by the character of the receiving water. However, the smaller particles are significantly affected by the character of the receiving water and may remain suspended within the water column because of turbulence and density factors, much as are plankton.

The removal efficiency given to floatable materials by secondary treatment processes combined with favorable currents should prevent accumulations of objectionable amounts of these materials on the surface of the waters in Kailua Bay. Filter flies (Psychodidae) associated with trickling filter plant operations have been observed occasionally in the existing discharge area. The installation of mechanical fine screens at the proposed Kaneohe and Kailua effluent pumping stations will remove the flies and other floatables effectively.

Studies of floatable materials over the existing Sand Island outfall during WQPO have pointed to the need of removing large persistent particles at the treatment plant. A treatment design parameter for 60 percent removal of the total floatable mass was recommended for the substantially complete removal of the large persistent floatables. For the purpose of this discussion, floatables are classified into three general groups: large persistent, small persistent, and non-persistent particles. The large persistent particles comprise an estimated 35 percent of the total floatable mass in untreated waste flows and the small persistent

and non-persistent particles make up about 40 and 25 percent, respectively.

If one assumes that the efficiency of floatable removal by standard treatment processes follows the general trend that large persistent particles are easier to remove than the small persistent ones which in turn are easier to remove than the non-persistent particles, then it can be shown that a 60 percent total removal objective will provide for about a 95 percent removal of the first group and about 65 and 0 percent of the second and third groups, respectively.

By removing 95 percent of the large persistent particles and a substantial portion of the small persistent particles through treatment, aesthetic problems associated with these materials in the receiving waters should be eliminated or at least greatly reduced. Because the outfall system off Mokapu Peninsula does not call for field submergence, floatable materials removal efficiency at the treatment plants must be maintained over the 60 percent level.

Secondary treatment removal efficiency of floatables is about 65 percent for the Kailua and



Kaneohe plants, compared with a slightly lower efficiency of about 50 percent for primary installations. The installation of mechanical fine screens at the treatment plant will insure filter fly removal as well as to increase floatable material removal of about 5 to 10 percent. The presence of filter flies in the effluent will disappear upon the future conversions of the trickling filter plants to activated sludge plants.

Fortunately, surface currents in the discharge area are not consistently onshore as at other areas in Kailua Bay during the season when tradewinds predominate. Studies during the KMP indicate that the surface drift can move alternately against or with the prevailing winds depending upon the wind strength and direction, the strength of the tidal current at the Point, and the amount of wave activities along the immediate shoreline. The combination of these factors makes the circulation pattern extremely complex. In summary, floatable materials should not create an aesthetic problem in the receiving waters due to (1) removal efficiency of floatable materials at the treatment plants, (2) favorable offshore ocean currents,

and (3) special attention given to the removal of filter flies and small persistent particles.

#### 7. Effects on Benthic Communities

A baseline survey was conducted to determine the dominant benthic flora and fauna of six stations in Kailua Bay. Stations 1(12) and 2(11) at the existing outfall, according to the survey were very similar in appearance. Algal growth at the two stations was similar both quantitatively and qualitatively. With respect to the algal population, the only thing noted of any consequence at Station 2(11) near the existing outfall was the abundance of the alga Ulva fasciata, a species often cited as an indicator of increased nutrient load and fresh water outfall.

Corals, Porites lobata and Pocillopora meandrina cover about two percent of the area near the present outfall. Small number of sea urchins of the species Echinometra matthaei, Triopneustes gratilla, and Echinothrix calamaris were observed. Factors determining growth of coral at Stations 1(12) and 2(11) are the force of large open ocean waves which both stations received during most of the year and the strong, continuous bottom surges that is characteristic

of the area. The flatter, encrusting coral Porites lobata and the robust coral heads thrive in regions of strong wave action. Viable corals, located about 50 feet from the outfall did not appear to be affected by the discharge. Coral growths around the existing Hawaii Kai outfall sewer off Sandy Beach have been observed to be unaffected by that discharge. Based on the observations made at the existing Kailua outfall sewer and unpublished report of the Hawaii Kai outfall sewer, coral communities do not appear to be adversely affected by open ocean discharge. Factors which may influence coral mortalities include (1) toxic substances in the effluent, (2) salinity in the receiving waters, (3) total dissolved solids in the effluent especially chlorides, (4) ocean currents and eddy diffusion in the receiving waters, and (5) initial dilution of the effluent.

Kaneohe's wastewater appears to be more toxic than Pearl City and Sand Island wastewaters although it is of primarily domestic origin while the latter two have industrial by-products in them. The toxicities of the Kaneohe (secondary) and Pearl City (primary) effluents are about equal, however, both effluents are more

toxic than Sand Island (raw wastewater). The other factors mentioned in the preceding paragraph are applicable to the Kaneohe discharge. These factors include lower salinity, lower chloride concentration in the effluent, poor circulation and low initial dilution of the effluent.

Species composition, diversity, trophic structures and standing crop of the micromollusks in Kailua Bay have been found to be comparable at other areas of similar depth and substrate around Oahu. The highest standing crop was recorded at Station 2(11) near the outlet of the existing outfall. The high standing crop may reflect the nutrient concentrations and hence higher productivity at this station. Based on available evidence there appears to be no adverse effects of the existing discharge on the micromollusks inhabiting the bay.

Chemical and physical analysis of sediment samples from Stations 11 and 11a (existing outfall terminus) were made. Station 11a was located about 50 feet away from the outfall sewer single outlet. Sediment samples were examined for phosphorus, ammonia and organic nitrogen, sulfide and BOD. Results of the

chemical analysis are shown in Table II-III-2 and those of the physical analyses are shown in Table II-III-3.

The lack of settleable solids and sludge were noted in the area around the existing outfall. The chemical analyses of the sediments indicated that only a small area of less than 50 feet around the existing outlet was slightly affected by the existing discharge. According to the special studies conducted during the WQPO, sediment BOD, bicarbonate extractable phosphorus, and total nitrogen (ammonia plus organic) concentrations in excess of 0.5, 0.05, and 0.6 mg/gm (dry weight) respectively were consistent with immature or unstable open ocean benthic communities. Results from Stations 11a, 13 and 4 indicate stable benthic communities.

Physical analyses of sediment samples from Stations 11, 13 and 4 indicate that the bottom materials were composed of sand only with no silty or clay materials.

Summarizing, the proposed deep water discharge off Mokapu Peninsula will have little effect on the benthic flora and fauna in Kailua Bay because of the high initial dilution provided (200 to 1

TABLE II-III-2

CHEMICAL ANALYSES OF SEDIMENT FROM KAILUA BAY  
(mg/gm, dry weight)

<u>Station</u>	<u>Phosphorus</u>	<u>NH<sub>2</sub></u>	<u>Nitrogen Organic</u>	<u>Total</u>	<u>Sulfide</u>	<u>BOD</u>
11	0.17	0.42	0.52	0.94	0.20	2.90
11a	0.05	0.00	0.29	0.29	N.A.	0.48
13	0.04	0.03	0.32	0.35	0.05	0.10
4	0.03	0.08	0.25	0.33	0.03	0.15

Note: N.A. not available

under average flow condition) and the predominantly along and offshore currents. There appears to be no adverse effects on the benthic communities in the bay from the existing short, shallow outfall sewer.

TABLE II-III-3

PHYSICAL ANALYSES OF SEDIMENT FROM KAILUA BAY

<u>Parameter</u>	<u>Station</u>		
	11	13	4
Sand Equivalent (percent)	100	100	100
Soil Classification	SP	SP	SP
Grading Analysis (sieves)	Percent	Passing	
2"		88	
3/4"		87	
1/2"		84	
#4	100	67	94
#10	98	38	68
#20	93	7	21
#40	49	2	4
#80	2	1	0
#100	2	1	0
#200	1	1	0

## B. Construction Impact

### 1. General

Construction activities will have definite effects on the environment. Various construction activities, processes and methods and their effects will be discussed in this section. Engineering including the preparation of construction plans and specifications is underway for the entire effluent disposal system. The system includes the Mokapu Outfall (land and ocean portions), Kailua Effluent Pump Station, Diversion Line from Kaneohe STP to Kailua STP, Kaneohe Effluent Pump Station, and Kahaluu Effluent Sewer. Except for the Kahaluu Effluent Sewer, all plans were completed in September 1973. Construction scheduling for the effluent disposal system is highly speculative at this time (April 1974). This condition is due to the lapsing of City funds on December 31, 1973 and the uncertainty of State participation in the funding scheme.

Section 202 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) provides for Federal participation in the construction of treatment works and sewer collective system in



the amount of seventy-five (75) percent. A local municipality such as the City and County is responsible for the remaining 25 percent. State participation in the funding scheme is not a requisite as a condition of the grant, a provision formerly required in PL 84-660.

State financial assistance, however, is possible under present State statutes. Section 342-34 Hawaii Revised Statutes, as amended by Act 118, 1973, provides that "If Federal funds are available, the applicant (County governments) shall be required to pay at least fifteen percent of the estimated reasonable cost of such approved treatment works as defined by PL 92-500. If Federal funds are not available, the Director (Department of Health) may take grants up to one hundred percent of the estimated reasonable cost of the project." The statute as written allows discretionary use of State funds and there are no mandatory requirements.

Act 118/73 also included a proviso which provides for a grant of State funds, not to exceed \$12 million for the construction of the diversion lines, including the force mains and

outfall sewer. The City and County of Honolulu is required to provide the remaining fifteen percent of the cost of the project. Presently (April 1974), the City is requesting funds for its share of the construction costs of the Mokapu Outfall Sewer, the Kailua Effluent Pump Station, the Kaneohe Effluent Pump Station, and the Diversion Line from Kaneohe STP to Kailua STP. If Federal and/or State funds become available by June 1974, construction can begin by the end of 1974 and be completed by the end of 1976. If State funds are not released, construction could be delayed from one to three years, depending upon the statewide priority listing established by the Department of Health.

Construction plans and specifications are presently (July 1973) being prepared for the Kahaluu Effluent Sewer and construction can begin in the 1974-1975 Fiscal Year if funds were available. Construction will take at least two years on this 6-miles sewer. Construction of the proposed Kahaluu treatment plant is scheduled in the 1976-1977 Fiscal Year after plans and specifications are completed in Fiscal 1975-1976. It should be emphasized that these schedules are

nature is anticipated.

b. Excavation

The depth of the trench for the land portion of the outfall will vary from 9 feet to 16 feet with an average of approximately 10 feet. A minimum 2 feet earth cover over the pipe will be provided. Trench width for pavement purposes will be 7 feet - 7 inches. The actual width may be slightly more or less, depending on the contractor's operation. After completion of pipe laying and backfilling, the finished surface shall be restored to match the original ground. The finished surface shall be equal or better than the original. For trench section in areas exposed to wave action on sandy ground, about 2 feet (thick) of concrete shall be placed on the top and crown of the pipe and backfilled with native sand. In areas exposed to wave action on hard ground, the top 2 feet - 8 inches (minimum) surface layer would consist of pressure grouted native rocks. These measures will be taken to prevent erosion of the excavated trench and loss of

material into the ocean (siltation).

The ground water elevations of the project vary from a low of -6.0 feet to a high of 3.6 feet. The high water table along the entire length of the land outfall combined with average and relatively deep excavation over considerable portion of the project indicate that trench dewatering will be necessary if the pipes are to be connected in the "dry". The contractor will be required to control the discharge of these operations and comply with existing regulations. No direct discharge which would pollute Nuupia Pond or the ocean will be permitted. In respect to the proximity of the pond, the nearest distance from the excavation is about 50 feet near the shoreline; however, this portion of the pond is usually dry and the actual distance is about 200 feet.

As was stated earlier, no direct discharge of silty or muddy water from trench dewatering operation into the ocean will be permitted. Water will be required to be ponded to remove sand and other fine settleable particles before-

hand or be recharged directly into the sandy coral ground. The exact method of disposing the trench's waters will be left to the discretion of the contractor. In the event the trench cannot be properly dewatered, the pipeline will be laid under water.

Two methods are available to protect the ocean outfall pipes from induced forces from waves and currents. One method consists of laying the pipe directly on the rock cushion on the bottom of the ocean floor and ballasting both sides of the pipe with 3-foot diameter rocks from the shoreline for a distance of approximately 2250 feet where the depth is 55 feet. Since the amount of 3-foot diameter rock ballast is not readily economically available and they are too large to be practical, other means of providing adequate anchorage must be provided. This method consists of burying the pipe below the bottom of the ocean and "backfilling" the trench with tremie concrete and smaller sized quarry stones. The upper limiting size of quarry stones ranged from 14 inches to 5 inches.

Excavation of the ocean outfall will be very difficult to control. To protect the pipeline against damages from hurricane waves (the maximum design wave height of 46 feet was used), the outfall will be buried from the shore to about the -80-foot depth, a distance of approximately 3500 feet offshore. The width at the top of the trench will vary depending on the ocean bottom contour and cover over the pipe. The bottom width will vary from about 6-8 feet. The minimum trench width will be about 6 feet, while the maximum could be as much as 28 feet.

Excavation through the coral formation is expected to increase the turbidity of the waters; however, the overall effect is expected to be minor since only a relatively small section can be excavated at one given time. These localized areas of turbid waters are expected to be carried offshore by the prevailing ocean currents.

Although attempts were made during design to avoid the viable coral heads that exist to about the 40-foot depth, some will be

destroyed during the excavation. This destruction may occur within a 1500-foot distance from shore.

Hard coral bottom encountered during construction may require blasting. Such blasting will be done in accordance with all applicable industrial safety regulations. Safety precaution for the public and the working force will be enforced at all times. Such blasting is not expected to have any effect on wildlife on shore or on "bird isle." Some fish kill can be anticipated. An attempt to determine the magnitude of potential fish kill by blasting was made by the City. A proposal by the University of Hawaii was solicited; however, the high cost of the experiments and the inability of the City to obtain the necessary permits prevented the experiment from being carried out. If fish kill occurs, it will be minimal and temporary. Blasting in Pearl Harbor and Midway Island for the purpose of dredging do not indicate widespread fish kill.

Excess excavated material from the land portion of the outfall will be hauled away from the site and will be the responsibility of the contractor. Excess excavated material from the ocean portion will be deposited along the trench. Local turbidity will be created by this placement when the very fine excavated material will be separated from the coarse by the operation and then be carried away by the prevailing currents. The fine materials would be created as the result of the crushing effects of the excavation process on the coral surface inasmuch as only small coarse sand pockets exist interstitially between the bottom coral and rock formation. Material deposited along the pipe are expected to remain there since the bottom currents' velocities at the outfall are relatively small. Bottom currents will generally range from 0.0 to a maximum at 0.5 knots at the 30-foot depth level. The average bottom velocity is not expected to exceed 0.2 knots and will be frequently 0.0 knots. Hence, no nuisances are expected from placing the excess material there.

The estimated quantity of quarry stone is 24,500 cubic yards. The source of the quarry



stone is not known at this time but will probably be from the Kapaa Quarry. The rate which the quarry stones are deposited will be dependent upon the contractor's operation, but the placement will be accomplished within the 18-month construction period. Assuming actual hauling will take place within 8 months, it will require 6 truckloads per day of 20 cubic yards capacity each. Therefore, the hauling of quarry stone is not expected to have an adverse effect on traffic leading into the contractor's base of operation.

All underwater excavation will be in accordance with the water quality standards and Corps of Engineers requirements.

Two methods are usually used for pipe-laying in the marine environment. The diameter of the outfall pipe was deliberately reduced from 54-inch diameter to 48-inch for economic and hydraulic reasons. The 48-inch pipe is the upper limit for laying the line by pulling the connected pipes from the staging area into the prepared trench. The other method of pipe-laying is the conventional way of using a "strongback" to hold several lengths of short pipe sections together and lowering them into the prepared trench from a

Texas-tower type platform or other type of derrick rig. The selection of the former method, i.e., pulling the pipeline in place, by the contractor could result in substantial savings in the construction, as well as shortening the construction period.

c. Air Quality

Construction activities of the land portion will affect the quality of the air. This effect is expected to be minimal. There will be little effect for the ocean portion since exhaust fumes from construction equipment or boats will be the only emission into the atmosphere. Little dust will be generated during construction of the land portion because of the dewatering operation. Exhaust fumes from construction equipment are not expected to become a problem. Only conventional construction equipment are expected to be used.

d. Water Quality

Construction activities will have temporary effects on water quality.

Water from dewatering of trenches, excavations, and other construction activities must be disposed of without creating nuisances or unduly restricting usage of the surrounding waters. Soil borings were made along the entire land portion of the outfall and generally indicated that the subsurface materials are porous and recharge into the ground may be possible. If such recharge is unsuccessful, silting basins will be utilized with the overflow being discharged into the natural drainage waterway or to the ocean.

Construction activities on the ocean portion may cause localized water pollution in the form of increased turbidity from suspended materials. This will occur during excavation, gravel and stone placement, tremie concrete placement, and backfill placement. Some of the fine materials in the bottom including sand, gravel, and cement from freshly placed concrete will be washed out and will be transported away by the prevailing ocean currents. Control of this turbidity

may not be possible. The overall effect, however, is not expected to be significant in that the total particulate matter under consideration is not large and the net transport of this water is away from shore. The effect of this pollution is expected to be of a very short duration and no long term effects are anticipated.

The effluent from the existing Kailua waste treatment and disposal systems will not be affected during construction and no diversion or by-passing of wastewater is anticipated.

e. Noise

Some noise will be generated by construction activities. They will come from internal combustion engines, compressors, jackhammers, saws, pile drivers, explosives (blasting), and other construction equipment and processes.

The land portion of the outfall is located near the bird sanctuary areas, several subdivisions, including Aikahi and Kaimalino, and the KMCAS Enlisted Men Housing Area. As such, all construction work including blasting will be kept to the absolute minimum. Nuisance and inconvenience to families will also be minimized.

The distances from the construction activities to the residences along the south boundary and the Enlisted Men Housing Area are about 60-70 feet and 80-90 feet respectively. Because the average depth of the trench in these areas will be only 9-10 feet deep, the contractor is not expected to drive sheet pilings, hence no piledriving nuisance is anticipated at this time. Blasting (of explosives) is also not anticipated.

Construction activities near the KMCAS animal corral, stables, and kennels along Middaugh Street may frighten the animals. The contractor, while working in this area, will be cautioned and requested to coordinate his activities with the stable manager and other animal handlers especially if explosives are used.

The natural wilderness of the area around the ocean portion of the outfall indicates that noise and vibration from the outfall construction will be of no significance.

The only area of human activity in the vicinity is the KMCAS rifle range located about 900 feet mauka from the base of the ocean outfall. Birds inhabit Ulupau Crater, and use Mokumanu and Mokolea Islands. The distances from the construction activity of the outfall to Mokolea and Mokumanu Islands are 1.5 and 1.2 miles respectively. At these distances, construction noise is not expected to be a problem. The Booby colony in Ulupau Crater is not affected by gunfire or noise.

Fish and marine life in the construction area will be affected by construction activities, as was mentioned earlier; however, this effect is expected to be temporary.

f. Public Safety

Personnel of KMCAS and the public will be protected from construction hazards. The contractor will be required to provide barriers, guards, lights, warnings and other safeguards as may be necessary to prevent injury to persons and property. Public access to trestle and floating equipment for the ocean outfall will not be permitted.

g. Nightwork

No night work will be required for either the land or ocean portions of the outfall, even though the project is considered a critical solution to the Kaneohe Bay problem. Excavation and pipe laying cannot be done efficiently at night.

h. Traffic

The land outfall crossing of Mokapu Boulevard at the entrance to KMCAS and the KMCAS visitor parking lot is expected to cause some traffic inconveniences and annoyances. This occurs at all highways and roadways, especially if they serve a major employment center and military base such as KMCAS. Access into KMCAS will be available at all times; however, traffic may be hindered during excavation and pipe-laying operation. Because of the weight of the 54-inch pipe used for the land outfall, a medium-sized crane and other heavy equipment will have to be used. Movements of heavy equipment are cumbersome and involved and traffic may have to be temporarily stopped during some phases of the construction. Adequate detour routes will be

provided if the traffic is adversely affected by the construction.

The contractor will employ flagmen and the Base Provost Marshall will direct traffic flow. During the "rush" morning and afternoon traffic, two lanes of inbound and outbound traffic lanes into the base will be provided. During the other periods, there will be a minimum of one inbound and one outbound lane available.

Construction through the visitor parking lot may cause some inconveniences and result in a shortage of parking spaces during the daylight period. During the night, the trench can be covered with steel plates if it is necessary. If necessary, temporary parking areas will be provided.

### 3. Kailua STP Effluent Pump Station (Kailua SPS)

#### a. General

The proposed improvements at the Kailua plant would include the pumping building, fine screening structure and the force main connections from the Kaneohe EPS and KMCAS EPS.



b. Clearing and Grubbing

None is required. The area is planted in grass.

c. Grading and Earthwork

Only minor grading around the finished station structure will be required. Major excavation for the station substructure will be required.

d. Air Quality

Little dust will be generated by the construction activities and whatever is created will be confined within the plant site. The nearest residences are located in Aikahi subdivision, approximately 600 feet away. Exhaust fumes from construction equipment will be discharged into the atmosphere but is not expected to be a nuisance. Only conventional construction equipments are to be used.

e. Water Quality

Dewatering of trenches and excavation for the substructure must be disposed of without creating a water pollution problem. Ground

water from the dewatering process may be recharged directly into the ground or will have to be ponded prior to discharge into the natural waterway. No discharge of polluted or silt-laden water will be permitted to discharge directly into Nuupia Pond.

f. Noise

Some noise will be generated by the construction activities. They will come from internal combustion engines, compressors, jackhammers, saws, pile drivers, and other construction equipment and processes.

Piles will be required to support the station because of the lack of carrying capacity of the supporting soils. About 180, 12-inch square, pre-stressed concrete piles are expected to be driven about 40 feet into the ground. The contractor may also elect to drive sheet piling for the "cofferdam", however, pile-driving activities are not expected to exceed a two-month period. No pile-driving will be permitted in the early or late hours of the day.

g. Night Work

No night work is anticipated. Hours of work will normally be confined between the hours of 7 am to 3:30 pm.

h. Traffic

There will be no interference with traffic. All work will be confined within the plant site.

i. Public Safety

No construction hazard will be created for the public. All work will be done within the plant site which is completely enclosed by a 6-foot high chain link wire fence. Public access into the plant is not normally permitted.

4. Diversion Line from Kaneohe STP to Kailua STP  
(Kaneohe Effluent Force Main - Kaneohe EFM)

a. General

The proposed 42-inch force main will consist of approximately 16,525 feet of pipeline laid beneath the ground surface. It will start at the proposed Kaneohe EPS and end at the intake box of the proposed Kailua EPS. Where applicable, all work must comply with the State Rules and Regulations Relating to the Accommodation and Installation of Utilities on State Highways and Federal-Aid Secondary County Highways.

In general, the force main will be laid in trenches at various depths, but to comply with Federal Highway Administration policies, the pipeline will be encased within a jacketed pipe section under the completed ramp sections of the H-3 Freeway.

The force main will have a minimum cover of four feet under vehicular traffic areas and a minimum cover of two feet cover in easements through private property and within the treatment plant site. Where the force main crosses utility lines either the force main or the utility line involved will be jacketed when the affected utility agency so requests.

Construction operations within the Kokokahi YWCA property will be scheduled for non-summer months so as not to disrupt summer fun programs. Use of chain-link barricades at open trench locations during non-working hours have proved effective in other areas and will be specified for this area.

b. Clearing and Grubbing

A minimal amount of clearing or grubbing will be required for this project. Most of the force main will be laid beneath the existing pavement of Kaneohe Bay Drive. Within this

section, there are no traces or shrubbery that are expected to be removed by the construction of the force main.

c. Excavation

The pipe will be laid within a trench approximately 8 feet wide and 20 feet deep maximum. The excavated material will be used for trench backfill and all excess material will be hauled off the job site.

d. Air Quality

Construction activities will affect the quality of the air. This effect is expected to be minimal. Little or no dust will be generated during construction because work will usually be in paved areas. Exhaust fumes from construction equipment are not expected to become a problem. Only conventional construction equipments are expected to be used.

e. Water Quality

Improper construction methods can cause severe soil erosion resulting in the carrying of silt, clay and other material into Kaneohe Bay. This would be especially true during mass grading for a subdivision where large amounts of surface or ground cover is removed. The problem of siltation with trench excavation for pipelines is considerably less severe particularly in paved areas. Two

ways will be used to control the washing away of the excavated material into the Bay. The first is to limit the amount of trenching that can be opened in advance of the pipe-laying. This limitation will be not more than 150 feet over existing improved streets, sidewalks, driveways and paved areas, and 200 feet in other areas. The other way is to limit the placement of excavated materials. Because of the requirements of traffic control over most of Kaneohe Bay Drive, the contractor may not be able to stock-pile the excavated materials, and he may be required to make arrangements to stock-pile it elsewhere.

In areas where sufficient width exists which will allow the placement of excavated materials, the contractor must place the materials adjacent to the trench in such a manner as to economize space and minimize interference with traffic. If necessary, such material shall be confined by suitable bulkheads or other devices.

With close and proper supervision by the City and County inspection forces, there will be little or no run-off of excavated material into Kaneohe Bay.

f. Noise

Some noise will be generated by the construction activities. They will come from internal com-

bustion engines, compressors, jackhammers, pile drivers, saws, and other construction equipment and processes. These noises are unavoidable, but will be limited to the daylight hours of the day.

Pile-driving of short wooden piles will be required at both the beginning and end of the EFM to support the pipe. Pile-driving will not be permitted in the early or late hours of the day.

g. Night Work

No night work is anticipated. Hours of work will normally be confined between the hours of 8:00 am to 3:00 pm.

h. Traffic

One of the disadvantages of the Kaneohe Bay Drive alignment alternative will be the traffic inconveniences that will be created during construction. This problem has been partially alleviated, however, by the completion and use of the Mokapu Saddle Road, State Highway Project No. S-0630 (1) and S-0630 (7). The H-3 Interstate Freeway system serving the Kaneohe Marine Corps Air Station and Kailua has been mired with controversy and the utilization of the system as a relief for traffic through Kaneohe Bay Drive cannot be predicted at this time (July 1973). The Mokapu Saddle Road is being

used to by-pass through-traffic, and the Kaneohe Bay Drive is used essentially for local traffic.

During construction of the two sections of Kaneohe Bay Drive which are under the jurisdiction of the State of Hawaii, Department of Transportation, at least one lane will be opened to traffic at all times. However, this will not be possible through the narrow segments of Kaneohe Bay Drive where the force main alignment must be in the middle of the pavement due to existing utilities that occupy most of the roadway. These segments which are under the jurisdiction of the City and County, will be impassable during some periods of the normal working hours (8:00 am to 3:00 pm) forcing local traffic to use the Saddle Road to circumvent the construction site. The pipeline will be constructed in short increments not to exceed 200 feet to minimize the inconvenience to the local residential traffic. It will be the responsibility of the contractor to inform the residents so affected. During non-working hours, all trenches shall be covered, and all lanes shall be maintained open for traffic. The contractor will be required to provide, install, and maintain all necessary signs, lights, devices, barricades, marker cones and other



protective facilities. During working hours, he will make, whenever feasible arrangements to accomodate the affected residents. He shall also hire off-duty policemen to provide smooth flow of traffic as required by the City Department of Transportation Services.

Prior to the design of the Kaneohe EFM, the City Department of Transportation Services (DOTS) was consulted and they had no objection to the closure of streets along Kaneohe Bay Drive that would occur during construction. After review of the draft statement, they realized that the closure of traffic during construction through the narrow segments of Kaneohe Bay Drive would affect the City bus route. The DOTS have requested that one lane be kept open or other provisions be made to permit passage of buses. A review of the construction plans indicate that vehicle passage will not be possible along the narrow portions of the highway during the construction of the EFM. As an alternate solution, it appears that DOTS could re-route their buses on Mokapu Boulevard or on the completed portion of TH-3 and run a shuttle vehicle along Kaneohe Bay Drive if this services are desired. The buses could use Kaneohe Bay Drive during the evening hours, and the early morning and late afternoon hours when passenger loads are generally the heaviest. During the construction working

period between 8:00 am to 3:00 pm when light passenger loads could be expected, the buses can use the Mokapu Boulevard route. The distance between the intersection of Mokapu Boulevard and Kaneohe Bay Drive (at Mikiola) to the intersection of TH-3 and Kaneohe Bay Drive is approximately 1.5 miles which indicates maximum walking distance of 3/4 miles if shuttle services were not available.

i. Disturbances of Wild Life

The northern boundary of the Kailua STP abuts a wildlife refuge consisting of Outer Nuupia, Halekou Pond and Inner Nuupia in KMCAS. The force main within the plant will be laid parallel to this boundary 40 feet towards the south. There is a heavy growth of brush for several hundred feet between the plant and the ponds where the protective birds nest. At this distance, construction operations and its associated noise levels are not expected to harm the wildlife of this refuge.

j. Public Safety

The public will be protected from the hazards of the construction activities. While working on roadways and streets, the contractor

shall be required to control traffic in accordance with the "Manual on Surface Traffic Control During Performance of Construction Work" of the City Department of Public Works; the requirements of the Department of Transportation Services; and during work on State highways, the requirements of the "Rules and Regulations Governing the Use of Traffic Control Devices at Work Sites on or Adjacent to Public Streets and Highways" of the Highway Safety Coordinator, State of Hawaii.

When substructure excavations cross street intersections, safe crossings for vehicles and pedestrians shall be provided and maintained by the contractor. Pedestrian crossings shall be separate from vehicle crossings and shall be provided with handrails except in paved areas opened for vehicular traffic. In addition, the contractor shall locate, install, and maintain warning signs, lights, walkways and detours.

The contractor shall notify the public of the commencement of construction by suitable announcements in the morning and evening

newspapers. As was mentioned previously, all trenches in roadways and streets will be covered at night.

5. Kaneohe STP Effluent Pump Station (Kaneohe EPS)

a. General

The proposed improvement consists of the effluent pump station, the effluent fine screening, and the discharge outlet of the Kahaluu Effluent Sewer. All work will be done within the existing plant site.

b. Clearing and Grubbing

None is required. The area is already cleared.

c. Grading and Earthwork

Ground elevation at the proposed pump station site varies from 5 feet to about 2 feet. To prevent the station from being flooded, the finished floor elevation was established at 10.0 feet; and the existing ground elevation will be raised to a maximum of about 9 feet. The slope for the earthwork will be 4 to 1. Side slopes will be planted with Lippia grass to prevent erosion.

Excavation for the construction of the substructure will be required. The contractor has the option of an "open" excavation or may construct a steel-lined "cofferdam". If the contractor decides to use a cofferdam, he will drive interlocking steel sheet piles around the periphery of the proposed substructure. Upon completion of the cofferdam, the material within will be excavated to a depth of about 17 feet. If open excavation is used, more material will be excavated because of the need to maintain the slope of the excavation. The excavated material will be stock-piled within the plant site and be re-used for fill material.

d. Air Quality

Exhaust fumes from construction equipment will be discharged into the atmosphere. This emission cannot be avoided. Because clearing and grubbing will not be required, and the filling operation will be restricted to an area of about 15,000 square feet (equivalent to one medium-sized house lot), very little dust will be generated. Whatever dust is

generated will be confined within the plant site.

e. Water Quality

Dewatering operation from the cofferdam or open pit excavation for the substructure may or may not be a problem depending on the contractor's construction method. Regardless of his method, polluted or silt-laden water from the excavation will not be allowed to be discharged directly into the nearby Kaneohe or Kawa Streams. Information of soil condition at the site indicates that recharge into the ground will not be possible, hence silting basin for the dewatering operation may have to be utilized.

f. Noise

Some noise will be generated by the construction activities. They will come from internal combustion engines, compressors, jackhammers, saws, pile drivers, and other construction equipment and processes.

Piles will be required to support the station

because of the lack of adequate carrying capacity of the underlaying soil material. About 110 pre-stressed concrete piles, 12-inch square are expected to be driven to the -59.0 feet elevation. Pile-driving activities are not expected to exceed a two-month period. No pile-driving will be permitted in the early or late hours of the day.

g. Night Work

No night work is anticipated. Hours of work will normally be confined between the hours of 7:00 am to 3:30 pm.

h. Traffic

There will be no interference with traffic. All work will be confined within the plant site.

i. Public Safety

All work will be done within the plant site, hence the public will not be exposed to any construction hazards. The plant site is completely enclosed by a 6-foot high chain link wire fence. Public access into the plant is

## 7. Kahaluu WWTP Effluent Sewer

### a. General

The proposed 24-30-inch force main and gravity sewer will consist of approximately 31,600 feet of pipeline beneath the ground surface. It will start at the proposed effluent pump station on the Kahaluu treatment plant site and end at the intake box of the proposed Kaneohe EPS.

In general, the force main and gravity sewer will be laid in trenches at various depths. Both force main and gravity sewer will have a minimum cover of four feet under vehicular traffic areas and a minimum of two feet cover in easements through private property and within the treatment plant sites. Where the lines cross utility lines, either the effluent sewer or the utility line involved will be jacketed when the affected utility agency so requests. Design parameters along and across the State portion of Kahekili Highway will conform to the requirements of the Rules and Regulations Relating to the Accommodation and Installation of Utilities on State Highways and Federal-Aid Secondary County Highways.



b. Clearing and Grubbing

A minimal amount of clearing or grubbing will be required for this project. Most of the effluent sewer will be laid beneath existing City Street pavement or alongside the pavement of Kahekili Highway. Within this section, there are no trees or shrubbery that are expected to be removed by the construction of the effluent sewer.

c. Excavation

The pipe will be laid within a trench 50 inches wide by 14 feet deep maximum. The excavated material will be used for trench backfill and all excess material will be hauled off the job site.

d. Air Quality

Construction activities will affect the quality of the air. This effect is expected to be minimal. Little or no dust will be generated during construction because work will usually be in paved areas. Exhaust fumes from construction equipment are not expected to become a problem. Only conven-

tional construction equipments are expected to be used.

e. Water Quality

As was mentioned previously, the problem of siltation resulting from trench excavation is minimal. The amount of trenching that can be opened in advance of the pipe-laying operation will be limited to not more than 150 feet over existing improved streets, sidewalks, driveways, and paved areas, and 200 feet in other areas. The pavement trench width for a 24-inch concrete pipe is 50 inches, hence the surface area disturbed will be only about 4 square feet per lineal foot. The placement of excavated material shall also be controlled because of the requirements of traffic control over the two lanes portion of Kahekili Highway, Kealahala Road, Anoi Road, Paleka Road and Waikalua Road. Excavated material shall be properly stockpiled and safeguarded against erosion.

If material are stockpiled on the streets adjacent to the trench, such material shall be confined by suitable bulkheads or other

devices. Under the supervision by the City and County inspectors, there will be little or no run-off of excavated material into Kaneohe Bay.

Underwater construction will occur across Kaneohe Stream between the Kaneohe treatment plant and Holowai Place. In addition, crossing of Kahaluu and Ahuimanu Streams may be under the streams depending on final design consideration. Excavation and dewatering operations of stream crossing will be strictly controlled to prevent loss of soil material and to restrict and localize turbidity in the streams to the immediate construction sites. The usual procedures for the construction of these underwater siphon (actually reverse siphon) is to drive steel sheet pilings across the entire length of stream width to permit excavation and placement of the pipes. Using these construction techniques, there should be little or minor changes of the existing water quality of the affected stream (s).

Stream and ground waters from the dewatering

process may have to be ponded prior to discharge back into the natural waterways.

f. Noise

Some noise will be generated by the construction activities. They will come from internal combustion engines, compressors, jackhammers, saws, and other construction equipment and processes. These noises are unavoidable, but will be temporary and limited to the daylight hours of the day. Driving of sheet piling to cofferdams for the Kaneohe, and perhaps the Kahaluu and Ahuimanu Streams can be expected. Pile-driving activities at these sites are not expected to exceed a two-month period. No pile-driving will be permitted in the early morning or late hours of the day.

g. Night Work

No night work is anticipated. Hours of work will normally be confined between the hours of 8:00 am to 3:00 pm.

h. Traffic

There will be traffic inconveniences that will be created during the construction of this project. Within the State right-of way portion of Kahekili Highway, the effluent force main will be laid in the makai shoulders and traffic problems should be minimal. Also, within the two lanes City and County portion where the effluent sewer will be laid in the makai shoulder of the highway, traffic interference should be minimal and two way traffic should be available at most times.

It will be at the relatively narrow City and County roads at Keaahala, Anoi, Paleka, and Waikalua, where traffic interferences and inconveniences will be the greatest. The effluent sewer will be laid at or near the center line of the roadway that will necessitate only one way traffic during the normal working hours between 8:00 am and 3:00 pm. To minimize the inconveniences of local traffic, the pipeline will be constructed in short increments not to exceed 150 feet. During non-working hours, all trenches shall be covered, and all lanes shall be maintained

open for traffic. Off-duty policemen shall be hired by the contractor to direct traffic as required by the City Department of Transportation Services.

i. Public Safety

The contractor will be required to provide, install, and maintain all necessary signs, lights, devices, barricades, marker cones and other protective facilities because of the hazards of public safety caused by the construction activities. While working on roadways and streets, the contractor will be required to control traffic in conformance with applicable State and City traffic regulations and rules.

When substructure excavations cross street intersections, safe crossings for vehicles and pedestrians shall be provided and maintained by the contractor. Pedestrian crossings shall be separate from vehicle crossings and shall be provided with handrails except in paved areas opened for vehicular traffic. The contractor shall notify the public of the commencement of construction by suitable announcements in the morning and evening newspapers. During the night and non-working hours,

all trenches in roadways and streets will be covered.

7. Kahaluu Wastewater Treatment Plant (Kahaluu WWTP)

a. General

The proposed plant site is adjacent to the Kahaluu Watershed Project. The Kahaluu Watershed Project is sponsored by the Windward Oahu Soil and Water Conservation District and the City and County of Honolulu. This project is authorized under the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666) as amended.

The proposed improvements to the Kahaluu WWTP will consist of a screening and grit handling building, primary and secondary clarifiers, aeration tanks, sludge handling facilities, administration and control building, chlorine application and storage building, raw and effluent pumping stations and other miscellaneous appurtenances. These are the components that will provide treatment for the 1990 anticipated flows. The layout will also permit expansion of the plant for additional flows at a later date if required.

b. Clearing and Grubbing

The entire area of the proposed site is covered with short to one-foot high grasses, predominately honohono, weeds and small shrubs. Land clearing will be accomplished

by bulldozing of shrubs, grasses and weeds. Vegetation spoil will be disposed of by presently acceptable means such as land fill. The use of herbicides is not anticipated. There is one small building on the site which will be demolished. The disposal of this building will be to a land fill.

There are two major streams on the south and east (makai) boundaries of the site. The present course of the Kahaluu Stream is about 700 feet from the makai boundary. In conjunction with the proposed Kahaluu Watershed Project, the present stream alignment will be altered and enlarged to form a 28-acre multi-purpose lagoon adjacent to the plant boundary. The southern boundary of the site and the existing Waihee Stream form one common boundary. The present alignment of Waihee Stream will be changed so that it will cut across the makai-southern portion of the site. In addition to these two major streams, there is a small ditch on the Waihee Road side of the site (north boundary). The ditch is located in lands that are proposed for park use. Prelimi-



nary planning indicates that the existing ditch will be replaced by a small grass lined swale.

A drainage plan will be developed as a part of the treatment plant construction plans. It is intended that all surface waters be collected in the plant internal drainage system and conveyed either to the Waihee Stream and/or to the lagoon. A swale will be constructed on the mauka boundary to intercept a small quantity of sheet flow onto the existing plant site to the Waihee Stream. Drainage patterns during construction is not expected to differ with the present drainage condition. The relatively small plant area (14 acres) indicates that surface runoff and erosion will not be a major problem during construction, if care is exercised during the clearing, grubbing, and grading operations. The amount of rainfall at the plant area is considerable and often in bursts (75 inches annually). Because of this reason, the contractor will be required to exercise good judgment in these operations which will be strictly

supervised by City's inspector.

c. Grading and Earthwork

The treatment plant site will be graded to conform to an overall grading plan. The plant will be graded to provide maximum utility of the site, satisfy the hydraulic requirements of the plant processes, and to blend the proposed improvement of the plant with the surrounding environment. The mauka portion of the site is expected to be excavated to provide fill for the lower portion. Cut areas will be immediately grassed to prevent erosion of the ground. Cut slopes will be relatively flat--(3:1 minimum and 4:1 where possible). Swales will be provided at the top of cut slopes.

Deep trenches, foundations and structures will probably require dewatering. The contractor will be required to control discharges from these operations by ponding or other acceptable methods to prevent loss of sediments to the adjoining streams.

Soil samples and borings do not indicate that

hard materials will be encountered during construction. Hence, no blasting will be anticipated.

d. Air Quality

Construction activities may affect the quality of the air. This effect is expected to be minimal. Dust may be generated and could affect the area downwind of the construction site. The construction specifications would require that the contractor control dust by watering, applying dust palliatives, or other methods acceptable to the City.

Use of chemical sprays such as insecticides or herbicides are not expected. Exhaust fumes from construction equipment are not expected to become a problem. Only conventional construction equipment are expected to be used.

e. Water Quality

Construction activities will have temporary effects on water quality. Water from trench dewatering, excavation for structures and

other appurtenances must be disposed of without creating nuisances or increasing the turbidity of the already turbid streams. Preliminary soils information indicates that the subsurface materials are generally non-porous and recharge into the ground will probably not be possible. Hence, silting basins will probably be utilized with the overflow being discharged into the streams.

f. Noise.

Some noise will be generated by the construction activities. They will come from internal combustion engines, compressors, jackhammers, saws, pile drivers, and other construction equipment and processes.

Piles will be required to support to heavy structures of the plant because of the lack of carrying capacity of the subsurface soils. The number and kinds of piles that will be used will be determined during the final design stage of the plant. Length of piles will exceed 50 feet. The contractor may also elect to drive sheet piling for the cofferdam for the major plant structures

including the pump stations. Noises will be generated during the pile driving operation and also during the withdrawal of the steel sheet piles. Pile driving activities are not expected to exceed a two-month period. No pile driving will be permitted during the early or late hours of the day.

g. Night Work

No night work is anticipated. Hours of work will normally be confined between the hours of 7:00 am to 3:30 pm.

h. Traffic

There will be no interference with traffic. All work will be confined within the plant site.

i. Public Safety

The public will be protected from construction hazards. The contractor will be required to provide barriers, guards, lights, warnings and other safeguards as may be necessary to prevent injury to persons and property.

After the site is cleared and graded, a chain link or other type of fence will be built, enclosing the entire plant site.

## 8. Construction Permits

Prior to the construction of the components of the Kaneohe-Kailua sewer system, permits will have to be obtained from several Federal, State and County agencies. These requirements are listed below.

### Federal

Corps of Engineers permits for construction of the Mokapu Ocean Outfall and underwater construction of the Kahaluu Effluent Sewer across Kaneohe Stream will be required under the authority of the River and Harbor Act of 1899. An application for construction of the Mokapu Outfall was filed on October 11, 1973. Application for the Kaneohe Stream crossing will be made later when final design is completed and the project is ready for construction.

A National Pollutant Discharge Elimination System (NPDES) permit will be required for the construction and operation of a municipal wastewater facility discharging into the navigable waters of the United States pursuant to Title IV, PL 92-500, the Federal Water Pollution Control Act Amendments of 1972. Applications for NPDES permits for the existing Kaneohe and Kailua sewage treatment plants were filed on December 21, 1973. Mention was made in the applications of the change in disposal locations to be effected

by the construction of the Mokapu Outfall and the Kaneohe Effluent Force Main. Pending clarification, a State "zone of mixing" may be made a condition of the NPDES permit.

State of Hawaii

Since all offshore waters are considered to be within the conservation districts, a Conservation District Use Application to construct the Mokapu Outfall and the Kailua Effluent Force Main will be required from the Board of Land and Natural Resources. An application was filed with the Board on December 12, 1973.

A Shorewater Construction Permit to construct the ocean outfall off Mokapu Peninsula must be obtained from the Harbors Division of the Department of Transportation. Concurrence is usually based on the granting of a Corps of Engineers permit and approval of a Conservation District Use Application. The application for this permit was filed on October 11, 1973.

A request for a zone of mixing for the Mokapu Outfall under the provision of Public Health Regulations Chapter 37-A was filed on July 17, 1972 with the Department of Health and is still pending. Pending clarification, this request may be incorporated in the NPDES permit.

City and County of Honolulu

Construction along the shoreline requires compliance with the Shoreline Setback Rules and Regulations administered by the Department of Land Utilization. The public hearing requirements of Section 14.6 were held on April 30, 1971, April 5, 1972, and January 16, 1974.

A permit must be obtained from the Department of Transportation Services before work on any portion of a public street or highway may begin. All traffic control shall conform to the requirements of the department, the "Manual on Surface Traffic Control During the Performance of Construction Work" of the Department of Public Works, the current Traffic Code of Honolulu, and the "Rules and Regulations Governing the Use of Traffic Control Devices at Work Sites on or Adjacent to Public Streets and Highways" of the State Highway Safety Coordinator.



## C. Long-Term Environmental Impact

### 1. Mokapu Outfall

#### a. Predicted Water Quality Changes Off Mokapu Peninsula

Any sewage discharge, even though highly treated, will have some effect on the quality of its receiving water. This is particularly true if a waste effluent, with its load of biostimulants and toxicants is discharged into an oligotrophic receiving water as would be the case with the proposed marine disposal systems for Oahu. The questions needing answers are: (1) Will the effects be detrimental? and (2) What will their magnitudes be?

Combined secondary treated effluents from the Kaneohe, Kailua, KMCAS, and proposed Kaha-luu plants should have little effect on the ecology, sanitary quality, or aesthetics of the receiving waters off Mokapu Peninsula. Water quality data gathered at both the existing Kaneohe and Kailua discharges that water quality standards are being met with the exception of nutrient concentrations. In this respect, ambient nutrient concentrations in

Kailua Bay were higher than the standards. Since the diffuser system of the outfall sewer is proposed to be emplaced in 100 feet of water with dilution ranging from 100 to 200 to 1, the effluent will be quickly diffused into the open ocean by the offshore currents.

The ocean floor at the discharge area is relatively free of biological communities having important economical or ecological values. In a few areas, there are medium-sized colonies of pinna clams which may be influenced by the discharge; however, these same type of clams are found in large numbers near the present Sand Island raw sewage discharge which suggests that they would not be affected adversely by the proposed discharge. Adverse biostimulatory effects on plankton communities will be slight in the immediate area of the diffuser because uptake of nutrients from the secondary effluent will be immediate. In this respect, the discharge of secondary effluent into the ocean will be less desirable than primary effluent.

By providing for a lesser degree of treatment, the adverse effect of the effluent can be minimized, however, paradoxical this may seem. The nutrients in the secondary effluent are in a form that will be readily converted to algal cells in the immediate vicinity of the outfall diffusers. Because the average offshore currents off Mokapu are substantial and diffusion of the nutrients will be rapid, biostimulation should not become a problem.

Removal of floatable materials at the treatment plant will protect aesthetic quality of the surface of the receiving waters. Unlike Sand Island, one of the dominant factors for recommending secondary treatment for Windward Oahu, is the improbability of maintaining a submerged effluent field throughout the year. The high initial dilution anticipated (about 200 to 1 at average flow) would prevent the field from being noticed by casual observers.

b. Water Quality Changes in Kaneohe Bay

With the diversion of all wastewater from

the Kaneohe, KMCAS, the Ahuimanu plants, the discharge of nitrogen, phosphorus and organic suspended solid materials into the Bay will be substantially terminated. On an annual basis, this represents 104 tons of nitrogen, 44 tons of phosphorus, and 340 tons of suspended solids. The magnitude of this quantity can be visualized by realizing that the amount of nitrogen discharged annually can fertilize approximately 700 acres of sugar each year. The removal of nutrient from the bay will eliminate approximately 85 percent of the nitrogen and 95 percent of the phosphorus entering the bay from known point sources.

The amount of pollutant entering the bay from the leachate of existing and abandoned cesspools cannot be determined accurately. There are approximately 1,900 existing cesspools draining into Kaneohe Bay. This represents a population equivalent of approximately 8,000 people or the discharge from leachate of approximately 45 tons of nitrogen and 12 tons of phosphorus annually into the groundwater system of the bay. These leachate discharges will be eliminated upon the sewerage of the affected lots in Kaneohe and Kahaluu.

The diversion of effluent to Mokapu Peninsula will increase the salinity of the bay slightly. This effect on the breeding and nursery zone

cannot be assessed inasmuch as the status of Kaneohe Bay as a nursery ground still remains unanswered (Reference 35). However, before 1954 no effluent discharge existed and the diversion will allow the salinity to return to its previous levels.

It is not possible to predict how long it will take before there is substantial improvement of water quality in the bay. An interesting parallel case is the situation in San Diego, California. Municipal wastewater from a population of over 860,000 (80 mgd) was being discharged in the crescent shaped bay of about 18.5 square miles prior to 1963. Because tidal flushing was small, the bay was soon grossly polluted and unfit for many of its potential uses. These uses included a navy base, shipping, industrial use, research, aesthetic enjoyment and recreation including boating, fishing, swimming, and water skiing. Late in 1963, the flows from metropolitan San Diego were conveyed to a primary treatment plant at Point Loma and discharged into the Pacific Ocean 2 miles off the Point at a depth of 200 feet. Since that time, the bay has recovered remarkably from the pollution, even though, there are still some localized problem areas due to a thermal discharge, and ship

and industrial wastewater flows within the bay.

Similar results from the State of Washington indicate rapid rates that the waters of Lake Washington and Puget Sound were able to cleanse themselves. Hopefully, the same effects could happen in Kaneohe Bay.

c. Water Quality Standards

The Department of Health, State of Hawaii has classified the water area offshore off Mokapu Peninsula as Class A water (See Figure I-2).

The water uses to be protected and water quality standards that are applicable to the treated effluent to be discharged into the water area are as follows:

- (1) Water Uses to be Protected (Reference 19; Chapter 37-A, Section 3, Classification of Water Uses; Paragraph A-2, Class A Waters)

"The uses to be protected in this class of waters are recreational, including fishing, swimming, bathing and other water-contact sports and aesthetic en-

joyment. It is the objective for this class of waters that their use for recreational purposes and aesthetic enjoyment not be limited in any way. Such waters shall be kept clean of any trash, solid materials or oils and shall not act as receiving waters for any effluent which has not received the best practicable treatment or control compatible with the standards established for this class.

(2) Applicable Water Quality Standards  
(Chapter 37-A, Section 6, Water Quality Standards; Paragraph B)

(a) Microbiological Requirements:

The median coliform bacteria shall not exceed 1000 per 100 ml nor shall more than 10% of the samples exceed 2400 per 100 ml. Fecal coliform content shall not exceed an arithmetic average of 200 per 100 ml during any 30-day period nor shall more than 10% of the samples exceed 400 per 100 ml in the same period.

(b) pH - Units:

Not more than  $\frac{1}{2}$  unit difference

from natural conditions but not lower than 7.0 nor higher than 8.5 from other than natural causes.

(c) Nutrient Materials:

Total phosphorus, not greater than 0.025 mg/l. Total nitrogen, not greater than 0.15 mg/l.

(d) Dissolved Oxygen (except from natural causes):

Not less than 5.0 mg/l.

(e) Temperature

Temperature of receiving waters shall not change more than 1.5 degrees Fahrenheit from natural conditions.

(f) Turbidity:

Secchi disc or secchi disc equivalent shall not be altered from natural conditions more than 10%.

(g) Radionuclides:

The concentration of radioactivity in water shall not exceed 1/30th of the  $MPC_w$  values given for continuous occupational exposure in National Bureau of Standards Handbook No. 69. The concentration



of radioactive materials present in marine waters shall be less than those that would require restrictions on the use of organisms harvested from the area in order to meet the Radiation Protection Guides recommended by the Federal Radiation Council."

Public hearings were held in July 1973 by the Department of Health relative to proposed amendments to Chapter 37-A. The proposed amendments as it relates to Class A waters are as follows:

Section 3, Paragraph A-2, Class A Waters

"The uses to be protected in this class of waters are recreational including fishing, swimming, bathing and other water contact sports, aesthetic enjoyment and the support and propagation of aquatic life.

It is the objective for this class of waters that their use for re-

creational purposes and aesthetic enjoyment not to be limited in any way. Such waters shall be kept clean of any trash, solid materials or oils and shall not act as receiving waters for any effluent which has not received the best degree of treatment or control practicable under existing technology and compatible with the standards established for this class".

Section 6B, Water Quality Standards  
Microbiological Requirements:

"The median coliform bacteria shall not exceed 1000 per 100 ml, nor shall more than 10% of the samples exceed 2400 per 100 ml during any 30-day period. Fecal coliform content shall not exceed an arithmetic average of 200 per 100 ml during any 30-day period nor shall more than 10% of the samples exceed 400 per 100 ml in the same time period. To determine compliance with the above microbiological re-

quirements where a '30-day period' is specified, a minimum of ten samples shall be collected."

Radionuclides:

"Radioactive materials in excess of minimum concentrations which are physically and economically and feasible to achieve. In no case shall such materials exceed the limits established in the 1962 Public Health Service Drinking Water Standards (or later amendments) or 1/30th of the  $MPC_w$  values given for continuous occupational exposure in the National Bureau of Standards No. 69. The concentrations in water shall not result in accumulation of radioactivity in plants and animals that result in a hazard to humans or harm to aquatic life.

The concentration of radioactive materials present in fresh, estuarine, and marine waters shall be less than those that would require

restrictions on the use of organisms harvested from the area in order to meet the Radiation Protection Guides recommended by the Federal Radiation Council."

Whether these amendments will be adopted by the State is too early to speculate, however, their adoption will not create any problem in meeting the standards.

It is anticipated that the proposed wastewater discharge will have a negligible effect on the present water quality off Mokapu Peninsula and Kailua Bay. In fact, the water quality of Kailua Bay should improve after the existing outfall off Kapoho Point is abandoned. If continuous chlorination is required by the State, there will be no significant deviation from the water quality standards. Ambient nutrient concentrations exceeds the water quality standards, hence these

standards cannot be met under any condition in the oceanic waters of Oahu. If continuous chlorination is not required, the median total and fecal coliform counts after initial dilution under average flow conditions are estimated to be 85 and 35 per ml respectively. A "zone of mixing" for coliform bacteria and/or nutrient concentrations will have to be established beginning at the ocean floor and extending upwards to the surface. The initial and subsequent diffusion dilution of the wastewater effluent and the rapid rate at which coliforms are killed in Island waters will eliminate the necessity for a large zone of mixing and will be sufficient to protect the near-shore waters.

Summarizing, the present water quality in Kaneohe and Kailua Bay should improve considerably since the proposed effluent disposal sys-

tem will (1) replace an interim disposal system that consists of the discharge of secondary effluent 500 feet off Kapoho Point in 13 feet of water in Kailua Bay; (2) eliminate the discharge of secondary treated effluent from the Kaneohe municipal plant and KMCAS in the southern part of Kaneohe Bay; and (3) eliminate the discharge of tertiary effluent from Ahuimanu into Ahuimanu Stream which flows into Kaneohe Bay.

d. Chlorination

(1) Application of Chlorine

Chlorine can be used to disinfect the treated sewage effluent prior to its discharge into the ocean from the sub-district plants, including KMCAS. With the application of a proper dosage, thorough mixing, and adequate detention time, the treated effluent should easily meet the microbiological requirements of the water quality standards. Chlorine requirements for disinfection for the Kailua, Kaneohe, and

the KMCAS effluents will range from 10 to 15 mg/l. The dosage rate for the proposed Kahaluu plant which will employ the activated sludge process will range from 6 to 8 mg/l. Upon conversion of the Kailua and Kaneohe plants to the activated sludge process, chlorine dosage can be reduced from 15 to 8 mg/l. A residual of 0.5 mg/l total chlorine is usually required after a contact period of 15 minutes.

Based on the continuous dosages of trickling filter effluent of 15 mg/l initially and 8 mg/l later for activated sludge the annual chlorine consumption in pounds for the 1970 and 1990 design period are as follows:

	<u>1970</u>	<u>1990</u>
Kailua	231,000	241,000
Kaneohe	137,000	163,000
KMCAS	42,800	60,000
Kahaluu	-	34,000
TOTAL (lbs.)	410,800	498,000

Other uses of chlorine such as odor control and sludge handling are not included in the above figures.

(2) Chlorine Handling and Storage

Chlorine is not manufactured in the Islands at present. It must be imported from the U.S. mainland by ship or barge. Transportation of chlorine from the West Coast to Honolulu is being done using ton containers. Tank barges, with capacities of 600 to 1200 tons are the other method commonly used in the transportation of chlorine. Because chlorine is a hazardous substance, special care is required in their handling. Storage of ton containers can be indoors or outdoors. If stored outdoors, the storage area should be designed and constructed to protect all elements of the chlorination system from fire and be clean and free of any accumulated trash in order to avoid the possibility of fires. Ventilation systems should be provided for indoor storage areas.

(3) Chlorination Facilities at the Kailua and Kaneohe Plants

Chlorination equipment and chlorine storage area for both Kailua and Kaneohe plants are



located in specially designed chlorination buildings. The chlorinators at both plants are of the automatic control, solution feed, vacuum type, capable of manual operation. The rate of feed is automatically adjusted to the rate of effluent flow. Chlorinators are equipped with the necessary meters, orifices and other parts capable of delivering chlorine at the range adequate to produce a chlorine residual of 0.5 mg/l after 15 minutes contact period with the final effluent. All equipment and materials used, conform to the Chlorine Institute standards.

One chlorinator at each plant is maintained as a stand-by unit and ton containers are used in both installations. Safety measures at the chlorination building include first aid equipment and industrial type gas mask with chlorine type canisters located on the outside of the building. Warning signs are also posted outside.

#### (4) Effluent Chlorination

Chlorination facilities provided at the Kaneohe and Kailua plants have adequate capacity for continuous disinfection of the secondary effluent since the present discharges are into an estuary and near-shore waters.

The need for continuous chlorination for discharges into deeper offshore waters is debatable at this time because of the rapid bacteria decay rates in Oahu's waters and favorable off-shore currents. Recognizing this problem, the State has adopted regulation permitting a variance of this requirement if the Director of Health "determines that such discharge(s) will not adversely affect the open ocean environment adjoining near-shore waters" (Section 7B4, Chapter 38, Sewage Treatment and Disposal Systems, Public Health Regulation, State of Hawaii).

Based on design consideration, the City sees no need to chlorinate the effluent continuously except during adverse conditions in the receiving waters and in emergencies, such as process upset at the plants. Without chlorination, the microbiological requirements will be met except in a limited area around the diffuser. In this regard, a zone of mixing is presently being processed by the State Department of Health for the proposed Mokapu Outfall Sewer. The proposed zone of mixing shown in Figure II-7.

The proposed zone is 250 feet wide on each side of the pipe and extends 250 feet outward from both ends of the diffuser section (1,460 feet by 500 feet).

The distance of the proposed zone of mixing to Kii Point, the nearest land point is approximately

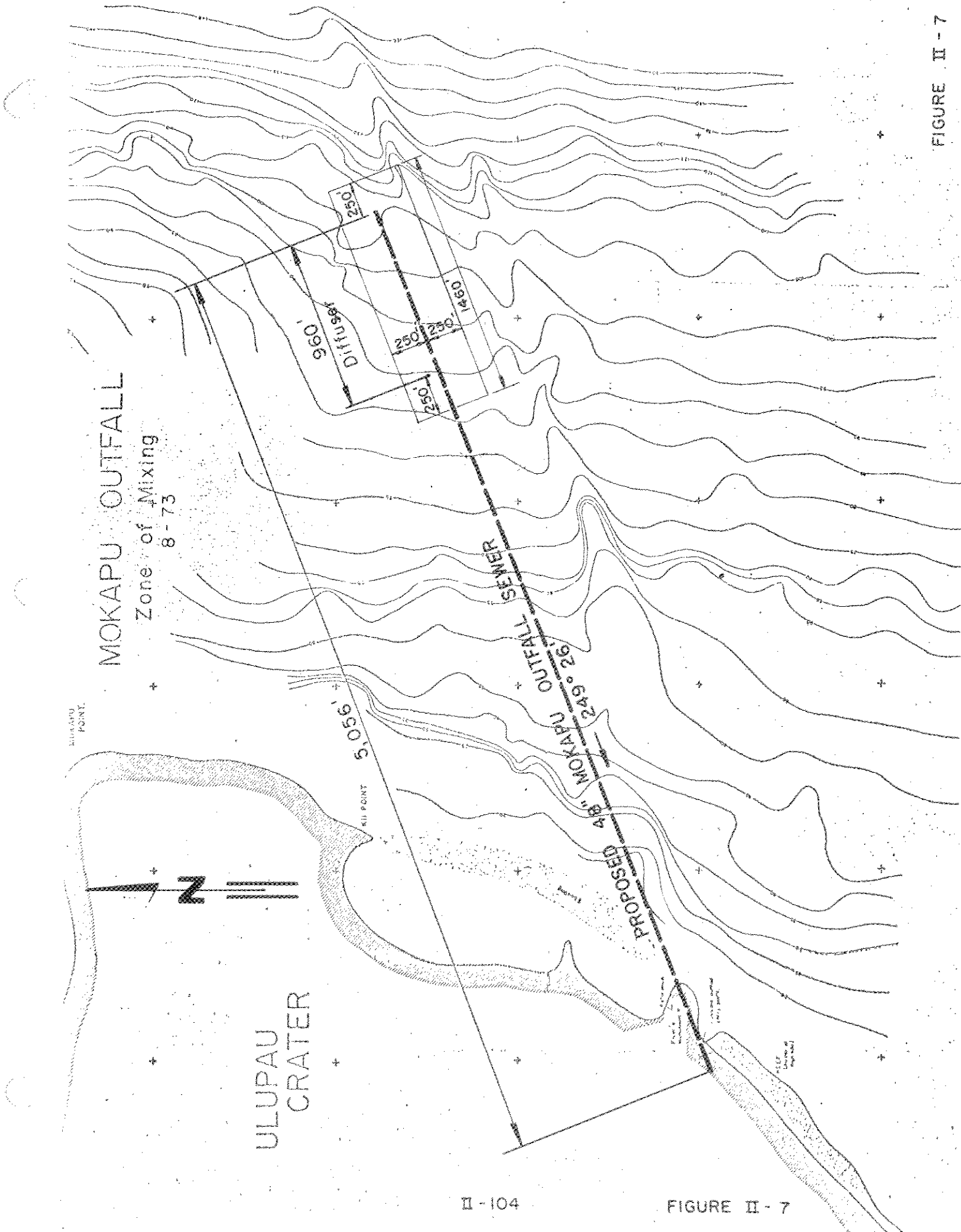


FIGURE II - 7

2300 feet. We strongly believe that this zone of mixing will not unreasonably interfere with any actual or proposed uses of the water area.

To determine if the marine environment will be significantly affected by the discharge, the City intends to pursue an intensive ocean monitor program off Mokapu Peninsula and Kailua Bay prior to and after the completion of the effluent disposal system. The future monitoring program will include surveys on standing fish population, benthic biota, coral formation, periphyton, coliform bacteria group and perhaps viruses, and chemical and physical parameters. The physical, chemical and bacteriological parameters will be monitored monthly for the first year after the completion of the outfall, and quarterly thereafter. The benthic biota studies will be conducted 6 and 18 months after the completion of the outfall and every 5 years thereafter. The other studies will be made every five years.

The monitoring program will be conducted by City personnel using facilities which include two well-equipped laboratories and an 18-foot outboard motor powered boat. Special studies will be conducted by consultants. City personnel assigned to the water quality program include three engineers, three sanitary chemists, and two laboratory assistants. These personnel are well versed with the conduct of the monitoring program, having actively participated with the consortium of WQPO.

The major factors which must be considered in chlorination are (1) hazards of transportation, (2) cost, and (3) need. Other related factors are minor hazards in the application of chlorine, the large amount of electric power required in the production of chlorine (contributing to thermal pollution), and the release of mercury vapor to the atmosphere during its production

(a) Hazards of Transportation

From the standpoint of safety, importing chlorine from the U.S. mainland is a problem. If continuous effluent chlorination is mandatory, several thousand one-ton containers must be shipped annually into the island during the initial period up to 1990 and beyond. Assuming mandatory chlorination on the continuous basis for major treatment plants discharging into offshore waters of Oahu, the total quantity of chlorine in terms of ton container for the year 1990 would be as follows:

	<u>One ton Container</u>
Kaneohe-Kailua District	400
Sand Island	3,300

Honouliuli	570
Waianae	100
	<hr/>
Annual Total Number	4,370

The greater the number of containers handled, the greater is the possibility of mishap. If chlorine escapes from a container, it could result in a serious health hazard for people on board ships or barges and in the trans-shipment areas since the gas irritates the respiratory system and may cause death from suffocation. Hence, handling, at the factory, during transportation and at the plant sites must be done with utmost care.

(b) Cost of Chlorination

The price of liquid chlorine delivered at the various district sites is estimated to be about 12 cents per pound for low and intermittent use and about 10 cents per pound for year round use. The estimated operating cost of the liquid chlorine system, including amortization as well as operation, maintenance, power and water costs is about \$300 per day. At the average

use of 1900 pounds of chlorine per day for continuous disinfection and odor control during the initial period to 1990, the estimated daily cost of using the liquid chlorine systems would be \$490, using an average chlorine cost of 10 cents per pound and an operating cost of \$300 per day. For continuous disinfection, the annual cost would average \$180,000 (rounded) for the combined flows.

If chlorination for disinfection was practiced only during plant upsets and unfavorable conditions in the receiving waters, the annual chlorination cost would amount to \$130,000 for the combined flows. The difference in annual cost would amount to \$50,000.

(c) Need for Chlorination

It is well established fact that the indicator coliform bacteria undergo a drastic reduction in number in the ocean. The rate at which bacteria decay, frequently called bacteria die-away rate by engineers, can be the result of a number of processes.

Bacteria probably decay due to exposure to insolation, saline water, unfavorable changes in temperature, and bacteriophages and other predators. Other bacteria may be absorbed by the sediments or settle to the bottom with particulate material. The individual importance of each of these stresses on the decay of coliform bacteria in the marine environment is not fully understood. Many processes may affect the decay of coliform bacteria around an outfall, not all of which cause a rapid die-away of the bacteria. In the design of an ocean outfall system, engineers generally refer to coliform decay in terms of T-90 time. This is the time it takes for 90 percent of the bacteria to decay once they reach the marine environment.

The T-90 values taken off Sand Island for the summer varied between 9 and 18 minutes and for the winter it was 15 minutes. The average Sand Island value was 13 minutes. A coliform bacteria decay-rate of 99 percent in 10 minutes was determined in Kailua



Bay during 1950 using radioactive carbon and making allowances for dilution. The data off Sand Island and Kailua Bay indicate a rapid coliform decay-rate when compared with the 3-hour T-90 value established off the southern California coast. Low T-90 values have been reported in England, Israel and Brazil. For design purposes, a conservative T-90 value of 1 hour is being used.

Investigation of ocean currents in Kailua Bay indicated that general circulation is controlled by tides. The tidal contribution to the current structure is about 40 percent (also influenced by the wind). During flooding tide, current moves water in a northerly direction and during ebbing tide, the current moves in a south-southeasterly direction. A strong current up to 1 knot was found around Mokuapu Point in the southeasterly and southwesterly direction (offshore). A shoreward surface layer drift was found to occur through most of the bay most of the year but is not as pronounced in the discharge area where variable drift patterns

occurred; the prevailing pattern depends upon the strength and direction of the winds and the character and strength of the tides.

Sub-surface daily resultant transports were found to be to the southwest during the fall, winter and early spring months of September to March and to the northwest during the late spring and summer months of April to August.

The velocities of nearshore current (Station D) varied from 0.3 to 0.7 knots and average flood and ebb directions were southerly and southeasterly respectively. Offshore currents at the proposed outfall terminus (Station C) ranged from 0 to 1 knot at the 20-30 foot depth and average flood directions were southeasterly, southwesterly, and northwesterly (offshore and along shore directions). During ebbing condition, average direction at this depth were southeasterly, southerly and southwesterly.

At the 70-80 foot depth (Station C) the

velocity ranged from 0 to 0.4 knots and average flood and ebb directions were generally southeasterly. The direct onshore currents of the upper layer occurred 5.6 percent of the time with velocity (90 percent speed) of 0.4 knots. The deeper layer direct onshore currents occurred 2.7 percent of the time with velocity (90 percent speed) of 0.2 knots. These conditions make the area off Mokapu the most favorable site for the discharge of wastewater effluents on Windward Oahu.

The probability of transport of the effluent to shore within two hours is about 2.8 percent of the time. The coliform reduction factors (combined reduction for diffusion and bacterial die-off) for the outfall ranged from 0.089 to 0.0072 for one hour to two hour respectively. It is anticipated that the effluent will meet Class A standards for bacteria within 10 minutes without chlorination.

In summary, the probability of significant coliform concentrations on the shore due

to the discharge of unchlorinated secondary effluents from the district's plants at the new Mokapu Outfall will be nil. Class A standards for coliforms will be met within 10 minutes after the effluent is discharged from the diffuser ports. If bacterial standards are exceeded outside the mixing zone, then intermittent or limited effluent chlorination will be used to keep the frequency of coliform counts within the limits of the microbiological standards at any monitoring station outside the zone of mixing.

d. Land Commitment

There will not be any permanent encumbrance of land for the outfall, however, sewer easements in favor of the City and County will be required for that portion of the line in KMCAS and the waters off Mokapu Peninsula. The U.S. Navy has indicated that there should be no problem in the granting of these easements by the Federal government.

e. Aesthetics

The entire pipeline will be buried. After construc-

tion, the affected areas will be restored to the existing grade and surface.

f. Local Social Effects

This project will not displace any homes, businesses or churches.

g. Natural and Historic Landmarks

At one time, Mokapu Peninsula was separated from mainland Kailua by several shallow bodies of waters. These bodies of waters are commonly referred to as Outer Nuupia, Inner Nuupia, Halekou, and Kaluapuhi. Historically, the entire area was once the site of a gigantic fishpond owned by a local royalty. In 1943, the fishponds and the adjoining area were sold to the Federal government by the Castle Estate. At one time, Nuupia pond was leased to a private individual who raised valuable commercial marine life of various types and species. These included the Amaama-Mullet, Awa-Milk Fish, Makimaki-Balloon Fish, Ulua-Jack Crevalle, Oio-Bone Fish, shrimps and Samoan crabs.

Outer and Inner Nuupia ponds are shallow, turbid bodies of water overlying a thick layer of muddy bottom. The ponds, of approximately 215 acres are enclosed on the north and south by adjoining land masses, and on the east and west by Mokapu Road and an artificial dike. Interchange of water be-

tween ponds and with Kaneohe Bay is made possible by means of pipes, openings, and a canal installed through the road and levees. The average water depth in 1959 was 1.5 feet and the bottom silt layer was about 9 inches thick.

Historically, Nuupia Pond and the adjoining land area were not always barren and desolate as they are now. Abundant marine, plant and fowl life existed in the past. At one time, a Fish and Game farm was established on Mokapu Peninsula in a tract of land north of Nuupia. Practically all the birds kept at the farm were imported. It was stocked with green-winged doves and red-crusted wood partridges of the East Indies as well as pheasants and other fowl. The bird farm was disbanded right after the beginning of World War II. Aside from the native birds of the island, the area is devoid of fowl and animal life except rodents and mongooses. The Hawaiian Stilt, Cattle Egret, and Night Heron are permanent residents of the pond at the present time. The ponds and its environment is a potential Federal or City site of about 506 acres for a natural wildlife sanctuary. These areas have been listed as excess to the needs of KMCAS. The proposed outfall will have no effect on the ponds or its habitants.

A portion of the Kailua Effluent Force Main will traverse a State Registered Historic Site and could possibly be within a Hawaiian burial site in the KMCAS property.

We have notified the State Department of Land and Natural Resources regarding our finding and have submitted a set of our construction drawings for their review and evaluation. The usual reinternment and other arrangements will be made by the City in any event.

2. Kailua STP Effluent Pump Station (Kailua EPS)

a. General

No additional area needs to be acquired to construct the Kailua EPS. The proposed station will be constructed within the existing treatment plant site near the makai (North) boundary, west of the existing chlorine building. The area of the plant site is 25.136 acres. The location of the proposed EPS is shown in the existing plant layout in Figure II-8. The nearest residence is located over 500 feet away in Aikahi subdivision. The proposed improvements at the Kailua plant would include, in addition to the pumping facility, a fine screening devise for the Kailua plant effluent, and the discharge force main outlets from the Kaneohe EPS and KMCAS EPS. The proposed station will be located downstream of the parshall flume (measuring device) and point of chlorine application and would consist of five pumps initially, each having a capacity of 8,400 gpm (gallons perminute).

Two of the pumps will be driven by electric motors

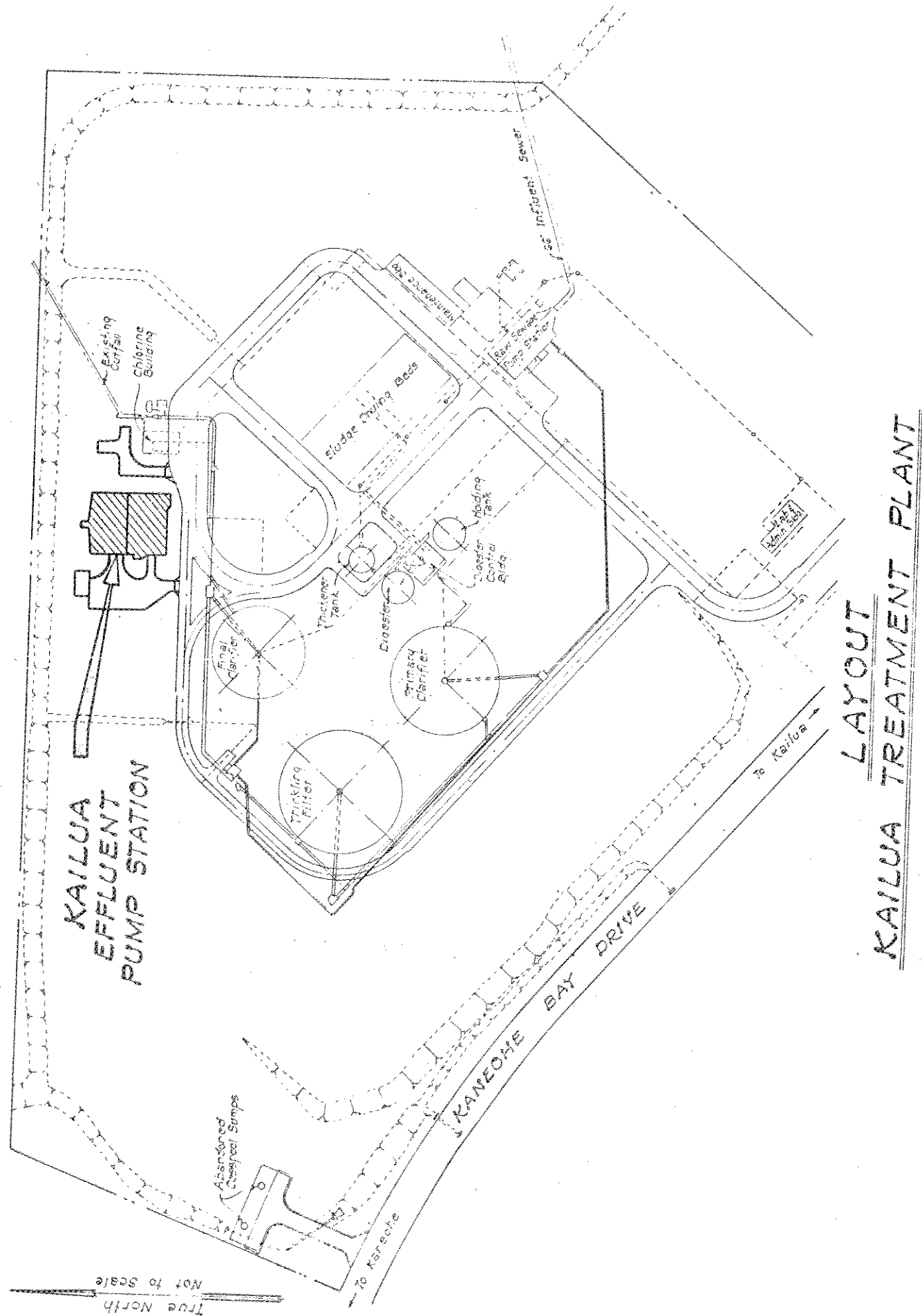


FIGURE II-8



mounted on top of the pump and three pumps will be driven by diesel engine located inside the station superstructure. Space for two additional diesel-driven pumps are provided for the future and ultimate flows. Pumps will be wet well vertical turbine pumping units equipped with electric and diesel motor drivers. All pumps will be located over the enclosed wet well outside of the superstructure.

The overall dimensions of the proposed station including the superstructure are 82 feet wide and 104 feet long. The superstructure is 49 feet wide by 70 feet long and 21 feet high. The substructure is 19 feet deep and consists entirely of the wet well.

The superstructure will consist of a reinforced structure with concrete blocks. The engine room is separated from the control room, office and wash-room facilities by a solid wall. The building has been architectural designed by a registered professional architect and will not detract the environmental setting of the area. Because it is located on the lower makai portion of the site, the building will not obstruct any view of Ulupau Crater and Puu Papaa Ridge.

Rotary drum fine screening mechanical devices will be provided for the Kailua Plant effluent (as well as the Kaneohe and Kahaluu effluents). These screens will be "backwashed" with effluent and the screenings will be decanted and collected for disposal by landfilling within the plant. Screen size of approximately 1/8 inches will be used. The amount of solids collected is estimated to be less than 0.2 cubic feet per million gallons and will consist primarily of psychoda larvae and humus sludge carryover from the final clarifier. Upon conversion of the plant from trickling filter to activated sludge, the collected screenings will consist only of floatable suspended solids.

b. Noise

The use of diesel drivers in addition to electric motors was considered in order to avoid by-passing of the effluent during an electric power outage. The use of diesel engines could produce a noise pollution problem. Electric outage of the Kailua plant between December 1970 to November 1971 was 11.5 hours. The longest duration was 3 hours and 55 minutes. Because of the unreliability of commercial power source, diesel engines will also be utilized.

The diesel engines will be located within the superstructure that is completely enclosed and provided with acoustical treated materials. The exhausts from the diesel engines will be located outside of the building, but will be equipped with residential type silencer.

c. Aesthetics

The area around the pump station will be landscaped. Slopes will be planted with Lippia grass, other areas with tiftan. Four coconut trees, affected by the construction will be relocated and replanted beside the building.

d. Potential Bypassing of Effluent into Kailua Bay

The potential bypassing of effluent into Kailua Bay is practically nil, however, the existing 42-inch outfall sewer into the bay off Kapoho Point will be maintained as a standby facility. Upon completion of the Mokapu Outfall, the standby line will only be used if there is a break in the Mokapu Outfall and only upon specific approval by the State Department of Health. The only other alternative for this proposal to insure a 100 percent safe-proof system is to construct a dual sized pressure

main and outfall sewer. A dual-pipe system will increase the cost of installation at least by 75 percent. The possibility of breakage of the disposal lines, accidentally or otherwise is practically nil in the first 20-25 years based on our experiences with the Ala Moana, Hart Street and Kapahulu pump stations force mains.

### 3. Kaneohe Effluent Force Main

#### a. General

The proposed 42-inch force main will leave the treatment plant at the northeast corner of the site and cross a private property and the Kokokahi YWCA (which abuts the southern perimeter of Waikalua-Loko Fish Pond and Kaneohe Bay), then enter Kaneohe Bay Drive. That portion of the line through the private property and the YWCA is parallel to an existing 2,660 long, 27-inch gravity sewer. The remainder of the alignment is within the Kaneohe Bay Drive right-of-way for about 14,340 feet from the YWCA to the Kailua treatment plant (See Figure II-4).

Two segments of the alignment along Kaneohe Bay Drive are under the control of the State Department of Transportation. The first portion consists of a

2500 feet segment from the YWCA to Ikeanani Drive and the second is a 2300 feet segment from Malae Place to the Aikahi Gardens entrance.

b. Land Commitment

There will not be any permanent encumbrance of land for this project, however, sewer easements in favor of the City and County will be required for that portion of the line in close proximity of the Kaneohe plant. The easement width will be about 12 feet where the force main will be parallel to the easement for the existing 27-inch sewer and twenty feet elsewhere.

The land commitment within the State right-of-way along Kaneohe Bay Drive will be that subsurface volume that the proposed line will occupy. The surface area here and throughout the entire line will be restored to or be better than the existing conditions. Activities normally associated within the construction area will be restored.

c. Aesthetics

The construction of the force main within the State jurisdiction will not necessitate removal of any trees, however, ground cover on the shoulder

area will be restored to the existing grade and replanted to the specifications of the existing ground cover.

d. Natural and Historic Landmarks

There are no known natural or historical landmarks, other than Waikalua-Loko Fish Pond, located in or adjacent to the force main alignment. Waikalua Pond is presently utilized as a commercial mullet pond. The State Archaeologist has determined the pond's historic value is insufficient for its inclusion on the State Historical Registry.

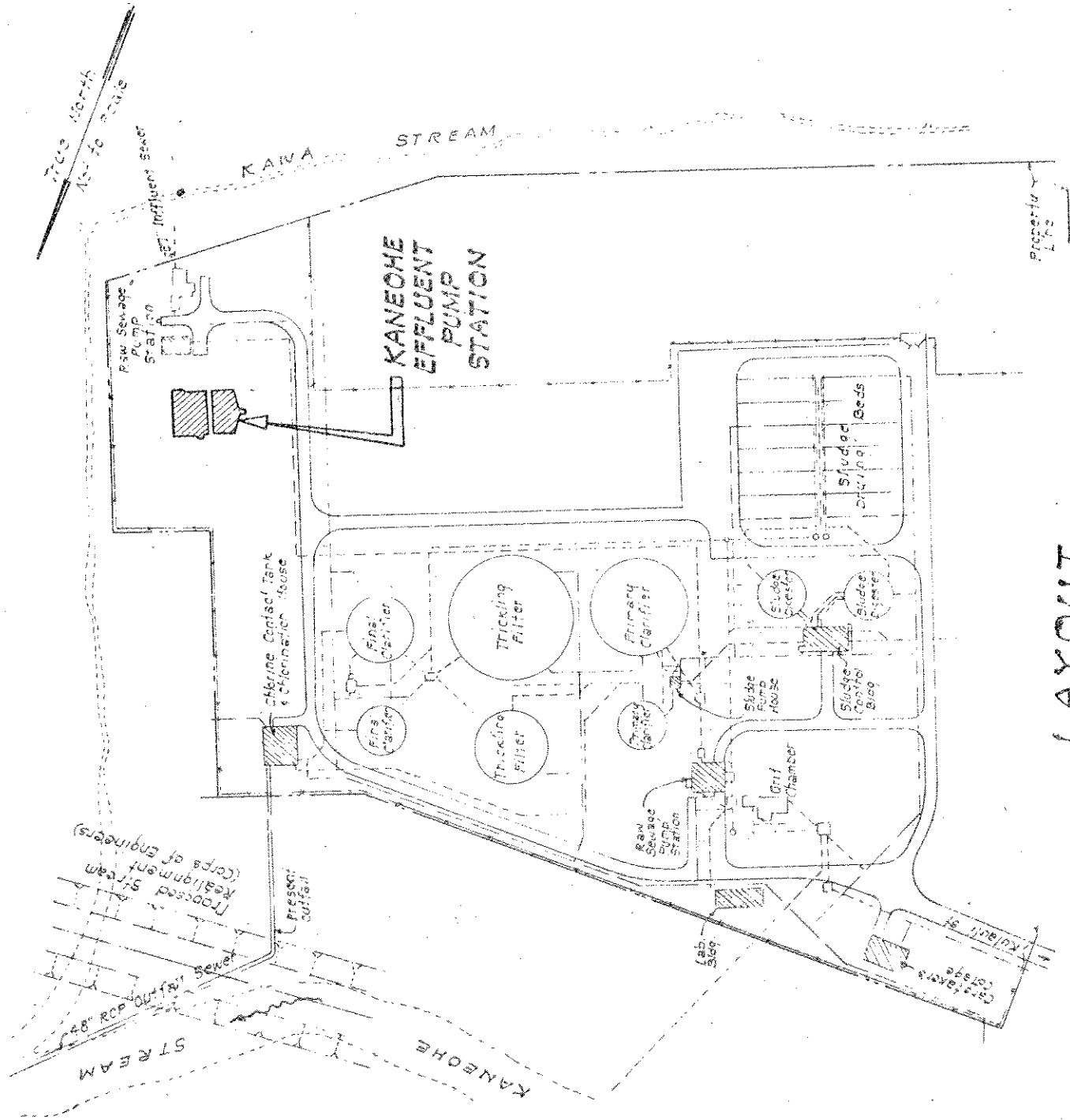
e. Local Social Effects

This project will not displace any business or person from their residences. No churches will be affected also.

4. Kaneohe STP Effluent Pump Station (Kaneohe EPS)

a. General

The proposed Kaneohe EPS will be constructed wholly within the existing Kaneohe plant site along the makai (northeast) boundary. The location of the EPS and the layout of the existing plant whose area is 15.895 acres is shown in Figure II-9. The clos-



LAYOUT  
KANEHOE WASTEWATER TREATMENT PLANT

est residences are located across Kaneohe Stream about 600 feet away at the end of Waikalua Road.

The structure and mechanical layout of the proposed EPS is almost identical with the Kailua EPS except it will be smaller. The overall dimensions of the station, including the substructure are 57 feet wide and 83 feet long. The height of the superstructure is 20 feet and is 57 feet long and 45 feet wide. The substructure containing the wet well and intake structure is 20 feet deep.

Space for five pumping units will be provided; two to be driven by electric motors; and the remaining three by diesel engines. Pump capacity will be 5,000 gpm initially. Rotary drum type, mechanical fine screening devices, similar to the Kailua installation will be used in Kaneohe.

b. Noise

Diesel engines, potential noise generator, are being installed since they will not be affected by electrical power outages and will reduce the possibility of emergency by-passing of the effluent into Kaneohe Bay. Between July 1971 to October 1971, the Kaneohe STP experience electric power outage of



7.5 hours, the longest duration being 5 hours and 3 minutes. As in Kailua, the diesel engines will be housed in the superstructure that will be acoustically treated. Residential type silencer will be used on the exhausts from the engines.

c. Aesthetics

The area affected by the construction of the pump station will be landscaped. Side slopes will be planted with Lippia grass, other areas with tiftan. Plumeria will be planted along the entrance to the station. Mock Orange and Hibiscus hedges will be planted on the mauka and makai boundaries respectively. Additional coconut trees will be added to complement the existing ones.

d. Potential By-passing of Effluent into Kaneohe Bay

The existing 48-inch outfall sewer into the bay will not be maintained as a standby facility and will be abandoned upon the completion of the proposed Mokapu Disposal System. At that time, a physical separation between the existing outfall sewer and the chlorine contact chamber will be made.

5. Kahaluu WWTP Effluent Sewer

a. General

The proposed effluent sewer, consisting of 31,600 feet of 24-30 inch pipe will begin from the proposed treatment plant site and end at the Kaneohe EPS. It will generally follow the alignment of the existing Kahekili Highway to Keaahala Road, then follow an easterly path toward the Kaneohe plant via Keaahala Road, Anoi Road, Paleka Road, Waikalua Road, and finally into the plant. That portion of Kahekili between the Kahaluu Fish Pond to Ahuimanu STP is under State control; the remaining portion is under City control (See Figure II-18).

b. Land Commitment

There will be no permanent encumbrance of land for this project, however, sewer easements in favor of the City and County will be required for that portion of the line near the proposed Kahaluu plant and both sides of the Kaneohe Stream crossing. The easement width will be about 15 feet. Since the effluent sewer will be below ground throughout the length of the project, there will be no interference or conflict with the intended or proposed use of the affected lands. Activities normally associated

above the pipeline will be restored after construction.

c. Aesthetics

It is not known at this time whether construction of the effluent sewer would require removal of any trees because final design has not been completed. Trees that may be in conflict with the alignment will be transplanted, however, according to the affected agency or owner wish. Ground cover on the shoulder area and the existing pavement will be disrupted and cleared. After construction, the existing pavement and shoulder areas will be restored according to their applicable specifications.

d. Local Social Effects

This project will not displace any business or person from their residences. No churches will be affected also.

6. Kahaluu Wastewater Treatment Plant

a. Land Commitment

The proposed Kahaluu treatment plant will be located on a 14-acre (actual area is 13.725 acres) site mauka of the proposed 28-acre multi-purpose

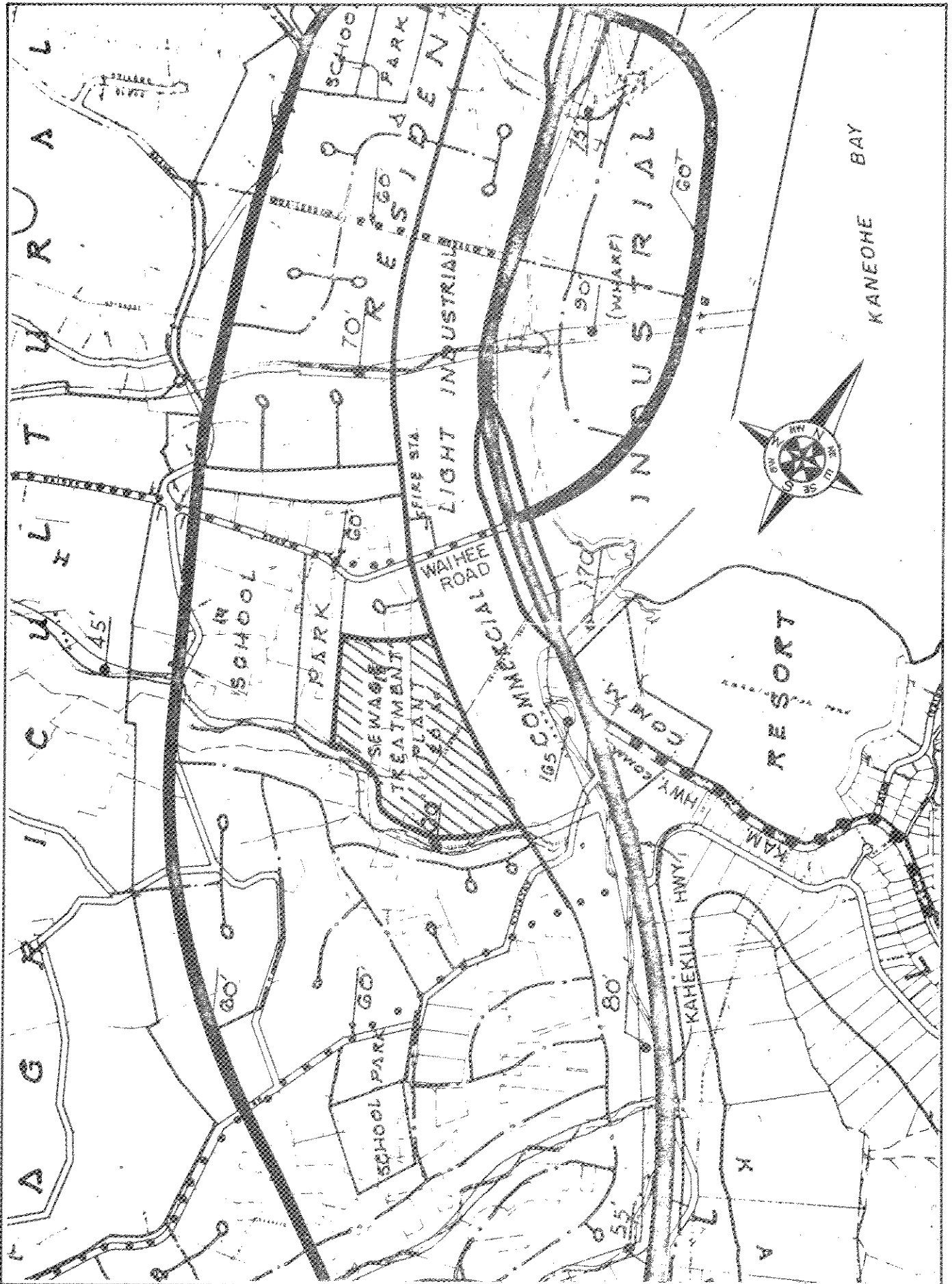
lagoon of the Kahaluu Watershed Project. The City and County intends to acquire the site in fee during the 1973-1974 Fiscal Year. The 14-acre site represents the ultimate (2020) land area required for secondary treatment and sludge handling facilities. The lagoon will be grass-lined and encircled by a park with recreational facilities. Two energy dissipating structures will be built to reduce the stream flow velocities, thereby all except the fine silt and other colloidal materials will settle to the bottom of the lagoon. Areas for park usage have also been proposed for all sides of the treatment plant with major acreage located on the mauka and Kahaku boundaries of the site.

The proposed park will encompass the school park and will serve as a regional park for the City and County park system. The exact acreage and configuration are still to be delineated at this date (July 1973), however, a potential area of 22 acres has been mentioned. Recreational facilities planned for the regional park include trails, comfort stations, picnic sites, parking area, and a ramp for small boats. The proposed park will be extensively landscaped.

Existing land uses in the immediate area of the plant site include the Kahaluu Elementary School and Park, and three homes. In addition on the Kahuku side of Waihee Road, there are the Methodist and Baptist churches, several residences, and utility companies base yards. The land uses in the area as delineated in the General Plan (GP) and Detailed Land Use Map (DLUM) are shown in Figure II-10. and include an area of about 20 acres for the proposed treatment plant site. Other uses proposed include commercial on the makai boundary (now intended for the flood control project), residential developments on the north and south boundaries of the plant and park on the mauka boundary.

The Kahaluu Elementary School complex is located on a 11.335 acre site off Waihee Road. The school has 32 classrooms including 8 portables and a 1974 enrollment of 532 students staffed by some 43 persons. A cafetorium and administration buildings complement the major structures. Projected future enrollment is 800 students staffed by approximately 60 persons.

The southern boundary of the plant site will be bisected by the re-aligned Waihee Stream. There have



PORTION OF DETAILED LAND USE MAP FOR KANEOHE  
HEEIA, KAHALUU, WAIHEE, KAALAEA, HAKIPUU & KUALOA

FIGURE  
II - 10

been no decisions yet whether the lower end of the stream will be covered as it enters the plant site and lagoon. The factors governing the stream cross-section will be governed by safety, aesthetics, and costs in that order of priority.

In order to assure compatibility of the plant with the development of the proposed park, construction plans for the plant will be submitted to the Department of Recreation for their scrutiny and advice relating to aesthetics and landscaping. A buffer of 200 feet of open space or landscaping is planned around the periphery of the plant site.

The decision to locate the proposed treatment plant on the site was not a hasty decision. An area of 20 acres, set aside as Public Facility - Sewage Treatment Plant has been designated on the GP and DLUM for Kaneohe, Heeia, Kahaluu, Waihee, Kaalaea, Hakipuu, and Kualoa since its adoption on July 29, 1964. The use of mechanical sludge handling facilities in lieu of sludge drying beds allow the reduction of the area requirement from 20 acres to 14 acres. Access to the plant site will be through an easement to the existing improved Waihee Road.

There are two rather old dilapidated buildings within

the proposed plant site. The one on the north-mauka boundary appears to be vacant while the other, near the center of the site, is occupied by an individual. Based on the latest observation (July 1973) only one person will be displaced by the acquisition of the plant site. Relocation assistance will be provided by the Honolulu Redevelopment Agency.

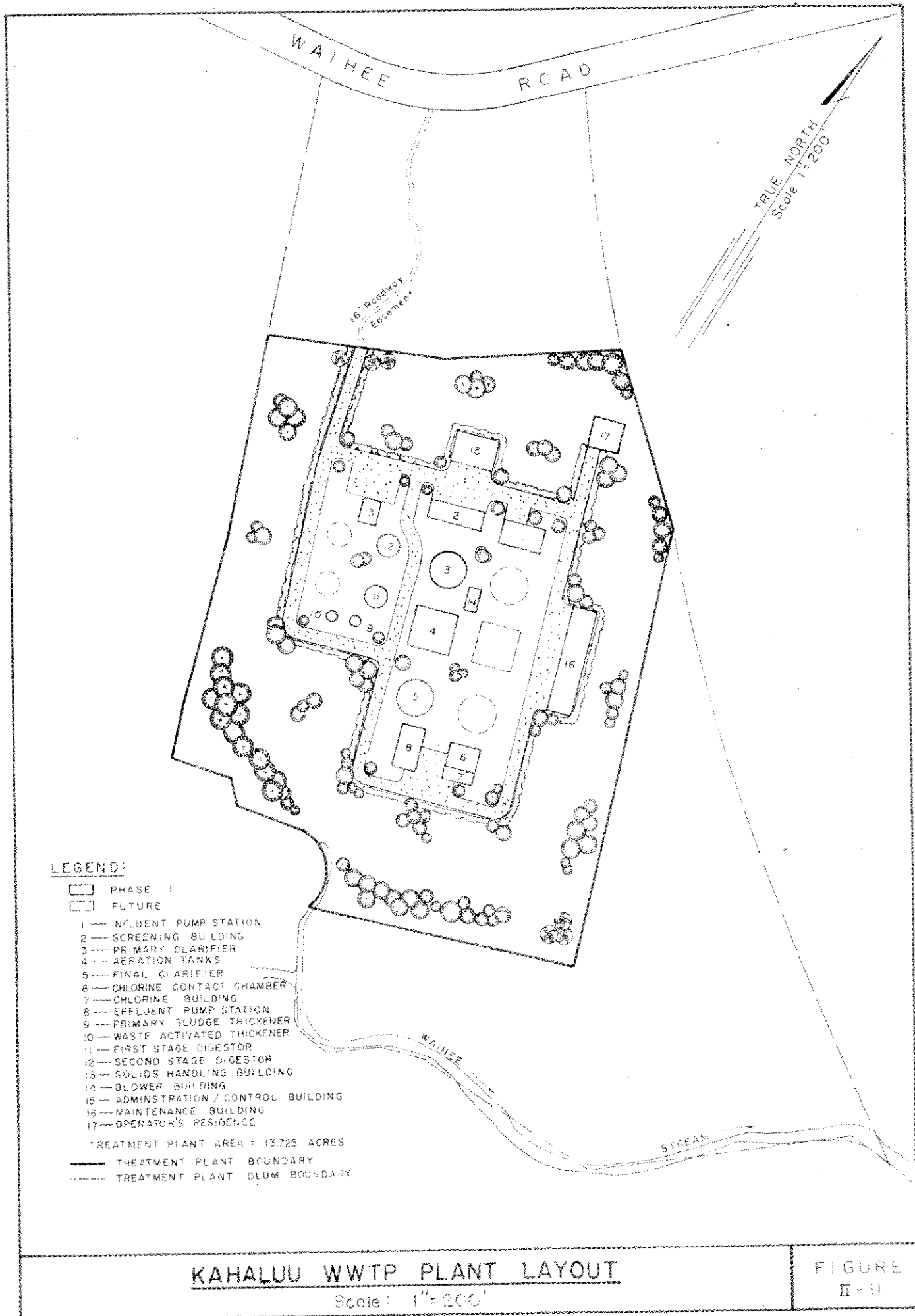
b. Aesthetics

The aesthetic goals in the development of the treatment plant site were threefold:

1. To relate the various parts of the plant to each other in a functional and economical way.
2. To insure that the presence of the plant does not create a nuisance and deter recreational development of the adjoining regional park.
3. To maintain the above mentioned functional and environmental qualities as phased expansion of the plant proceeds.

With these goals in mind, design and layout have been developed. Control and maintenance facilities are located to facilitate optimum utilization of staff and equipment. Grouped together are the primary sedimentation tanks, aeration basins, final clarifiers, and sludge handling facilities. Process flow is direct and concise. The plant layout is shown in Figure II-11.





**LEGEND:**

- PHASE I
- FUTURE

- 1 — INFLUENT PUMP STATION
- 2 — SCREENING BUILDING
- 3 — PRIMARY CLARIFIER
- 4 — AERATION TANKS
- 5 — FINAL CLARIFIER
- 6 — CHLORINE CONTACT CHAMBER
- 7 — CHLORINE BUILDING
- 8 — EFFLUENT PUMP STATION
- 9 — PRIMARY SLUDGE THICKENER
- 10 — WASTE ACTIVATED THICKENER
- 11 — FIRST STAGE DIGESTOR
- 12 — SECOND STAGE DIGESTOR
- 13 — SOLIDS HANDLING BUILDING
- 14 — BLOWER BUILDING
- 15 — ADMINISTRATION / CONTROL BUILDING
- 16 — MAINTENANCE BUILDING
- 17 — OPERATOR'S RESIDENCE

TREATMENT PLANT AREA = 13.725 ACRES

- TREATMENT PLANT BOUNDARY
- TREATMENT PLANT BLUM BOUNDARY

**KAHALUU WWTW PLANT LAYOUT**

Scale: 1" = 200'

FIGURE II-II

Visual emphasis in the overall site plan will be given to the landscape rather than to individual buildings. The finished ground elevation of the site has not been determined yet, however, the usual hydraulic losses through the plant for an activated sludge process will be in the neighborhood of 8 to 10 feet, and these losses will determine the general profile of the plant. The tentative finished ground elevation will be 10 feet on the makai boundary and rise to about 18 feet on the mauka side. The approximate elevation of the major structures will be: raw sewage pump station building - 35 feet; grit building - 28 feet; clarifiers - 25 feet; chlorination tanks - 17 feet; chlorination building - 25 feet; effluent pump station - 30 feet; and sludge handling facility - 30 feet. These elevations will be finalized during final design and are only tentative now.

When possible, trees will be provided around the perimeter of the site to further obscure the architecture of the plant structure.

c. Air Quality

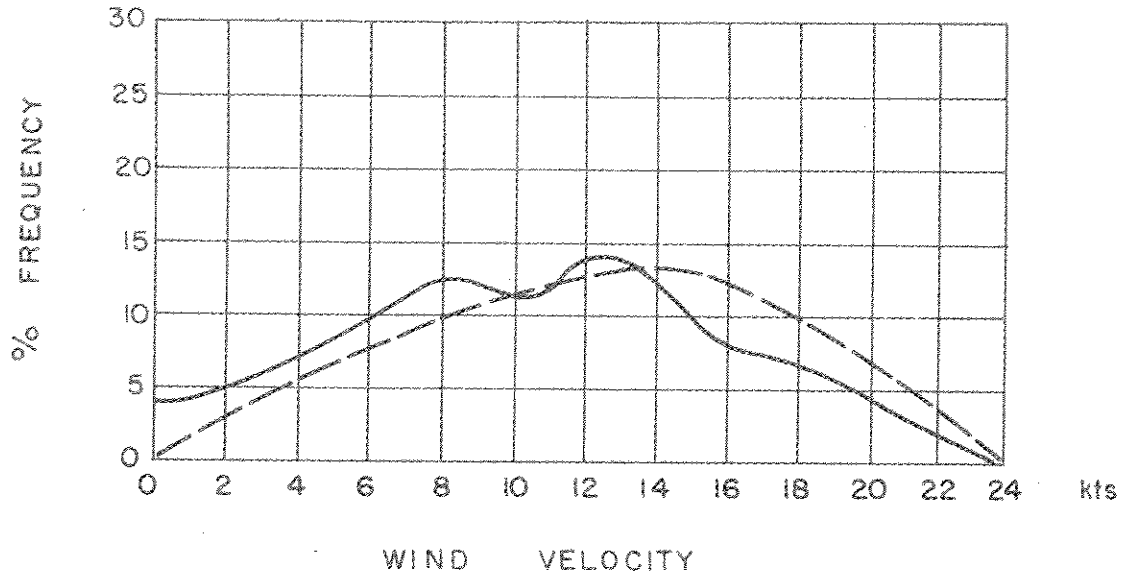
(1) General

Oahu is slightly south of the Tropic of Cancer

in the tropical region and within the belt of northeast trade winds. The prevailing winds are of an anticyclonic pattern from the east-north-east at an average velocity of 12 miles per hour. The reverse pattern of winds is associated with major storms of cyclonic circulation. These cyclonic patterns can occur throughout the year; however, they are generally prevalent during the period of November to April. Anticyclonic winds are trade winds while cyclonic winds are called "Kona winds" and blow from a southerly direction (south to southwest).

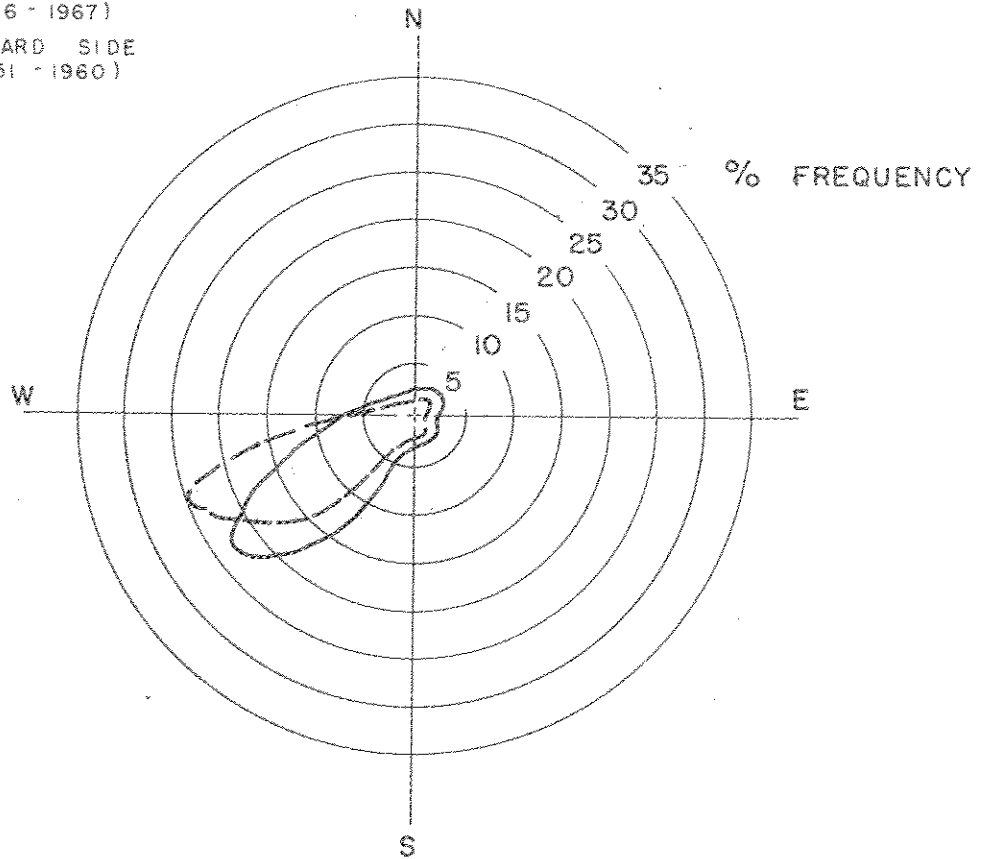
The studies by Bathen on annual and monthly wind velocity and direction for Windward Oahu are shown in Figure II-12 and II-13. On the basis of annual average wind velocity and direction there appear to be great similarity with Leeward Oahu. Bathen found that the trade winds came from  $10^{\circ}$  to  $70^{\circ}$  magnetic direction and varied in velocity from 6 to 14 mph. His average velocity was 10.5 mph, slightly lower than the previous seven years' average of 11.8 mph. Annual frequency of "trades" is about 70 percent and 7 percent for "Kona". Average

NOTE: 1. KNOT = 1.2 MILES/HR.  
(APPROX.)

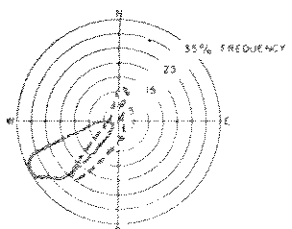
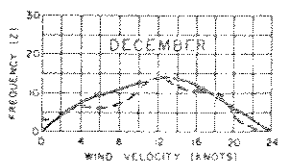
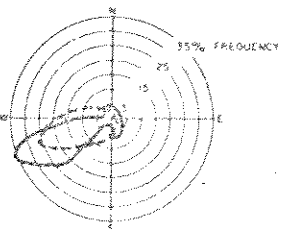
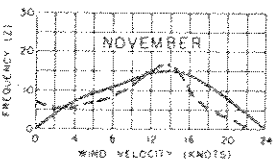
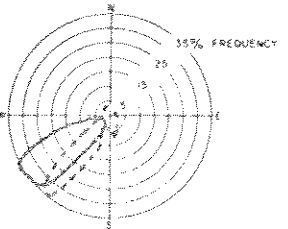
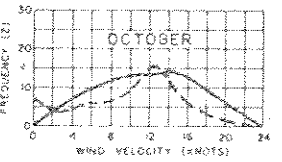
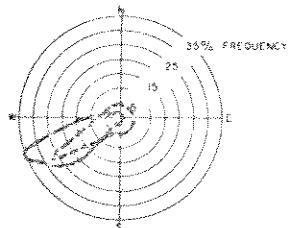
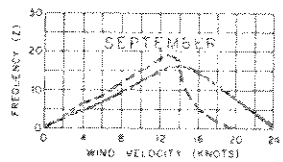
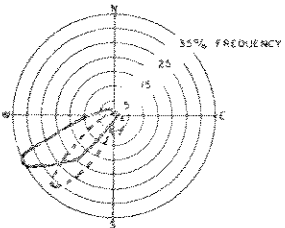
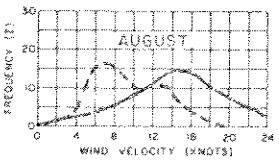
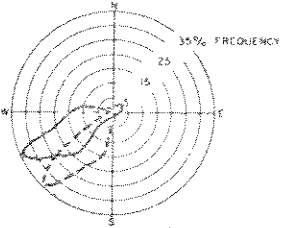
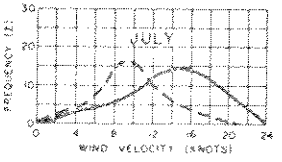
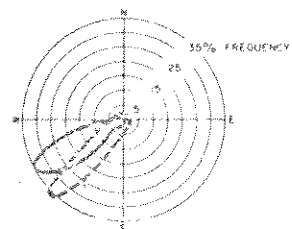
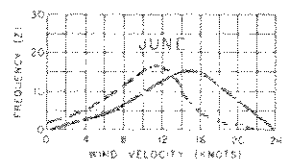
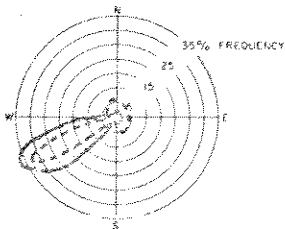
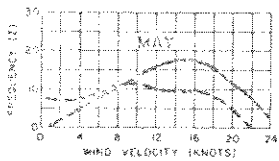
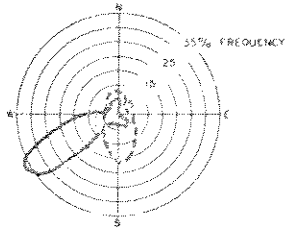
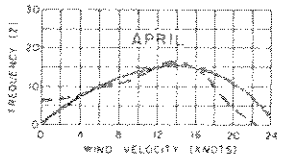
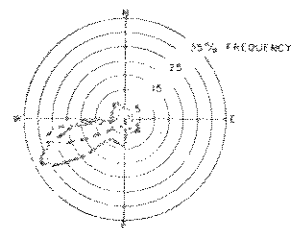
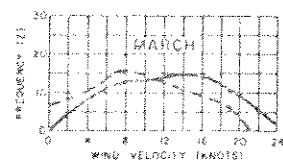
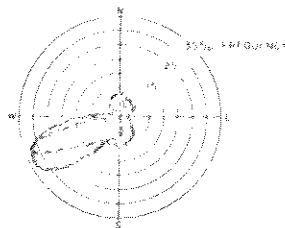
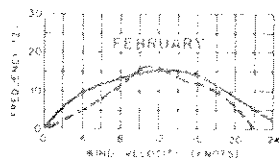
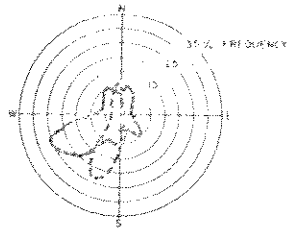
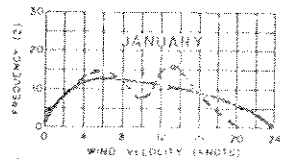


**LEGEND:**

———— WINDWARD SIDE  
(After Bathen) (1966 - 1967)  
----- LEEWARD SIDE  
(1951 - 1960)



(SOURCE - WQPO)



**LEGEND:**

WINDWARD SIDE - 1966 TO 1967 (After Bathen)

LEEWARD SIDE - 1951 TO 1960

(SOURCE - WQPO)

velocity of Kona winds is about 12 mph. Maximum gusts have reached 70 mph.

Due to the orientation of the site, the winds from the south (Kona) will pass through the plant and onto the park site. Easterly winds which occur about 15 percent of the time will pass over the plant and onto the elementary school. The school and the adjacent regional park are critical areas that may be subjected to unsatisfactory air quality and odor nuisances. The approximate airline distances from the treatment structures to the school buildings is about 900 feet. The distance to residences on the Kahuku side of Waihee Road is estimated at 700 feet.

(2) Odor Control

(a) General

The organic component of the solids in wastewater can cause putrefactive odors at the treatment plant. The inorganic solid component, usually in the form of grit are usually innocuous. Odors in sewage can be broadly classified as odors of fresh and

septic sewage. Sewage has been described as having a slightly pungent odor, somewhat like a damp, unventilated cellar. Fresh sewage has a faint and not necessarily unpleasant odor. It is almost odorless. Septic sewage, on the other hand, gives off nauseating odors of hydrogen sulfide, the familiar "rotten egg smell", as well as indole, skatole and other products of anaerobic decomposition.

If sewage entering the plant can be kept fresh, odor problems at the treatment plant can be significantly minimized. Because sewage travel long distances and undergo long detention time in pumping stations and collection systems, they usually arrive at the treatment plant as stale or septic sewage. Decomposition of organic material in the wastewater begin immediately after being discharged in the collection system. Utilizing the small amount of dissolved oxygen in the fresh sewage, decomposition begins under aerobic condition with the production of carbon dioxide and other odorless gases. After the depletion

of dissolved oxygen, the decomposition proceed under anaerobic condition. This process is accompanied by the production of hydrogen sulfide, foul smelling mercaptans, and other gases.

Three general methods of controlling odors have been classified by Stone (Reference 26). They are (1) preventing odors to be formed; (2) preventing the odors from reaching the atmosphere; and (3) removing or renovating the odors which have been formed. Stone in his study summarized the alternatives which are available to control sewage odors. These are:

- (1) Sewer maintenance to remove biological slimes, grease, and grit;
- (2) Addition of oxidation or reduction compounds;
- (3) Precipitation of sulfides;
- (4) Waste pre-treatment to reduce waste strength;
- (5) Use of perfumed masking agents;
- (6) The use of sealed enclosures with air collected under partial vacuum and oxidized; and



- (7) The use of toxic material such as chlorine to stop biological decomposition.

The WQPO (Reference 1) evaluated the effect of waste discharges on the odor of receiving waters and determined the usefulness of odor as a criterion for the protection of aesthetic uses. The odor parameter was quantified on the basis of threshold odor measures applied to effluent samples.

Threshold odor is defined as the number of times an odor-bearing effluent sample has to be diluted for the odor to be detectable.

According to the results of the study, treatment appeared to have a pronounced effect on odor with raw sewage being roughly five times more odoriferous than primary treated sewage, which in turn was two to four times more odoriferous than trickling filter effluents. The recommended initial dilutions of effluents which will prevent "objectionable odor" in the receiving waters were raw sewage, 130 : 1; primary treatment 18 : 1; and secondary treatment (trickling filter) 13 : 1.

Odor threshold levels for selected chemicals were published in Stone's report. These are shown in Table II-III-4. Concentration for threshold odor is given in parts per million by volume. The chemicals requiring the greatest dilution was ammonia ( $\text{NH}_3$ ) and chlorine ( $\text{Cl}_2$ ). Ammonia is the product of the decomposition of organic nitrogenous material which is present in all organic wastes. There is no problem handling this ammonia gas (free state) since there is small amount of gas present in the plant. Chlorine which is used for disinfection of the effluent and odor control is combined with water to produce hypochlorous acid ( $\text{HOCl}$ ). Chlorine gas within the plant is under strict control and presents no problem. Other chemicals listed in the table are hydrogen sulfide, skatole and mercaptans.

TABLE II-III-4

SELECTED ODOR THRESHOLD CONCENTRATION  
(From Stone)

<u>Chemical</u>	<u>Symbol</u>	<u>Concentration</u> <u>(ppm by volume)</u>
Hydrogen sulfide	$\text{H}_2\text{S}$	0.00047

TABLE II-III-4 (cont'd.)

<u>Chemical</u>	<u>Symbol</u>	<u>Concentration (ppm by volume)</u>
Nitrogen compounds	-	0.00021 - 100.0
Skatole	$C_6H_6N$	0.019
Mercaptans		
Ethyl	$C_2H_6S$	0.001 - 0.00026
Methyl	CH S	0.041 - 0.0021
Chlorine	$Cl_2$	0.314
Ammonia	$NH_3$	46.8
Phenol	$C_6H_6O$	0.6

Of the aforementioned methods for odor control, alternatives "2", "3", and "4" are not being used or considered by the City and County because of the economic and impracticality involved. Good sewer design with adequate flushing and carrying velocities in addition to good maintenance can eliminate fifty percent of potential odor problems. "Good housekeeping" and proper maintenance of equipment on the plant site can eliminate another twenty-five percent. The control of the remaining twenty-five percent is handled in a variety of ways.

These include prechlorination of raw septic wastewater as it enters the plant, enclosure of structures where potential nuisance from odor exists, and use of perfumed masking agents. The precipitation of sulfide by the use of ferrous sulfate has been tried and has been partially successful. The use of hydrogen peroxide in place of chlorine for odor control has been attempted in Florida and shows great potential saving and control. Engineers have designed plants during the past with features to minimize noxious odors. Because of increased urbanization, encroachment around treatment plants and public demand for improved environmental air quality, this is not enough. Treatment facilities must be odor and pollutant free systems.

(b) Basic Design Criteria at the Proposed Plant

All facilities will be designed to eliminate, destroy and minimize odors because the treatment facilities will be located in a proposed recreational area, and in close proximity to school, churches, and homes.

(c) Liquid Treatment Units of Plant

Pretreatment for odor control upstream of the raw wastewater pumping station, either by the use of chlorine or hydrogen peroxide will be practiced. Chlorine and hydrogen peroxide will destroy hydrogen sulfide and halt biological activity. The most potential source of odor in the liquid treatment units is the screening and grit handling facility. Septic or partially septic raw wastewater, if exposed to the atmosphere can be a source of odor nuisance. Hence, the unit will be totally enclosed. Exhaust gases will be treated with ozone for odor destruction and piped into the aeration tanks. The latter method has been proved effective as well as economical.

Potential coliform aerosols emission from the enclosure should not be a problem since the exhaust gases will be treated by ozone or "wash" in the aeration system. Dissolved oxygen levels in the primary sedimentation tanks is usually minimal or exhausted and odor emission from these facilities are possible if odor control by prechlorination is not effective

or practiced. Initially primary sedimentation tanks will not be enclosed but will have provisions for total enclosure if conditions warrant it.

Dissolved oxygen levels in the aeration tanks will be from 2.0 mg/l to 0.5 mg/l and therefore no odor problems are anticipated. Final clarifiers, operated properly will have dissolved oxygen levels from 0.5 mg/l to 0.75 mg/l, hence no odor problems are anticipated. These two biological treatment components need **not** be enclosed.

(d) Solids Treatment Units of Plant

Positive odor control will be accomplished by covering all the tanks and odor-emitting equipment in the system. A forced draft system will be used to collect the odor-laden air and pass it on through the aeration tanks to remove the odors. Chlorine can be applied in the sludge thickening process for odor control during the holding period. It can also be applied to the incoming sludge, as necessary.

(e) Solid Wastes

(1) General

Solid wastes resulting from wastewater treatment processes include settleable solids and floatable solids. The settleable solids include sludge, the major solid waste constituent, and grit. The floatable solids consist of screenings, scum, grease, and "float", the material that floats to the water surface of process tanks either naturally or under the influence of induced forces such as gas bubbles.

The handling and disposal of these wastes are probably the most troublesome part of any wastewater management program. The advent of newer processes and more efficient treatment plant operations tend to produce solid wastes that are not only more difficult to handle but are also greater in volume.

(2) Brief Description of Solid Wastes

aa. Sludge

Sludge is the precipitate resulting from the treatment of wastewater and

includes both organic and inorganic substances. It may be defined as a semi-liquid waste having a total solids concentration of at least 2500 ppm. It flows, can be pumped, and exhibits hindered settling characteristics in a sedimentation tank. This waste product is removed from the liquid flow in a clarifier or sedimentation tank and is handled and disposed of separately. The handling and disposal of this material is discussed further later in this section.

bb. Grit

Grit can be described as small inorganic solids that are removed from the wastewater. Examples are sand, silt, gravel, ashes, bones and coffee grounds. These solids are removed from grit chambers and clarifier or sedimentation tank underflow together with sludge. The grit is separated from the sludge in a degritter, de-



watered in a classifier, and conveyed to a sludge incinerator for disposal with the sludge or transported directed to a land fill site or buried in the plant site.

cc. Screenings

Screenings are materials in the raw wastewater that are caught on screens placed at the head of a treatment plant having openings usually  $\frac{1}{2}$  inch to 2 inches. These screenings, consisting of materials such as rags and sticks, are conveyed to a sludge incinerator for disposal together with sludge or transported directly to a land fill site, or buried within the plant site.

dd. Scum and "float"

Scum and "float" consist of all types of floatable material which rise in clarifiers and similar tanks. These are skimmed off the water surface of

the tanks and are processed along with sludge, usually beginning at the dewatering stage.

(3) Solids Loads (dry weights)

The solids loads for the Kahaluu, Kaneohe, Kailua and KMCAS plants are listed below by design periods in 1000 lbs of dry solids per day.

	<u>1970</u>	<u>1990</u>	<u>2020</u>
Kahaluu	1.1	2.3	5.6
Kaneohe	4.8	10.1	22.7
Kailua	6.5	11.9	24.6
KMCAS	1.6	2.2	3.2

Since the Kailua, KMCAS and Kaneohe plants have their own sludge handling facilities, the discussion hereafter will apply only to the proposed Kahaluu plant.

(4) Sludge Handling and Disposal

There are two distinct phases involved in sludge handling; (a) processing of the sludge to convert it to a form suitable for disposal, and (b) the ultimate disposal of the sludge.

aa. Applicable Unit Processes

Applicable unit processes include:

- (1) thickening, (2) conditioning,
- (3) dewatering, (4) digestion, and
- (5) combustion. These are discussed in the following paragraphs.

Thickening:

The basic objective of thickening is to reduce the volume of liquid sludge to be handled in subsequent processes. Thickening is usually accomplished by gravity settling, biological and dissolved air floatation, centrifugation, and chemical conditioning.

Conditioning:

Sludges from the different wastewater treatment processes vary in composition, physical characteristics, ease in handling, etc. The objective of sludge conditioning is to render the sludge more amenable to dewatering.

The addition of inorganic chemicals has long been the method of choice.

Chemicals used include lime, slum, and iron salts. The recent trend has been to utilize polyelectrolytes (long-chain organic polymers) which have the advantage of accomplishing equal or better results at a fraction of the dosage of inorganic chemicals. Although the unit costs of polyelectrolytes are significantly higher, the total cost of sludge conditioning is usually lower because of the smaller dosages required.

A recent innovation has been the application of heat and pressure to the sludge which reduces the hydrophilic nature of the sludge. The generic name given to this process is heat treatment. Several proprietary processes are on the market, including the Porteus Process, Farrer Process, and the Zimpro wet oxidation process at low pressures.

The required pressures range from 150 to 300 psig, and temperature range from 290 to 370 degree centigrade.

The treated sludge is completely sterilized but not completely stabilized with respect to organic decomposition.

Another recent process involves the application of high doses of chlorine, which not only sterilizes, but enhances dewatering properties, and can be carried to the point of complete stabilization. The operating experiences with this process are still very limited. It is patented under the proprietary name of Purifax Process.

#### Digestion:

The most common method of processing sludge has been anaerobic digestion. It stabilizes raw sludge and makes it suitable for final disposal. The process results in the reduction of volume by the destruction of organic matter with production of usable gas. As the word anaerobic implies, the process occurs in the absence of oxygen through specifically adapted

microorganisms. Because it is a biological process, it is subject to upsets especially from toxic materials (especially in raw primary sludge) which tend to be accumulative.

Aerobic digestion occurs in the presence of oxygen which is introduced into the reactor (tank) by means of compressed air or oxygen. It is particularly adaptable to waste activated sludges. Unlike anaerobic digestion, the process is relatively free of odors. The end product of aerobic digestion is a biologically stable humus-like material that contains more of the basic fertilizer values than anaerobically digested sludge.

#### Dewatering:

The primary objective of any dewatering operation is to reduce the sludge moisture content to a degree which allows ultimate disposal by incineration, landfilling, heat drying, or other means. It differs from thickening in

that the sludge is processed into nonfluid form.

The following dewatering processes have been used with varying degrees of success: (1) vacuum filtration, (2) pressure filtration, (3) gravity filtration, (4) centrifugation, (5) sand bed drying, and (6) screening.

#### Combustion:

Sludge combustion is becoming increasingly popular as land areas for sand beds, lagoons, and landfills become more difficult to find. The process results in the reduction of volume by conversion of organic sludge to an inert ash. Complete sterilization is achieved in this process. By comparison, digestion reduces the volatile (organic) content of the sludge by 60 to 75 percent, whereas combustion results in virtually complete destruction of the organic solids.

The following unit processes are included under the heading of combus-

tion: (1) multiple hearth incineration, (2) flash drying-incineration, (3) fluidized bed incineration, (4) spray evaporation, and (5) wet oxidation.

The disposal of ash on land is less objectionable than the disposal of unburned sludge on land because of complete sterilization, virtually complete destruction of the organic matter and the reduction in volume. With disposal into the ocean having a dismal future, it appears that incineration will become increasingly popular.

bb. Ultimate Disposal of Solids

The ultimate disposal of the solids after sludge processing is analogous to the disposal of the liquid fraction of wastewaters after treatment. As with the liquid fraction, the only repositories are land or receiving waters.



Many coastal cities use the ocean to dispose of their solids. However, increasingly restrictive regulations by the Environmental Protection Agency have discouraged recent efforts to use this method of solids disposal.

The only other recourse is disposal on land or possibly into the underground strata. The type of land disposal method used depends on the method of processing. Liquid digested sludge has been successfully applied to land reclamation projects. Dried digested sludge has been used as soil conditioners, both commercially and noncommercially (given free to whomever was willing to haul it away). Heat treated waste activated sludge has some value as a fertilizer, but agencies that market such a product are limited. Milwaukee, Chicago, and Houston have successfully marketed heat treated activated sludge. For Milwaukee and Chicago, marketing successes were due in part to the

high nitrogen content of the dried sludge.

Dewatered sludge has been successfully used as an additive when composting dry refuse and garbage. It enhances the composting operation because: (1) it provides seeding material for the required biological activity; (2) it helps to control the moisture content of the composting mixture; (3) it contributes nitrogen and other nutrients; and (4) it can be used to control the Carbon/Nitrogen ratio.

If consideration is being given to the composting of municipal refuse, it would be prudent to consider the addition of dewatered sludge. On the other hand, if composting is to be utilized primarily for sludge disposal, the real operational costs for processing the sludge approximate those for incineration. Operating costs can be reduced by selling the compost, but a market must exist for

the material.

(5) Sludge Handling and Disposal Alternatives

aa. General

Sludge handling and disposal is the most difficult and demanding component of the wastewater management and disposal systems. It also entails a major portion of the capital cost and operation and maintenance cost of the total wastewater treatment facility. To provide a basis for the selection of the optimum system for the Kahaluu plant, processing and disposal methods are considered and presented herein. The alternatives are compared on an economic basis and evaluated with consideration of environmental and other probable constraints. The alternatives include the following basic concepts:

- Alternative 1--Digestion, Dewatering, and Landfill
- Alternative 2--Dewatering and Incineration

Although disposal of sludge into the marine environment is presently being practiced by many U.S. coastal cities, the digestion and disposal of digested sludge into the ocean will not be considered here. The reasons being that (1) the Environmental Protection Agency is opposed to this practice; and (2) there is no direct access from the Kahaluu plant to the open ocean where the disposal site would be located, hence, the cost of this alternative would be prohibitive.

bb. Alternative 1

This alternative considers disposal of dewatered digested sludge by landfilling. It includes anaerobic digestion of waste sludge, mechanical dewatering by centrifuges, and hauling of dewatered sludge to a suitable landfill site. For the purposes of this report, hauling costs are based on a 20 mile round trip, presumably to the Kapaa sanitary landfill. One and perhaps two truckloads of dewatered sludge would be hauled each day during the initial design period hence there should be no traffic

problems. Deposition of sewage sludge in sanitary landfills is a permitted use according to Chapter 46, DOH Regulations, Solid Waste Management Control. Since all landfill operations must be designed for leachate control, there should not be a water pollution problem. Reclamation of sludge as a soil conditioner has been suggested, but its immediate implementation is speculative in view of the indefinite future of marketing and reuse of the product. Should composting of refuse with sludge or the marketing of processed sludge become viable in the future, this potential can well be worked into this alternative at the final sludge processing stage in place of landfill disposal.

cc. Alternative 2

This alternative considers the feasibility of sludge incineration. It includes sludge thickening, heat treatment, mechanical dewatering of raw sludge by centrifuges, incineration of sludge cake, and final disposal of ash to a landfill site 10 miles away. Disposal of ash into oceanic waters by mixing with the treated effluent has been proposed but appears to be an unlikely alternate solution under recent Federal water quality policies.

dd. Comparative Costs

The estimated cost of each alternative is shown in Table II-III-5. The cost estimates of the various alternatives are based on the total solids load for the first design increment of 2300 pounds per day for the year 1990 of which approximately 2070 pounds per day (90 percent removal) will be removed by the secondary process for handling and disposal. It is also anticipated that the total suspended solids contain 70 percent volatile matter, of which 50 percent would be reduced by digestion. Further, that centrifugation will provide a cake of 30 percent solids and that ash after incineration will amount to 30 percent of the total suspended solids.

Unit costs are also presented in Table II-III-5. They were derived on the basis of the estimated 378 tons of dry solids per year to be handled by the

TABLE II-III-5

ESTIMATED SLUDGE HANDLING COSTS

	<u>CAPITAL COST</u>	<u>AMORTIZED COST (per ton DS)</u>	<u>O &amp; M COST (per ton DS)</u>	<u>TOTAL (per ton DS)</u>
<u>ALTERNATIVE 1</u>				
<u>Digestion, De-</u>				
<u>watering and</u>				
<u>Landfill</u>				
Digestion	\$ 95,000	\$ 36.20	\$ 6.15	\$ 42.35
Dewatering	70,000	27.10	10.80	37.90
Hauling Sludge			12.90	12.90
Landfill			8.35	8.35
	<u>\$165,000</u>	<u>\$ 63.30</u>	<u>\$38.20</u>	<u>\$101.50</u>
<u>ALTERNATIVE 2</u>				
<u>Dewatering and</u>				
<u>Incineration</u>				
Heat Treatment	\$190,000	\$ 47.30	\$ 2.30	\$ 49.60
Dewatering	70,000	17.50	10.80	28.30
Thickening	45,000	11.10	2.70	13.80
Incineration	255,000	64.10	3.20	67.30
Hauling Ash			1.40	1.40
Landfill			.80	.80
	<u>\$560,000</u>	<u>\$140.00</u>	<u>\$21.20</u>	<u>\$161.20</u>

1. Capital cost does not include administrative, engineering, and contingency cost.
2. Amortized cost based on 7% for 20 years.

sludge handling facilities. The quantity of the end product from each alternative will vary with the process.

On an economic basis, the comparison indicates that the hauling of dewatered digested sludge is considerably less expensive than the incineration of raw dewatered sludge. Other sludge handling alternatives that were considered include the possibility of dewatering undigested sludge and hauling the cake either to an existing refuse incinerator or a landfill site for final disposal. Dewatering raw sludge would eliminate the high cost of anaerobic digestion and would make these alternatives comparable to Alternative 1. However, these alternatives cannot be considered at present because (1) there are no refuse incinerator in Windward Oahu, and (2) a suitable landfill site for disposal of dewatered raw sludge is presently unavailable.



(6) Sludge Treatment Provided

Digestion, dewatering and landfill (Alternative 1) was selected as the method of sludge disposal for the Kahaluu plant. Dewatering of raw sludge and incineration, the other alternative would cost approximately 30 percent more on the basis of cost per ton dried solids. Waste activated sludge will be thickened either by centrifuging and/or by thickener tanks using conventional gravity separation or air floatation. Initially a centrifuge may be used for both thickening and dewatering thus considerable savings may be realized with this alternative. Gravity or air floatation thickeners will have to be covered since they are potential odor producers.

In the dewatering process, chemicals will be used to render the sludge more amenable to moisture loss. If vacuum filtration units are used, ferric chloride and lime will be added; for centrifuges, polymers are generally utilized.

The vacuum filters or centrifuges will be

completely enclosed in a building since they are a potential source for odor and noise pollution. Dewatered digested sludge will be hauled to the Kapaa Landfill or the proposed Kawainui Landfill for final disposal.

Gases generated from the sludge digestion process will be utilized for sludge mixing and heating of the raw sludge. Excess gases will be burned by waste gas burners on the site.

d. Noise

All machinery and noise producing equipment will be located within structures. The diesel engines for the effluent pumps will be located in the effluent pump station building. Since the structure is expected to be totally enclosed, there will not be a noise problem. In addition, the diesel engines will be equipped with air intake filter-silencers and residential-type exhaust mufflers. Auxiliary electric pumps such as the plant irrigation pumps might be located outdoors but they are not expected to be a problem. Other noise producing equipment such as the air

blowers and compressors for the aeration system will be equipped with air intake and/or exhaust silencers and mufflers. Noise problems resulting from the use of these equipment are not anticipated.

IV. ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

A. Mokapu Outfall

There can be little doubt that the proposed wastewater discharge off Mokapu Peninsula will have some effect upon the ecology of its receiving waters. One of the basic principles of physical chemistry is that for a system in equilibrium, such as a natural ecosystem, any change in any one of the factors upon which that equilibrium depends, such as nutrient concentrations, will cause the equilibrium to shift in such a way as to diminish the effect of the change. The question to be answered then is whether or not this change and subsequent shift in equilibrium caused by the proposed discharge will be detrimental to the ecology of Kailua Bay.

Another factor that should not be overlooked is the fact that there is an existing effluent discharge in the near shore waters of Kailua Bay. This discharge will in the long run be more detrimental to the ecology of the bay if it is not eliminated. Based on all of the data gathered from the area, it appears that any effects resulting from the proposed discharge will be insignifi-

cant and certainly far less detrimental than the effects produced by the present discharge in Kailua Bay and the discharges in Kaneohe Bay from the existing Kaneohe, KMCAS, and Ahuimanu treatment works.

A slight increase in community metabolism may be expected in areas influenced by the proposed discharge, but this increase should not cause significant changes in the natural biota. Significant changes in the biota and in the productivity of the biota can be expected to occur in relatively small areas near the proposed outfall, however.

The destruction of some viable coral during the construction of the outfall cannot be avoided. There are no comparative alternative alignments for the outfall around Mokapu Point because of its configuration and topography (sheer cliffs). The proposed alignment was selected only after a bathymetric survey was made of the ocean bottom in the proposed discharge area. Irregardless of the alignment selected some destruction of viable coral would occur around Mokapu Point if the outfall is to be built there.

B. Kahaluu WWTP

The proposed WWTP will be located on a 14-acre site designated on the Detailed Land Use Map as Sewage Treatment Plant - 20 acres. Extensive park uses have been suggested and planned for the adjoining areas as part of the Kahaluu Watershed Project. Recognizing the need for more recreational facilities in Kahaluu, the land area for the plant was reduced from 20 to 14 acres to provide the additional acreage.

The location of a wastewater treatment plant surrounded by a park is not new in concept. The 50-acre Sand Island plant site is located adjacent to the State park. Treatment plant can be compatible with park usage if the plant facilities are designed for odor and other controls. Technology is now available for odor and pollutant free systems and the Kahaluu plant will be designed accordingly. In addition, the plant site will be adequately landscaped.

The proposed plant will require the displacement of one resident (presumably a squatter), however, relocation assistance will be provided by the Honolulu Redevelopment Agency.

V. ALTERNATIVES CONSIDERED WITH EVALUATION OF EACH

A. General

As with any comprehensive wastewater management program, a large number of alternatives and concepts were considered and evaluated in finalizing plans for the Kaneohe-Kailua sewer system. Only the more significant of these alternatives and concepts will be considered here. Because of the various types of alternatives which must be considered, they will be grouped in the following manner:

1. Treatment and Disposal Alternatives
2. Ocean Disposal System Alternatives
3. Alignment Alternatives
4. Treatment Plant Site Alternatives for Kahaluu

B. Treatment and Disposal Concepts

There are several concepts for meeting the water quality objectives for a basin or plan area. The concepts for the Kaneohe-Kailua sewer system include -

1. treatment of wastewaters,
2. relocation of discharge points,
3. diversion of flows from basin,
4. flow regulation,
5. water reuse, and

6. control of wastewater quantities through zoning and/or planned growth both for type and amount of expansion.

Treatment of wastewaters is believed to be the most feasible concept for the Kaneohe-Kailua district, inasmuch as the Federal Water Pollution Control Act Amendments of 1972, PL 92-500, requires all publicly owned treatment plants to have secondary treatment. From the standpoint of environmental compatibility and reuse, the discharge of raw or primary treated domestic wastes (without toxic laden industrial wastes) into an oligotrophic marine environment is considered the best system. However, further discussion is academic.

The concept of relocating existing discharge points is very applicable to the Kaneohe-Kailua disposal system. Under this concept, existing discharges into Kaneohe Bay and the near shore waters of Kailua Bay will be eliminated, and the combined effluents from the plants will be conveyed to a new ocean outfall sewer off Mokapu Peninsula. The discharge of secondary effluent in Kaneohe Bay has resulted in an "enriched" environment because of poor circulation in the Bay. This has threatened to destroy the bay's diverse beneficial water uses.



A diversion of wastewater from the drainage basin to an area outside of it was not seriously considered. The two best discharge points on Oahu from the standpoint of ocean disposal are at Kaena Point and Kahuku Point. The alignment of Kaena Point would be across a mountain range, a straight line distance of about 36 miles. The distance from Kailua to Kahuku Point is about 30 miles along the coastline. This concept was not given much consideration because of the high cost and the excessively long time required for implementation.

Flow regulation includes storage of effluent in detention or holding ponds at the treatment plant to await favorable conditions in the receiving waters. Storage of effluent at Deer Island, Boston is an example where stored effluent is released with outgoing tides. This concept would require a tremendous land area for the ultimate storage of 40 million gallons of effluent. Because land is scarce on Oahu, and ocean currents off Mokapu Peninsula are favorable for the discharge of wastewater effluent, this concept was not seriously considered.

Water reclamation and reuse were given serious consideration. Studies during the WQPO indicated that reclamation of wastewaters from the Kaneohe-Kailua district is not feasible nor desirable because of the high chloride content of the Kailua and Kaneohe flows (chlorides in excess of 1500 and 1800 mg/l respectively). The studies, however, indicate that the potentials for

wastewater reclamation are good in another area, the Honouliuli area in Leeward Oahu. Based on an average requirement of 10,000 gallons per acre per day of water for irrigation of cane fields in the Ewa plains, a considerable amount of the effluent from the City's proposed Honouliuli plant can be utilized.

The reclamation of the effluent (assuming more treatment) for agricultural reuse, including irrigation of golf courses and cemeteries is also economically unfeasible in Windward Oahu because of the high capitalized cost of the treatment and transmission systems, the lack of need and an abundance of rainfall in the area. Citing the Pali Golf course as an example, the average annual irrigation need for this 220-acre course is only 200,000 gallons a day. The balance of the irrigation need is provided by rainfall. The cost of constructing a 3.8 mile transmission line and pump station from the plant to the course is estimated to be at least \$600,000. Adding the operating costs of demineralization of the effluent and the pump station would make the expense of providing irrigation water to the golf course prohibitive at the same time, the bulk of the effluent would still have to be transported to the Mokapu Outfall for disposal.

The direct reuse of the effluent for domestic use, again assuming more treatment, is not desirable or economically feasible because of the availability of a good supply of drinking water there and the potential dangers from viral contamination and long term degradation of the potable water resources. Based on the foregoing, the concept of reclamation and reuse was not given further consideration.

Control of wastewater quantities is not necessary nor desirable since the existing plants have adequate capacity and can be expanded to accommodate the population in the subdistrict area within the study period (up to year 2020). The receiving waters can provide for the necessary dilution and dispersion of the effluent without any problem.

Control of flow by the use of better materials, methods, and technology is a continuing process. There appears to be none that can replace the present method of collecting and disposing of domestic wastewater. Control of the number of people in an area is a municipal planning function which is inter-related with complex social forces. These forces are not controlled by any single body but are governed by the existing democratic process.

#### C. Treatment and Disposal Alternatives

Eight major treatment and disposal alternatives were considered for the Kaneohe-Kailua sewer system. If one considers the maintenance of the present treatment and disposal practice of discharging effluents in Kaneohe Bay and the shallow waters of Kailua Bay as an alternative, there would be nine.

Alternative 1 considered the feasibility of maintaining the three existing facilities at Kaneohe, KMCAS, and Ahuimanu, providing tertiary treatment at each, and continuing discharge into Kaneohe Bay. The plants would be converted in 1975 and expanded in later years as required. Although no changes in disposal practices have been indicated for these plants, it is believed that some modifications should be considered. The Kailua plant will remain a secondary plant, but with an extension of the existing outfall indicated for 1975.

The question of which nutrient compounds causes primary productivity with specific types of treated effluents and specific aquatic environments is as yet unanswered. As a result, the costly treatment processes which remove specific nutrients such as nitrogen and phosphorus may not remove the growth limiting substances necessary to preclude biological responses in the aquatic environment. In addition, the waters of the Kaneohe Bay have been reclassified from Class A to Class AA, prohibiting any waste discharge from entering it. Based on these arguments, this alternative was not selected.

Alternative 2 also considered the utilization of the three existing plants discharging into Kaneohe Bay but with their secondary effluent being conveyed to the Kailua plant and disposed of through an extended ocean outfall off Mokapu Peninsula. Under this scheme, the Kailua plant would be retained. The inadequacy of the site at Ahuimanu for further expansion and the additional pumping costs of delivering raw sewage outside the present tributary of the treatment plant were sufficient reasons why this alternative was not considered.

Alternative 3 considered the feasibility of a single secondary treatment facility at Kailua and eliminating the existing plants at Kaneohe and Ahuimanu (see Figure II-14). It was assumed that the KMCAS plant would continue to be operated. At Kailua, the existing trickling filter facility (7.0 mgd) would be converted to an activated sludge facility with a capacity of 18 mgd. An additional area of about 15 acres must be acquired to accommodate the ultimate design flow of 41.2 mgd.

This acquisition poses some problem since the site can only logically be expanded in the makai direction, i.e. in the direction of Nuupia Pond in KMCAS.

Alternative 4 is a modification of alternative 2 with respect to the eventual construction of a new treatment facility in Kahaluu and the phasing out of the existing Ahuimanu plant. Effluent under this scheme would be conveyed to the Mokapu Outfall for disposal (see Figure II-15). The capacities of the existing plants would be utilized up to their designed flows, whereupon, the trickling filter plants will be expanded and converted to activated sludge facilities. The conversion to the activated sludge process will increase BOD and Suspended Solids removal by about 10 percent to about 85-90 percent for the Kailua and Kaneohe plants. Under this alternative, a new activated sludge plant would be built in Kahaluu, replacing the existing Ahuimanu plant.

Alternative 5 considered the eventual elimination of the Ahuimanu plant, the construction of a central raw sewage pumping facility in Kahaluu, and the conveyance of the wastewater to the existing Kaneohe plant for treatment. Under this scheme, acquisition of an additional 10 acres at Kaneohe would be required. The problem of transporting raw wastewater from Kualoa to the Kaneohe plant, a distance of approximately 12 miles and the attendant odor and treatability problems

associated with it at the Kaneohe plant were the principal reasons for the rejection of this alternative. In addition, the need for more land for the Kahaluu flows would probably require the acquisition and filling of Waikalua-Loko Fish Pond, makai of the Kaneohe plant. Subsurface soil conditions at the pond, based on soil borings at the Kaneohe plant would probably be inadequate to support heavy structures required for the treatment process units even with supporting piles.

Alternative 6 considered the feasibility of a treatment facility at Kualoa with a separate ocean disposal system to serve the Kahaluu area (see Figure II-16). Under this scheme, the existing Kaneohe, KMCAS, and Kailua plants would be retained with effluent disposal through the proposed Mokapu outfall. The proposed plant at Kualoa would be an activated sludge plant on a 14-acre site near Kaoio Point. The ocean outfall would consist of a 6,400 feet long 24-inch diameter pipe in 60 feet of water.

Alternative 7 considered the employment of ground injection of effluent in lieu of ocean disposal. Ground injection of effluent at Kaneohe and Kahaluu is not feasible because of subsurface

ground conditions. These conditions would result in the seepage of groundwater into the streams and the resultant discharge into Kaneohe Bay.

Kaneohe Bay drains the erosional remnant portion of the main caldera of the Koolau Volcano and its associated primary rift zone. The caldera remnant occurs chiefly in the Kaneohe-Kamooalii Stream basin, but the rift zone constitutes the entire region. The caldera area consists of highly weathered and secondarily mineralized massive lava flows and dikes, all of which are poorly permeable. Further, a mantle of alluvium, much of which is also poorly permeable, occurs below an elevation of about 600 feet. Because of the poorly permeable dike complexes which run in the northwesterly direction, direct ground discharge into Windward Oahu coastal waters including the Bay is small. The flows are impeded by these dikes, giving rise to high ground water tables. Consequently, except for direct surface storm runoff and groundwater, there is no continuous groundwater movement along a free hydraulic gradient toward the coastline and the Bay. Most of the groundwater seeps into the streams along the stretches from the coast to several hundred feet elevation and runs off into the nearshore



coastal waters including the bay. Therefore, because of the particularly poorly permeable mantle throughout most of the Kaneohe Bay region, and the high water table arising from the dike complexes which impede flows toward the bay, sewage disposal by landbased operations such as sewage spreading, effluent ponding, or ground injection are not promising. Such methods would lead to eventual discharge of effluent by seepage into streams and into the bay.

Kailua and Mokuapu Peninsula on the other hand have possible potential sites for ground injection. The Kailua site would be in the Coconut Grove district (see Figure I-4), presently completely developed as a residential area. Since Kaneohe and Kahaluu flows will have to be added to Kailua's, the total flows would amount to about 40 mgd. The Board of Water Supply has indicated that a fresh water supply meeting their requirements for potable water is unlikely in the Kailua area. Thus subsurface disposal of wastewater effluent would not interfere with their planning. The BWS also feel that deep well injection is feasible in the permeable sand and coral formation but not in the very poorly permeable underlying basalts.

This alternative was very attractive since it would eliminate the need for an ocean outfall sewer. Aside from the fact that the proposed injection area would be in the fully developed residential area of Coconut Grove, the feasibility of disposing of 40 mgd average flow (with peak flows of about 100 mgd) is definitely questionable. The disposal of municipal effluent through ground injection has not been very favorable on Oahu. Clogging of wells are common occurrences with secondary effluent. The minimum requirement would include further polishing of the secondary effluent, perhaps by micro-screening, an additional cost. Effluent injected into the ground in the Kailua area would eventually be diffused into Kailua Bay, an additional disadvantage.

The present status of ground injection of sewage effluent on Oahu is that it can be utilized to advantage only for small installations, especially those located in the caprock regions. "Small" is at present not precisely defined, but as it is judged here, it would mean flows less than 5 mgd. In contrast, average flows for the entire district is estimated to be 10.3 mgd in 1970 and 41.2 mgd by year 2020. The reasons for specifying constraints are as follows:

1. Although the underlying caprock aquifers may be extremely permeable, the life of injection wells has not been demonstrated to provide firm guidelines in design and operation. Such systems would more readily accommodate smaller flows economically by additional wells in the event premature well failure is experienced.
2. The ultimate fate of the injected effluent is not known in most cases and in some areas it may be that the outflow from the caprock aquifer would be in the nearshore coastal waters. However, for the smaller flows, injection wells can be designed for adequate dispersion to minimize the effects of effluent discharge from these aquifers into the coastal waters. Well field design, therefore, should achieve the same objectives as ocean outfall diffusers as well as meet the hydraulic requirements of the wells.

Based on these considerations, this alternative was not selected.

Alternative 8 considered the disposal of the effluent from the Kaneohe plant to the proposed Corps of Engineers Kaneohe Flood Control Reservoir.

Under this proposal, flows from the Kailua plant would be disposed off Mokapu and those from the Kahaluu plant would be discharged off Kualoa. The proposed reservoir will be created by the construction of a 2,200-foot long, 90-foot high, 30-foot wide earthfill embankment located on Kamooalii Stream, about 3.2 miles upstream of the mouth of Kaneohe Stream. The water level of the reservoir will be maintained at elevation 160 feet to create a 25-acre permanent pool. During the maximum flooding period, the maximum design pool area will be 120 acres. A side channel spillway will be located on the left abutment of the embankment in addition to an uncontrolled outlet consisting of a 9-foot concrete pipe through the embankment.

Transporting the effluent from the Kaneohe plant to the reservoir would require a 36-inch force main approximately 3 miles long (compared with the Kaneohe EFM consisting of 3.13 miles of 42-inch FM). The construction cost of the reservoir force main was estimated to be \$500,000 less than the Kaneohe EFM but the energy cost over a fifty-year period would amount to \$500,000 more. Consequently, in terms of present worth, the two force mains are practically similar. Comparing

costs, Alternative 8 is similar to Alternative 5, therefore, the present worth of Alternative 8 is about \$39,000,000.

Under this alternative, there will still be two ocean discharges, the one at Mokapu and the other at Kualoa. By present worth comparison, this alternative is slightly more expensive (\$2,500,000 rounded) than Alternative 4. With respect to environmental impact, this alternative is unsatisfactory, since the waters of the reservoir would eventually overflow causing the effluent with its load of nutrients to be discharged into Kaneohe Stream, hence into Kaneohe Bay. Because Kaneohe Bay has been reclassified to Class AA waters by the Department of Health, further discussion of this scheme is academic.

The last alternative for the treatment and disposal section considered the retention of the existing treatment and disposal systems for Kaneohe, Ahuimanu, KMCAS and Kailua. Aside from the environmental impact of Kaneohe Bay (due in part to the discharge of wastewater effluent), the Bay has been reclassified to Class AA waters; hence waste discharges are prohibited from entering the bay. Further discussion on this alternative is academic.

#### D. Present Worth Analysis

Stated simply, present worth is the amount of money required today to construct, operate, maintain, and replace all facilities required in the future. The procedure utilized in this section consists of (1) adjusting capital costs to reflect interest during construction, (2) calculating replacement costs for all structural and mechanical facilities, (3) bringing the adjusted capital costs, replacement costs, and operation and maintenance costs back to present worth, and (4) subtracting the present worth of the salvage value. This method is in conformance with the Environmental Protection Agency's (EPA) proposed regulation, "Cost-Effectiveness" (40 CFR Part 35). An interest rate of 7 percent per year is used for all present worth computations. The planning period of 20 years is used starting from 1976, the anticipated initial date of operation of the system.

#### E. Comparative Costs of Treatment and Disposal Alternatives

Present worth costs (1973) were calculated for the three major candidate alternatives of the nine alternative systems to serve the tributary area of Kaneohe-Kailua. These three major alternatives are -

1. Alternative 3

A single secondary treatment facility at Kailua and elimination of the existing plants at Kaneohe and Ahuimanu. Effluent from the central district plant will be discharged off Mokapu Peninsula through a new ocean outfall sewer.

2. Alternative 4

Retention of the three existing secondary plants at Kaneohe, Kailua, and KMCAS, the construction of a new secondary plant at Kahaluu and a new ocean outfall off Mokapu Peninsula. The existing discharges into Kaneohe and Kailua Bays will be eliminated and effluents from the four plants will be conveyed to Mokapu Peninsula for discharge via a new ocean outfall sewer.

3. Alternative 6

A four-secondary plant system with two ocean outfall sewers. A secondary plant and ocean disposal system at Kualoa to serve the Kahaluu area, phasing out of the Ahuimanu plant; and the retention of the Kaneohe, Kailua and KMCAS plants with their effluents conveyed to Mokapu Peninsula for discharge through a new ocean outfall sewer.

The results of the present worth analysis for the aforementioned alternative systems are as follows:

<u>System</u>	<u>Present Worth</u>
Alternative 3	\$ 46,838,000
Alternative 4	36,538,000
Alternative 6	39,198,000

Comparison of the three alternative systems indicate that Alternative 4 is the most economic system on the basis of present worth costs.

F. Considerations and Evaluations of Treatment and Disposal Alternatives

Alternatives were compared and evaluated with proper consideration of all factors and constraints that relate to or affect each alternative and environmental impact. Based on these comparisons and evaluations, treatment and disposal concepts 1 and 2, treatment of wastewater and relocation of discharge points respectively, were determined to be the most feasible. These concepts included retention of existing secondary treatment facilities with future expansion of facilities and upgrading of the effluent and the relocation of effluent discharge points from a bay (Kaneohe Bay) and onshore waters (Kailua Bay). General conclusions relating to the three major alternatives are as follows:



1. Alternative 3, with a single treatment and disposal facility located in Kailua, would be the most costly. The system has the advantage of operating and maintaining a single treatment and disposal facility. However, it requires a long pressure main (9.13 miles of 42 and 20-30 inch pipes) to convey the flows from the Kaneohe and Kahaluu pumping stations to the treatment facility. Utilization of this long pressure main is also costly from the standpoint of operation and maintenance. Further, the extended time required for sewage to reach the treatment plant is undesirable when considering treatability and probable odor nuisances. Of other concern is the lack of desirable land for the expansion of the existing Kailua plant site. To accommodate a flow of 40 mgd, an additional 15 acres (total 40 acres) would be required. Expansion of the site is only feasible in the direction of Nuupia Pond. This expansion, however, would encroach on land much better utilized for the enhancement and preservation of wildlife. The ponds and its surrounding area is a potential Federal or City site for a natural wildlife sanctuary.

Another disadvantage of this alternative is the extended time required to implement the system, since a new treatment facility must be built in Kailua to handle the district flows. This delay could possibly have a catastrophic effect on the waters of Kaneohe Bay.

2. Alternative 4 includes the retention of the existing treatment facilities at Kaneohe, Kailua, and KMCAS and the construction of a new ocean outfall off Mokapu Peninsula. It was the most economical of the three alternatives. It also considered the construction of a new treatment facility at Kahaluu and the abandonment of the Ahuimanu plant. Considering that each of the existing treatment facilities have sufficient capacity for the immediate future, this system would take the least time to implement. Oceanographic studies (References 1 and 11) conducted within Kailua Bay and Windward Oahu conclude that ocean disposal of secondary treated effluent off Mokapu Peninsula is feasible.
3. Alternative 6 also considered the retention of the existing treatment facilities at Kaneohe, Kailua, and KMCAS and a new outfall

sewer off Mokapu Peninsula. However, it included a separate treatment facility located in Kualoa, with ocean disposal of the effluent into the nearshore waters off Kaoia Point. Comparing present worths, the cost of this alternative is \$2,700,000 (rounded) more than alternative 4. Aside from this, the other disadvantage is the shortcoming of the Kualoa ocean disposal system. Analysis of ocean current patterns off Windward Oahu, and in particular the current studies within Kaneohe Bay (Reference 33) indicate that during incoming tides, water flows into the bay in the main ship channel at the northwest end of the bay. This flow is restricted to the surface flow (0 - 2 meters) but is more pronounced during strong trade winds when surface waters on the Windward coast is onshore. The possibility of effluent flowing into the bay is very real.

#### G. Conclusions of Treatment and Disposal Alternatives

General conclusions are that it is feasible and more economical to handle wastewater from the Kaneohe-Kailua sewer district with four separate treatment facilities with the discharge of secondary treated effluent through a common ocean outfall sewer off Mokapu Peninsula. Each existing

plant will be retained until its design capacity is reached. Thereafter, the applicable plant will be converted to the activated sludge process for greater BOD and suspended solids removal, and expanded if required, depending on the population trend in the subdistrict.

If additional treatment is required because of future State and Federal effluent standards, the activated sludge process is more amenable to advance (tertiary) treatment processes than the present trickling filter process. Extension of the proposed Mokapu outfall is possible in the future if more dilution is desired in the receiving waters. However, because of the steep slope beyond the 105-foot depth, certain structural and pipe stability problems will have to be solved before the outfall can be extended.

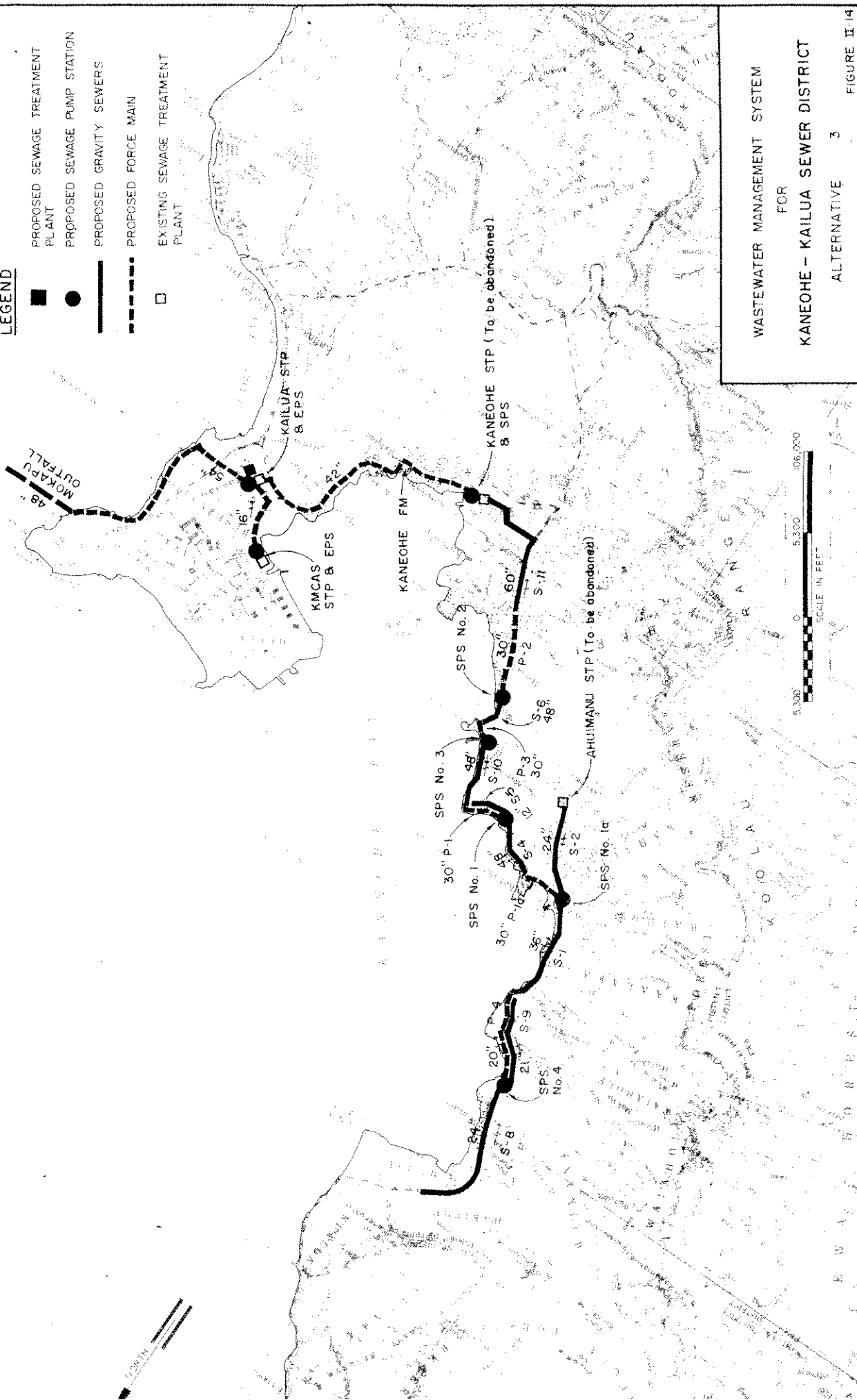
The existing Ahuimanu plant, under this alternative will be abandoned when the new Kahaluu plant is completed. Lack of adequate land area for future expansion and excessive pumping costs are primary reasons for the plant abandonment.

#### H. Ocean Disposal System Alternatives

Several ocean disposal system alternatives were considered for the Kaneohe-Kailua sewer systems. These alternatives include -

**LEGEND**

- PROPOSED SEWAGE TREATMENT PLANT
- PROPOSED SEWAGE PUMP STATION
- PROPOSED GRAVITY SEWERS
- - - PROPOSED FORCE MAIN
- EXISTING SEWAGE TREATMENT PLANT

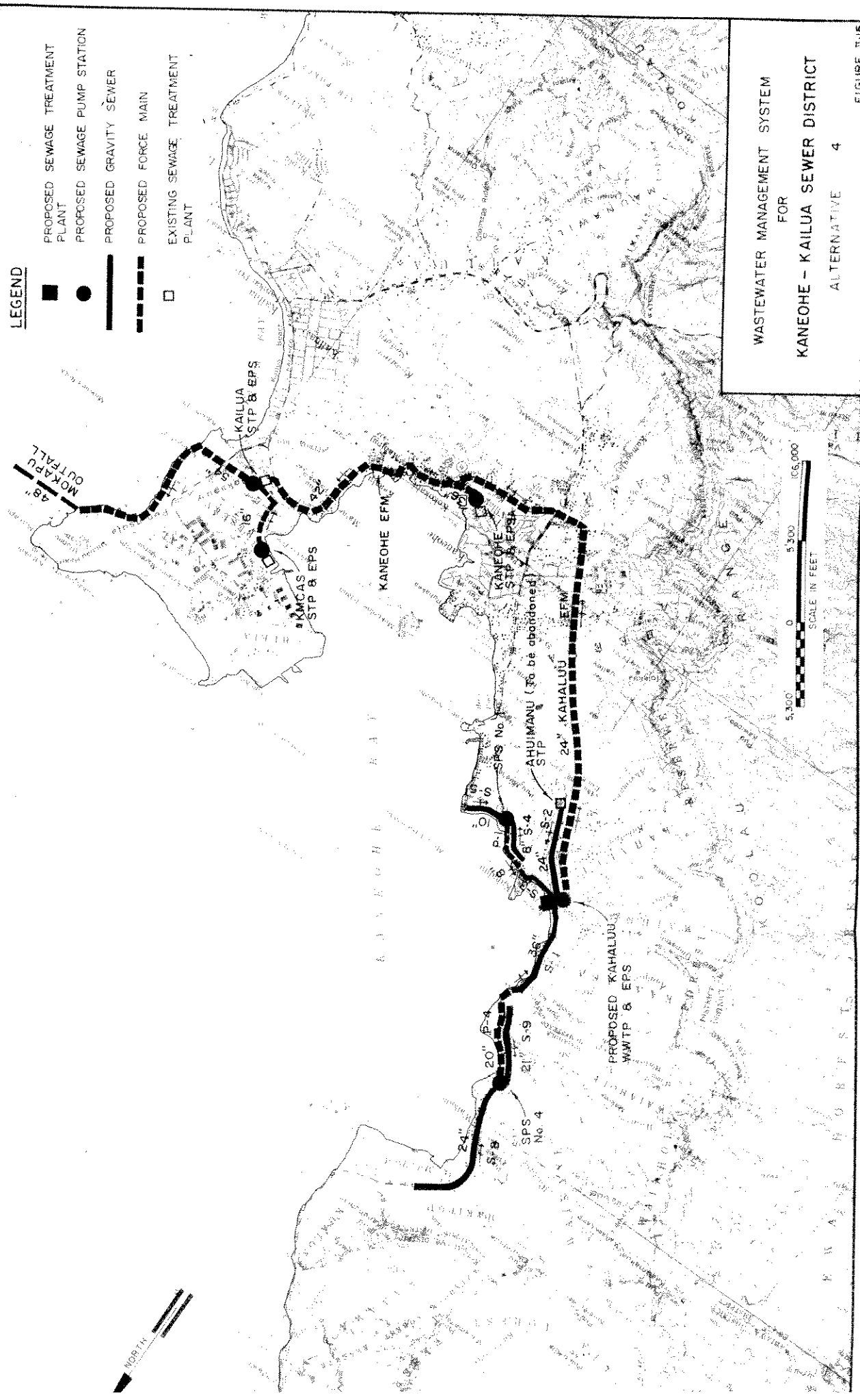


WASTEWATER MANAGEMENT SYSTEM  
 FOR  
 KANEOHE - KAILUA SEWER DISTRICT  
 ALTERNATIVE 3  
 FIGURE II-14

T. 10.1

**LEGEND**

- PROPOSED SEWAGE TREATMENT PLANT
- PROPOSED SEWAGE PUMP STATION
- PROPOSED GRAVITY SEWER
- - - PROPOSED FORCE MAIN
- EXISTING SEWAGE TREATMENT PLANT



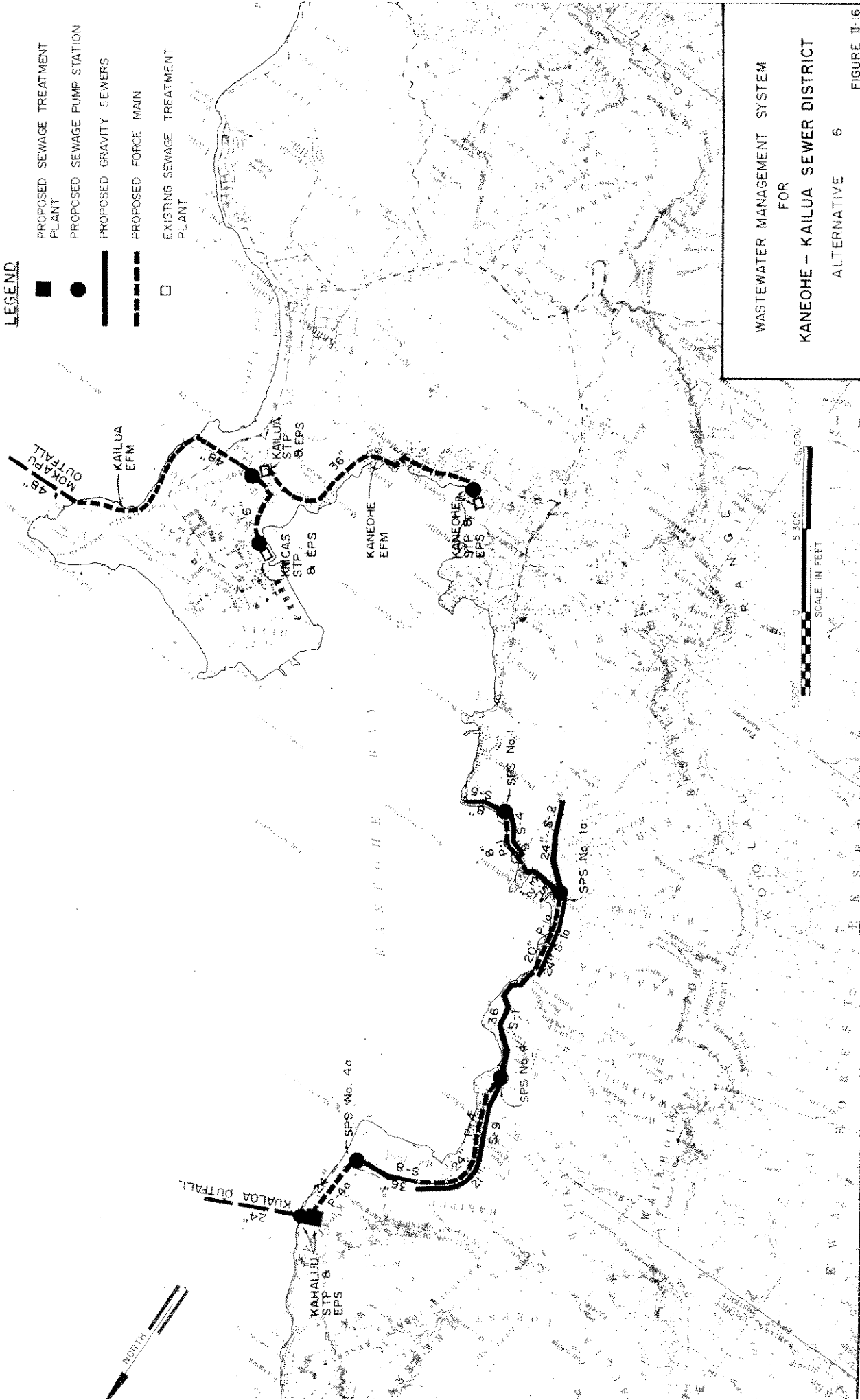
WASTEWATER MANAGEMENT SYSTEM  
FOR  
KANEHOE - KAILUA SEWER DISTRICT  
ALTERNATIVE 4

FIGURE II-15

II-195

**LEGEND**

- PROPOSED SEWAGE TREATMENT PLANT
- PROPOSED SEWAGE PUMP STATION
- PROPOSED GRAVITY SEWERS
- - - PROPOSED FORCE MAIN
- EXISTING SEWAGE TREATMENT PLANT



WASTEWATER MANAGEMENT SYSTEM

FOR

KANEOHE - KAILUA SEWER DISTRICT

ALTERNATIVE 6

FIGURE II-16

1. Advanced primary treatment with deep ocean disposal (discharge depth greater than 200 feet).
2. Secondary treatment with shallow ocean disposal (discharge depth between 80 - 100 feet).
3. Extension of the existing Kailua outfall to about the 100-foot depth for secondary treated effluent.
4. The construction of a new ocean outfall off Mokapu Peninsula to a depth of 100 feet.
5. An extended Kaneohe outfall to the open sea and a new outfall off Mokapu Peninsula.
6. New ocean outfalls at Kualoa and Mokapu.

Alternative ocean disposal system 4 has been discussed previously, hence it will not be discussed here.

The major consideration of the ocean disposal alternatives for Windward Oahu has been the termination of effluent disposal into Kaneohe Bay. The reclassification of Class A waters to AA by State regulations precludes effluent discharge into the bay. In addition, waste discharges into the bay appear to affect coral communities in two ways. The first is by the toxicity of the effluent on coral and the second is through the biostimulatory effects of the effluent on algae. Biostimulation and coral toxicity are the results of the



limited circulation in the bay. There is also not enough knowledge about biostimulation in Oahu's waters to justify expensive nutrient removal processes. Kaneohe Bay because of its biota and coral reefs, must be preserved.

Alternative 1 considered advanced primary treatment with the depth of effluent disposal greater than 200 feet. This alternative was determined to be unfeasible because of the large construction costs required to reach depths suitable for effluent field submergence. There is a virtual absence of a vertical density stratification from the surface to the 400-foot depth in the ocean off Windward Oahu during the winter months. Adequate stratification is present only when depths greater than 400 feet are present. Another limiting factor is the feasibility of constructing an outfall to that water depth. Construction technology for the placement of ocean outfalls is presently limited to about 300 feet. The present EPA requirement of a minimum of secondary treatment for municipal plants is another reason why this alternative is unacceptable.

Alternative 2 considered secondary treatment with shallow ocean disposal (depth between 80-100). The principal reason why secondary treatment with

a shallow ocean outfall was recommended for the Kaneohe-Kailua district was the lack of suitable density stratification throughout the year. Between depths of 80 to 100 feet, adequate dilution can be obtained with a reasonable diffuser length (1000 feet in the case of the Mokapu outfall). In addition, this alternative is in conformance with the Federal requirement.

Alternative 3 considered the extension of the existing Kailua outfall to about the 100-foot depth for secondary treated effluent. Under this alternative, the existing 42-inch outfall would be extended a distance of 7,000 feet in a direction slightly north of Mokolea Island (KMP Station E). Average flood and ebb directions of the ocean currents at the 23-foot depth at this station were  $181^{\circ}$  and  $165^{\circ}$  (mag.) respectively indicating a general offshore direction. Surface drift at Station E, however, is predominantly onshore during normal tradewind conditions and there appears to be greater likelihood that the effluent might enter Kailua Bay from this location than from the recommended discharge point off Mokapu Peninsula where surface drifts are more variable under the same conditions. Another drawback of this alternative is the inadequate hydraulic and structural

strength of the existing outfall to handle the ultimate flow of the district. Based on these reasons, this alternative was not selected.

Alternative 4 considered the construction of a new outfall off Mokapu Peninsula to a depth of 105 feet. What applies to Alternative 2, applies here.

Alternative 5 considered an extended outfall from the existing Kaneohe Outfall to serve Kaneohe and Kahaluu and another outfall off Mokapu Peninsula to serve Kailua and KMCAS. The discharge point of the Kaneohe extended outfall would be located in Class A waters outside of the barrier reefs. General ocean circulation and current measurements and pattern inside the bay (Reference 33) indicate that there would be a tendency for the effluent to be transported into the bay during flooding tides. Much of the water entering the bay passes over the central reef, hence, it is anticipated that the effluent will be similarly affected. Also, destruction of extensive coral formations can be anticipated during construction, in addition to increased turbidity of the waters by the silty material from the bay's bottom. This turbidity may exist for several years because of poor circulation within the bay. Based on these considerations, Alternative 5 was not accepted.

Alternative 6, a modification of treatment and disposal alternative 6, considered the construction of an ocean outfall off Kualoa in Class A waters and another ocean outfall off Mokapu Peninsula. The treatment facility at Kualoa would be constructed to serve Kahaluu and Kaneohe, and the Mokapu outfall would serve plants in Kailua and KMCAS. The same objections raised in treatment and disposal alternative 6 would be applicable here. With the discharge of larger flows at Kualoa (combined average flow is 18.8 mgd vs. 3.7 mgd for Kahaluu only), the possibility of effluent entering Kaneohe Bay will be greater.

I. Conclusions of Ocean Disposal System Alternatives

Alternatives for ocean disposal system were compared and evaluated with consideration of ocean current patterns and environmental impact. Based on these comparisons and evaluations, Alternative 4, the construction of a new ocean outfall off Mokapu Peninsula was considered the most feasible. Regardless of which alternative is selected, the wastewater generated within the Kailua subdistrict will be disposed of into the open ocean off Mokapu Peninsula. The question whether the Mokapu outfall sewer can accommodate the additional flows from Kaneohe and Kahaluu has been answered in the affirmative by the WQPO and City's design consultants.

J. Alternative Routes for the Kaneohe Effluent Force Main (EFM)

The selection of an alignment for the Kaneohe EFM is difficult, since the nearest road that could possibly be utilized between the two plants is Kaneohe Bay Drive. Many construction problems involving traffic and public inconveniences are associated with this route; hence, several alignment alternatives were investigated.

The possible routes for the EFM is limited due to the configuration of the bay and the adjoining ridge (Puu Papaa). There are two basic alternatives; one a water route across Kaneohe Bay and the other, land routes that follow existing roads. The land routes considered are (1) an alignment entirely along Kaneohe Bay Drive, and (2) an alignment partially along Kaneohe Bay Drive and later branching off into the Mokapu Saddle Road, then to Mokapu Boulevard and finally, to the Kailua plant. An alignment along the shoreline of the bay was considered impractical because of the irregular nature of the shoreline, inaccessibility, possible pollution of inshore waters, and the inconveniences to the residents that will be caused. An alignment paralleling the existing South Interceptor was also considered unfeasible since substantial

property damages and personal inconveniences would occur because of the very restricted working area.

Alternative Route 1 is a water route across Kaneohe Bay as shown in Figure II-17. The primary advantage of placing the force main in the bay is that construction work would be removed from the congested areas around Kaneohe Bay Drive, and personal inconveniences and property damage would be eliminated. The scheme would require the least pumping and operating costs. The disadvantage of this alternative is the probable adverse effects that the proposed construction would have on marine life in the bay. The area affected by construction is characterized by coral reef, mud flats, and a central region which had been dredged in the past for a seaplane runway. Siltation is very pronounced throughout this area. Coral is dead. Clam beds are maintained by the State Fish and Game Division, but harvesting has not been permitted lately because of diminished clam population.

The pipe would be installed in an excavated trench along the bottom of the bay with about a two-foot cover. Piles for pipe support may have to be used depending on subsurface soil conditions. Excavation would surely disturb the high-nutrient bottom sediments. The action could result in higher nutrients concentrations in the bay. In addition,

turbidity throughout the vertical water column can be expected. Excavated material will have to be taken to shore for stockpiling. The adverse effects of construction can be controlled to some extent by sheet piling along both sides of the trench, but the driving and removing operation may also be undesirable

Summarizing, the proposed construction activities will have an adverse effect on the ecology of Kaneohe Bay. Whether these effects will be of a temporary nature or permanent are questions that cannot be answered with certainty at this time.

Alternative 2, a land route beginning at the Kaneohe plant, considered an alignment traversing private property to Kaneohe Bay Drive, and then following that road to the Kailua plant as shown in Figure II-17. The proposed alignment is bounded on both sides by densely built-up residential areas throughout most of its length and is complicated by many horizontal and vertical curves, narrow pavement, and numerous utilities. The existing utilities include a 30-inch water main, storm drains, and sanitary sewers. The advantages of Alternatives 2 and 3, both land routes are (1) Kaneohe Bay will be untouched and (2) repairs,

in case of pipe breakage can be readily made. The disadvantages of Alternative 2 are (1) inconveniences during construction and (2) higher pumping costs than alternative Route 1.

Alternative 3, the other land route, follows Kaneohe Bay Drive but diverts to the Mokapu Saddle Road and enters the Kailua plant via Mokapu Boulevard as shown in Figure II-17. To avoid a high static head over the Mokapu Saddle Road, a tunnel may have to be dug under the Mokapu Saddle Road, a costly undertaking. Preliminary information on the subsurface condition indicates that the proposed tunneling area is underlain with dense, nearly permeable basalt flows of the Kailua volcanic series. If the tunnel is not constructed, severe water hammer problems in the pumping system can be anticipated.

K. Comparative Costs of the Kaneohe EFM Alternatives

The estimated construction costs of the various alternative routes based on a 36-inch force main were calculated and the results are as follows:

Alternative Route 1	\$ 4,697,000
Alternative Route 2	3,745,000
Alternative Route 3	4,120,000



Comparison of the three alternative routes indicate that Alternative 2, the recommended route is the most economical. Relative comparative costs for other pipe sizes would be similar.

L. Conclusions of Alternative Routes for the Kaneohe EFM

General conclusions are that it is feasible and more economical to select Alternative Route 2, the alignment along Kaneohe Bay Drive. The disadvantages of this alternative which include traffic problems and inconveniences to the residents are temporary in nature and can be alleviated to some degree by prudent construction supervision.

Alternative Route 1, the water route across Kaneohe Bay, is the least desirable, not only from the standpoint of cost, but also from the potential ecological damages which may occur during and after construction. The State Division of Fish and Game prefer the land route along Kaneohe Bay Drive. The Division stated that the effects of the water route would destroy the remaining bottom organisms; stir up silt in the bay, Waikalua-Loko and Nuupia Pond; ruin clam beds; disrupt bait fishing; and interfere with sport fishing and boating during construction.

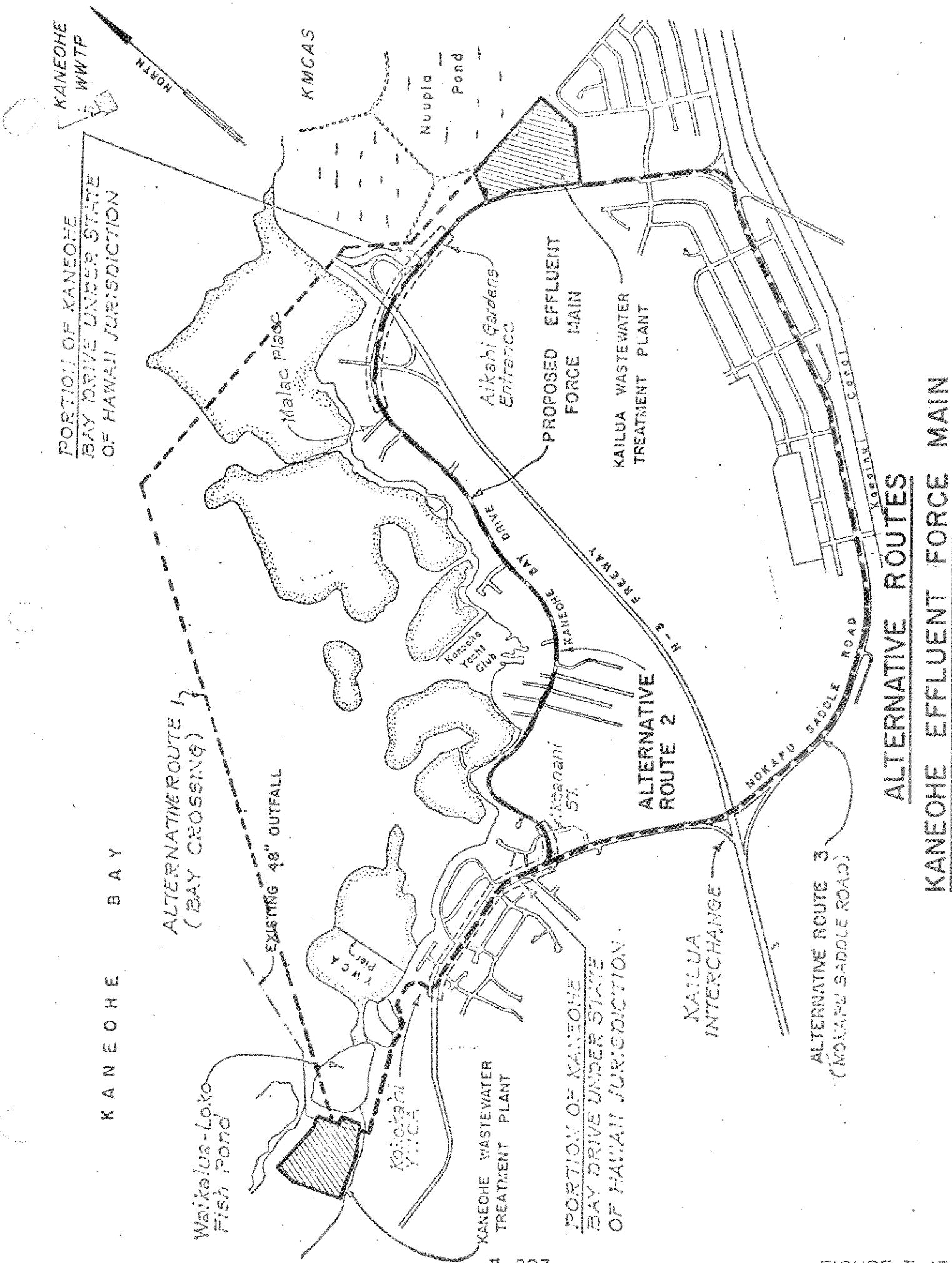


FIGURE II-17

Alternative Route 3 has the advantage of avoiding work in Kaneohe Bay and along the narrow portions of Kaneohe Bay Drive. However, this route is 3,650 feet longer than Alternative 2 and the operating costs are considerably higher because of the additional length and the high static head of the system. There would be severe water hammer problems associated with this alternative unless a tunnel is built.

A 42-inch force main instead of a 36-inch pipe was recommended by the design consultants even though it meant a six percent increase in the present worth costs (\$5,013,130 vs. \$5,349,780). A 42-inch force main would have the following advantages:

1. Lesser horsepower requirements;
2. Choices of standardized equipment;
3. Reasonable velocities in pipe; and
4. Protection of pipe against erosion and displacement by excessive high velocities.

M. Alternative Routes for the Kahaluu Effluent Force Main

Two basic alternative routes for the Kahaluu EFM were available. One is along Kamehameha Highway and the other along Kahekili Highway. The Kameha-

meha Highway route was rejected from further considerations because it is long, narrow, and winding. The route would create traffic congestion, and it lacks an adequate shoulder to accommodate a 20-inch pipe. The WQPO recommended an alignment along Kahekili Highway from the proposed Kahaluu treatment plant site to Likelike Highway, thence along Likelike Highway to Kaneohe Bay Drive to a point opposite the existing Kaneohe treatment plant; thence directly across private lands to the site. This alternative route was not considered further because of the reluctance of the State Department of Transportation to grant permission to install any utility in their right-of-way.

The alternative routes available for the Kahaluu EFM is limited to a portion along Kahekili Highway hence referred to as the basic route with alternatives only at the beginning and end of the EFM (See Figure II-18). Alternatives 1 and 2 relate to the beginning of the project at the proposed Kahaluu plant; Alternatives 3 to 7 relate to the Kaneohe portion of the EFM beginning at Kahuhipa Road.

Alternative Route 1 considered the placement of the force main from the southeast part of the proposed

Kahaluu plant across an easement to Ahaolelo Road, hence across the flood control project to Kahekili Highway and along the Highway to the Ahuimanu STP (See Figure II-18 for all alignment routes).

Alternative Route 2 is an extension of Route 1, except it would utilize Ahuimanu Road and Okana Road instead of Kahekili Highway up to the existing Ahuimanu treatment plant.

Alternative Route 3 considered using the basic route, but continues on Kahekili Highway thence along Keaahala Road, Anoi Road, Paleka Road, Waikalua Road, Holowai Place, and across Kaneohe Stream to the treatment plant.

Alternative Route 4 considered using the basic route, also continuing on Kahekili Highway thence along Keaahala Road, William Henry Road, then along an easement to the intersection of Waikapoki and Waikalua Roads; and thence to the treatment plant site as in Route 3.

Alternative Route 5 considered using the basic route, thence along Kahuhipa Road, Lilipuna Road, Waialele Road, Waikapoki Road to Waikalua Road, and thence to the treatment plant site as in Route 3.

Alternative Route 6, a modification of Route 3, considered the Waikalua alignment, but follows Halemuku Street, thence Halemuku Place, an easement parallel to Kaneohe Stream Interceptor and Kaneohe Bay East Interceptor, across Kaneohe Stream and into the plant.

Alternative Route 7 is another modification of Route 3 and considered the Waikalua alignment. However, this alignment enters and follows Halemuku Street, Halemuku Place, and an easement to a point opposite the end of Puohala Street; crosses Kaneohe Stream, follows Puohala Street, Hilinai Street, Kulauli Street and finally enters the treatment plant site.

Considering and evaluating Alternatives Route 1 and 2, Route 1 has the advantage of placing the force main in the shoulder of Kahekili Highway (State right-of-way) so that construction work would be simplified and public inconveniences and property damage would be minimized. There are no significant advantages for selecting Route 2 (City right-of-way), but there are several disadvantages. These include a 30 inch water line and several storm drains which will affect the installation of the line; a narrow pavement width;

the necessity to close the road during construction; and the need of a longer pipe line (800 feet). Based on these considerations, Alternative Route 1 was selected.

Alternative Routes 3 to 7 which are alignments at the Kaneohe end of the force main are much more difficult to analyze and evaluate. All have to some degree narrow roads, conflicting utility lines, and public inconveniences during construction; hence, only the advantages of the routes will be discussed.

The advantages of Route 3 are that ground grades slope continuously toward the treatment plant; this is the most economical route; construction is on a lower classification road and the least public inconveniences are expected; and this route has the least engineering problems. The advantages of Route 4 are that grades are generally in one direction. There are no advantages to using Route 5. The advantages of Route 6 are that grades are in one direction, construction would be away from congested areas, and public inconveniences would be minimized.

The advantages of Route 7 are that construction work would be simplified and public inconveniences would be minimized.

N. Comparative Costs of the Alignment Alternatives at the Kahaluu and Kaneohe Ends of the EFM

The estimated construction costs of the various alternative routes were calculated and the results are as follows:

Kahaluu Alternative Routes

Alternative Route 1	\$ 766,000
Alternative Route 2	959,000

Kaneohe Alternative Routes

Alternative Route 3	\$1,862,000
Alternative Route 4	1,864,000
Alternative Route 5	2,217,000
Alternative Route 6	1,957,000
Alternative Route 7	2,130,000

Alternative Routes 1 and 3 are the most economical of the Kahaluu and Kaneohe routes respectively based on construction cost estimates.

O. Conclusions of Alternative Routes of the Kahaluu EFM

Alternative routes for the Kahaluu EFM were compared and evaluated with consideration of traffic interference, public inconvenience, environmental impact and cost. General conclusions are that it is feasible and more economical to select Routes 1 and 3 for the Kahaluu and Kaneohe portions of



the EFM respectively. From the standpoint of lowest construction cost and least public inconvenience, these alternatives were selected.

The basic route selected was Kahekili Highway. This highway has ample room in the shoulder area for the placement of the pipe. The alignment is direct with large horizontal curves. It would also cause the least public inconvenience. On the other hand, the Kamehameha alignment was rejected earlier because the corridor is narrow and it contains many horizontal curves, has numerous utility lines in the roadway, and fronts residential areas for a major portion of the route. The WQPO recommended route along Likelike Highway at the Kaneohe end of the EFM was not selected because of the reluctance of the State Department of Transportation to grant permission to install the EFM in the highway right-of-way.

P. Alternative Sites for the Kahaluu WWTP

Six alternative sites for the proposed Kahaluu treatment plant were considered. The sites investigated included four areas in Kahaluu, one in Waiahole, and another in Kualoa. The sites considered are shown in Figure II-19 and included -

1. The General Plan (GP) designated site,

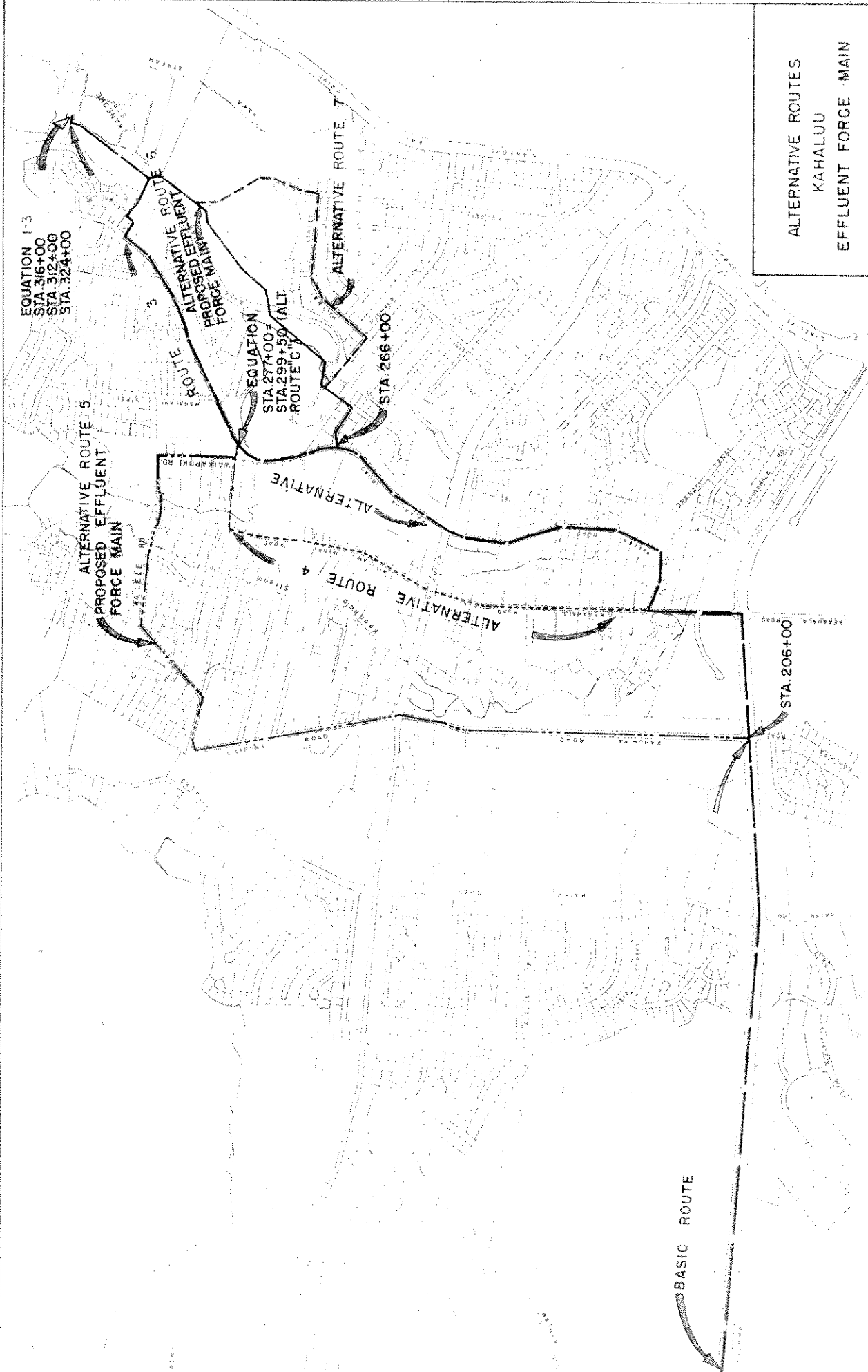
the EFM respectively. From the standpoint of lowest construction cost and least public inconvenience, these alternatives were selected.

The basic route selected was Kahekili Highway. This highway has ample room in the shoulder area for the placement of the pipe. The alignment is direct with large horizontal curves. It would also cause the least public inconvenience. On the other hand, the Kamehameha alignment was rejected earlier because the corridor is narrow and it contains many horizontal curves, has numerous utility lines in the roadway, and fronts residential areas for a major portion of the route. The WQPO recommended route along Likelike Highway at the Kaneohe end of the EFM was not selected because of the reluctance of the State Department of Transportation to grant permission to install the EFM in the highway right-of-way.

P. Alternative Sites for the Kahaluu WWTP

Five alternative sites for the proposed Kahaluu treatment plant were considered. The sites investigated included three areas in Kahaluu, one in Waiahole, and another in Kualoa. The sites considered are shown in Figure II-19 and included -

1. The General Plan (GP) designated site,



ALTERNATIVE ROUTES  
 KAHALUU  
 EFFLUENT FORCE MAIN

FIGURE I-18

41 516

1:2500  
1" = 200'

ALTERNATE ROUTE 2

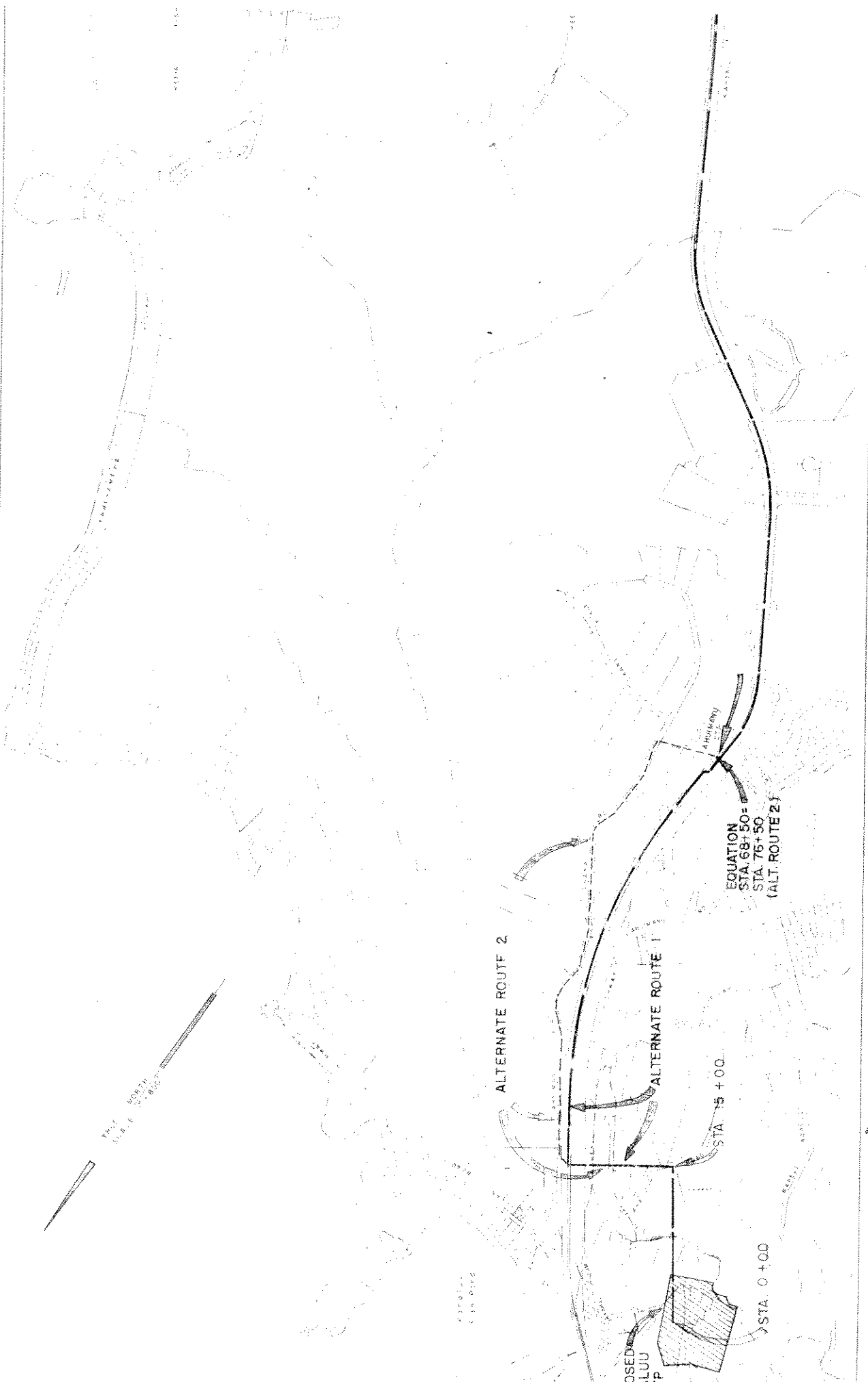
ALTERNATE ROUTE 1

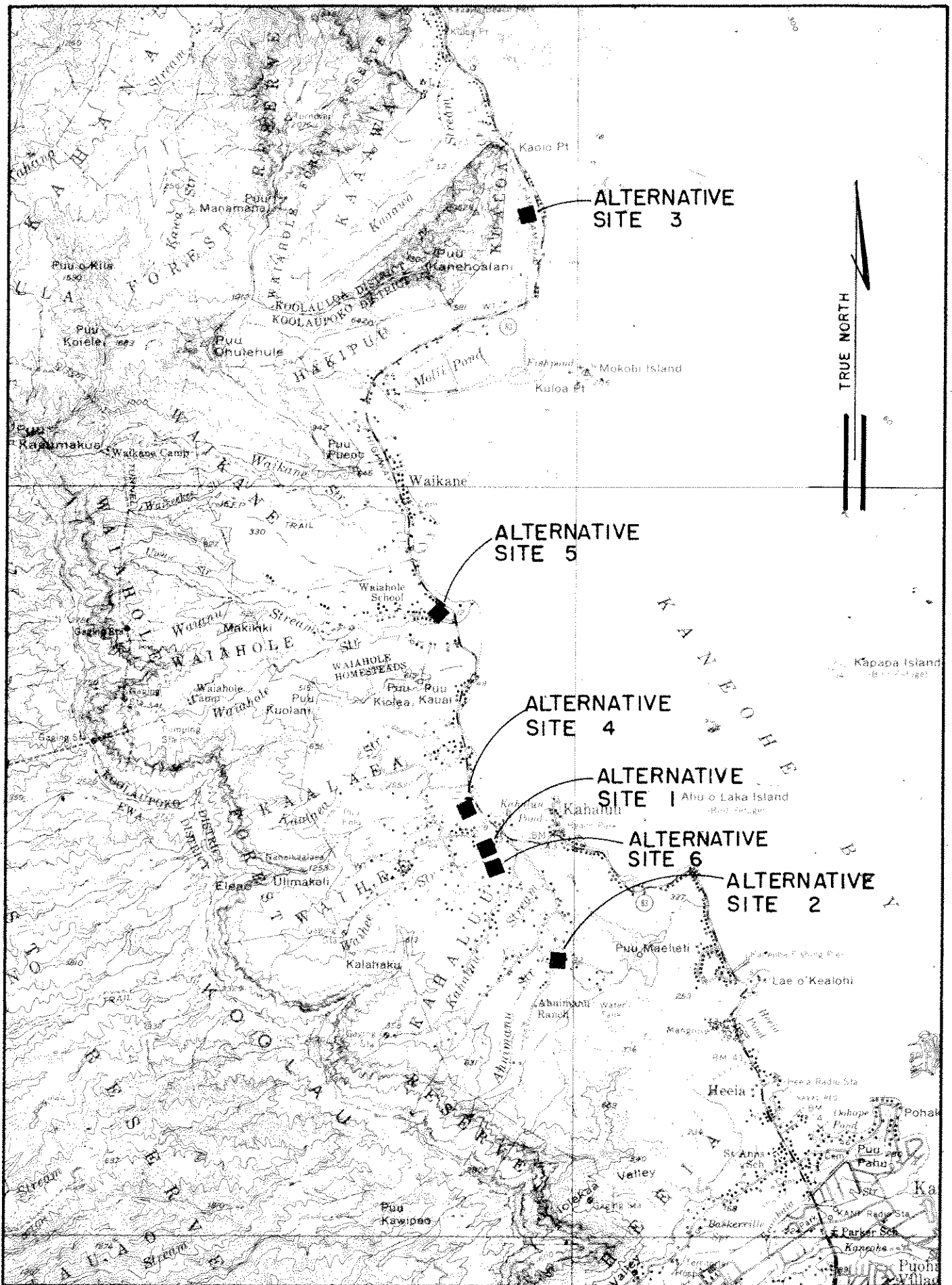
EQUATION  
STA. 68+50 =  
STA. 76+50  
(ALT. ROUTE 2)

STA. 15+00

STA. 0+00

POSED  
HALU  
VTP





**ALTERNATIVE SITES FOR THE KAHALUU WWTP**

**FIGURE  
II-19**

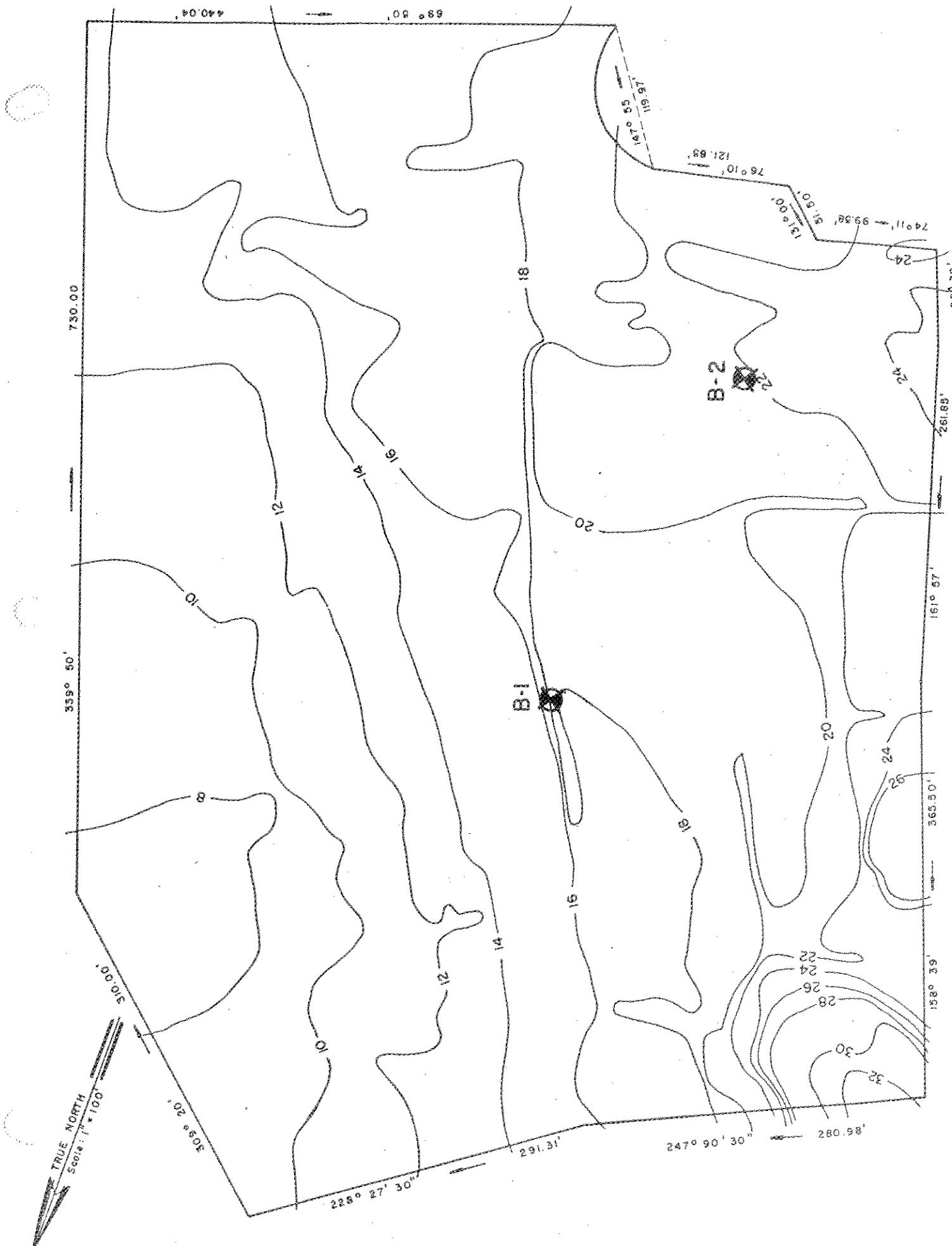


FIGURE II -

KAHALUU WWTP SITE

2. Existing Ahuimanu plant site,
3. A site at Kualoa,
4. A site located in the same vicinity of the GP site,
5. A site located in Waiahole, and
6. A site located adjacent the GP site and Ahaolelo Road.

Alternative Site 1, the GP designated site is located in the vicinity of the confluence of the Kahaluu and Waihee Streams, and Waihee Road. The slope of the land is relatively flat at the makai portion with ground elevations varying from 6 feet to 14 feet. The elevations of the mauka portion are higher and vary from 25 to 36 feet. The existing contour elevations are shown in Figure II-20. It is anticipated that the mauka portion will be excavated to provide fill material for the makai portion.

Two soil borings to depths of 100 feet were taken within the plant site to determine the underlying soil conditions. Results of the borings indicate a stiff surface layer of about 4 to 10 feet, underlain by soft swampy materials to at least the 45-foot depth. Stiffer clayey silt materials start from about 55 feet and extends to the limits of the borings. General conditions from the soil study indicate that heavy structures and structures that cannot withstand relatively excessive settle-

ments should be founded on friction or end bearing piles, driven to the firm materials at about the 60 to 90-foot depths.

Because of its elevation, no additional pumping costs will be incurred, however, raw sewage pumps will be necessary to lift the wastes to the initial treatment unit within the plant. Effluent pumping facilities will also be necessary here as well as at any other potential site since the effluent will be conveyed to the Kaneohe EPS. One of the advantages of this site, because of its central location within the subdistrict population center, is the minimum cost of conveying and pumping the effluent and the raw wastewater.

The existing Ahuimanu treatment plant is the location of Alternative Site 2. Within the site is a 1.4 mgd advanced waste treatment plant and a 0.8-acre polishing detention pond. The area of the plant site is 4.29 acres. The buffer distance to the adjoining Kahekili Highway is only about 50 feet. Ground elevation at the site varies from 40 to 50 feet which means that all wastewaters generated in low lying areas of Kahaluu must be pumped to the site. Situated between the two branches of the Ahuimanu Stream and Kahekili



Highway, the area of the plant cannot be expanded to the 14-acres required for the proposed subdistrict treatment facility.

Alternative Site 3 would be located on a 14-acre site at Kualoa, mauka of the highway on land zoned for agriculture. This alternative would include the construction of an ocean outfall in Class A waters off Kaiiao Point. On the basis of present worth cost and unfavorable ocean currents, as discussed earlier, this site was not considered further.

Alternative Site 4 would be located on a presently vacant 17 -acre site between Waihee Road and Kaalaea Stream fronting on Kamehameha Highway.

There appears to be no advantages in the selection of this site although sufficient acreage is available, the ground elevation is satisfactory, and the area is general planned for industrial use. From the point of aesthetics, the plant will be visible from the main highway, even through the site can be effectively landscaped. The cost of acquiring the site can be expected to be higher than that of Site 1 because of its proposed higher land use classification.

There are several potential sites in Waiahole. Alternative Site 5 would be located on existing

agricultural land on the Kahuku side of Waiahole Valley Road and mauka of Kamehameha Highway.

The advantage of this site is its isolation.

Alternative Site 6 would be located between Alternative Site 1 and Ahaolelo Road and slightly mauka of the multi-purpose lagoon. The existing Waihee Stream bisects the plant site in the center, however, this is not a major obstacle because this portion of the stream will be relocated as part of the Kahaluu Watershed Project. A medium size drainage line will still have to be constructed along the south boundary to serve a remnant of the stream's former drainage area.

To determine the structural characteristics of the ground to support treatment facilities, subsurface investigation of the site was performed in January 1974 after the Kahaluu Coalition suggested that this site be considered as an alternative in November 1973. According to the two soil borings, thick soft swamp materials exist to a depth of 25 feet at Boring No. 1 to about 65 feet depth at Boring No. 2. Underlying the soft swamp materials is a stiffer clay silt layer which varies from a thickness of 30 feet in Boring 1 to about 5 feet in Boring No. 2. It should be pointed out that Boring No. 2 is located near the center of the site while Boring No. 1 is at the south boundary hence subsurface characteristics at No. 2 are more significant to the proposed plant structure design.

Basalt rock formation was encountered in both the borings and they varied from a depth of 53 feet in Boring No. 1 to about 70 feet in Boring No. 2. The soil report recommended that treatment plant structures be founded on friction piles bearing in the stiff clayey silt layer or end bearing piles driven to the basalt rock.

Alternative 6 is located in a large depression between the Haiku range and the low lying hills on the south boundary. This depressed area serves as an recovery basin for sediments from the upper reaches of the stream. The surface area is covered with a thick grass cover and heavy root system. There are a few scattered bushes and trees.

One of the advantages of this site is an existing grove of thick and tall hau, mango and other trees on the south and west boundary of the proposed site. These trees would provide an excellent buffered area between the plant structures and nearby residences. Soil conditions at this site are about equal or slightly better to the adjacent GP site. Not being completely surrounded by the proposed park as the GP site is an advantage, nevertheless the north boundary would border the park.

There are about six or more homes that will be located from one to three hundred feet away from this alternate site in the downwind direction. This is much closer than the five hundred feet distance to homes from the GP site. This is the only disadvantage of this site.

Plant access will be through an easement from Ahaolelo Road. No residences are located on the proposed site and no one will be displaced. Since the site is located in the flood plain, the entire area will be filled and properly graded with reference to the calculated high-water elevation of the Kahaluu Watershed Project.

Q. Comparative Cost of the Kahaluu WWTP Alternative Sites

Comparative cost estimates, including construction costs and additional pumping costs for relocating the treatment plant site from Site 1 to Site 5 in Waiahole were prepared. The results of this analysis is shown in Table II-V-1. Since the site in Waiahole will be located away from the center of population, all the flows generated in Kahaluu, including Ahuimanu will have to be pumped to the plant site. Under this alternative, an additional pump station and force main would have to be constructed near Kaimalolo Place at a cost of \$1,160,000. Because of adverse grade conditions and the increased length of the effluent force main, as well as adjustments in sizes and distances of the main collection system, the total estimated cost of relocating the treatment plant to Waiahole would amount to \$6,094,000. This amount must be reduced by \$3,029,000, the construction cost for the facilities needed for conveying the Waiahole,

TABLE II-V-1

SUMMARY

COST ESTIMATE TO RELOCATE WWTP TO WAIHAOLE

I.	Adjustment to Sewer System	
A.	Costs to be Added	
1.	Kahaluu SPS & FM	\$ 1,160,000
2.	4,000 LF - 48 in. Sewer, Kahaluu	1,404,000
3.	4,000 LF - 48 in. Sewer, Waiahole	1,222,000
4.	11,000 LF - 30 in. Effluent FM	1,892,000
5.	3,200 LF - 24 in. Sewer, Kahaluu	416,000
	Sub-total	<u>\$ 6,094,000</u>
B.	Costs to be Subtracted	
1.	4,000 LF - 36 in. Sewer, Kahaluu	\$ 1,170,000
2.	3,200 LF - 36 in. Sewer, Kahaluu	624,000
3.	4,000 LF - 20 in. FM, Waiahole	468,000
4.	4,000 LF - 21 in. Sewer, Waiahole	767,000
	Sub-total	<u>\$ 3,029,000</u>
	Net Additional Costs	<u>\$ 3,065,000</u>
II.	Energy Costs Per Year	
A.	Costs to be Added	
1.	Kahaluu SPS	\$ 12,000
2.	Effluent Pump Station	12,000
	Sub-total	<u>\$ 24,000</u>
B.	Cost to be Subtracted	
1.	Waiahole SPS	\$ 9,000
	Net Additional Costs Per Year	<u>\$ 15,000</u>

Waikane and Kualoa raw wastewater to the GP site. The net construction cost in the collection system will be \$3,065,000. The cost of the treatment facilities are not being considered because they would be relatively equal for both site. Energy costs for operating the affected pumping facilities for the Waiahole site alternative would amount to an additional annual cost of \$15,000.

R. Conclusions on Alternative Sites for Kahaluu WWTP

Alternative sites for the proposed Kahaluu WWTP were compared and evaluated. Based on these evaluations and comparisons, Alternative Sites 1 and 6 were determined to be the most feasible. Alternative Site 1 has the only disadvantage of being located in the park, however, it would provide a buffer of 700 feet from the treatment unit to the nearest home. Alternative Site 6 would be located adjacent to the park, but it would only provide a buffer of 300 feet from the treatment units to the nearest home. The advantage of utilizing the existing rows of hau and mango trees for landscaping at the south and west boundaries of Site 6 may be short lived because these trees are slated to be cleared by the owner (oral communication). Construction costs and subsurface soil conditions at both sites are about equal, hence Alternative Site 1, being already zoned, is the preferred location.

Alternative Site 2 at Ahuimanu has the advantage of being operable at the present time with additional unused capacity. However, the unused capacity of this plant which was built by private capital has

been reserved for the developer's housing plans in Ahuimanu. Sewer connections from other areas which would have to be pumped would not be available at this plant. The major disadvantages of this site are: (1) location adjacent to a major state highway leading into Kahaluu; (2) inadequate area for future expansion; (3) odor problems since the plant was not designed for complete odor control; (4) close proximity to existing homes; (5) inadequate buffer area; and (6) the additional cost of pumping from other drainage areas. The plant could be retained on a temporary basis for an extended period of time with its effluent being diverted into the proposed Mokapu Outfall system, however, this action would only delay the eventual sewerage of Kahaluu, Waiahole, Waikane, and Kualoa.

Alternative Site 5 was advantageous because of its isolation, however, a cost comparison analysis indicated that an additional cost of \$3,065,000 would have to be expended to locate the plant in Waiahole. In addition, energy costs for the pumping facilities will increase by \$15,000 annually. Energy costs are expected to increase drastically because of higher fuel costs and shortages. Construction costs of the treatment facilities were not included in the analysis since these costs would be nearly equal for both sites. Extensive landscaping and odor control measures would be employed on both sites; hence these factors have no bearing on the cost analysis.

VI. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The implementation of the proposed wastewater treatment and disposal system will greatly enhance the aesthetic, sanitary, and recreational potential of Kaneohe and Kailua bays. The proposed system will eliminate four existing effluent discharges located at Kaneohe, Kailua, Ahuimanu and KMCAS. The Kaneohe and KMCAS discharges are into the southern portion of Kaneohe Bay where circulation is severely limited and the Ahuimanu plant discharges in Ahuimanu Stream which is a tributary of the bay. The Kaneohe and KMCAS plants' contribution to the enrichment of the bay is substantial and has been cited as one of the reasons leading to poor water quality and marine life deterioration. The proposed diversion of all joint sources of wastewater effluent from the bay will allow for the continuation of marine studies in the bay; and permit the bay to recover, to a limited degree, to its former conditions.

The elimination of the existing short discharge in Kailua Bay off Kapoho Point, while not a serious problem in the maintenance of water quality in the bay because of its limited flows and high quality effluent will in time impose certain stresses on the marine environment. These stresses will result in increased bacterial counts



and nutrient levels. The dilution ratio available for the present flows are on the order of 10 to 1 compared to 200 to 1 at the proposed discharge area.

The proposed discharge into deeper waters off Mokapu Peninsula will have no significant adverse effect on the beneficial uses of the waters and could conceivably benefit some of the uses by providing a diffused source of basic raw materials for phytoplankton. A sustained increase in algal production should be reflected by a concomitant increase in fish production, although realistically, these increases probably will not be of any significance due to the net transport out to sea.

The acquisition of land for the Kahaluu treatment plant in the designated General Plan site would replace the present inadequate uses of the land. Although the proposed site is fenced for grazing, very few animals have been observed. The animals are presumed to be used for an individual or family. Of the two dilapidated buildings which will have to be demolished, one is occupied. The proposed site could be developed as a park however, the reduction of the plant area from 20 to 14 acres will still allow for the development of a proposed regional park in the same general area.

Although the location of a treatment works may not be considered desirable, technology is now available for odor-free plants. With adequate landscaping, an

innocuous atmosphere could be created. A similar situation exists between the Sand Island regional park and proposed Sand Island treatment plant.

The construction of a treatment plant would lead to the eventual elimination of approximately 440 defective cesspools (1973) in the subdistrict. The annual cost of maintaining these defective cesspools by the City amounted to approximately \$45,000. After April 1974, these costs will be borne by individual households. Failures among the remaining 1300 cesspools can also be expected. Hence, the cost of maintenance can be expected to increase.

The resultant health and aesthetic problems of overflowing cesspools cannot be adequately described. It is suffice to say that these are considerable, not even counting the inconveniences caused. Hence, the construction of a treatment plant serving the subdistrict is a necessity.

VII. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

There are several irreversible and irretrievable commitments of resources created by the proposed sewer system. These include funds expended for the construction of the proposed system, easements for the placement of gravity sewers, force mains and the ocean outfall, the destruction of some viable coral during construction, and finally, the proposed treatment site in Kahaluu.

Except for the ocean bottom on which the outfall pipe and diffuser will lie, and the easement around KMCAS within which the land outfall will be buried, there does not appear to be any irreversible and irretrievable commitment of the resource for this outfall project. There are no important biological communities such as coral reefs in the vicinity of the proposed outfall diffuser that might be destroyed or degraded. However, there will be some destruction of live coral during construction. This destruction will be limited to the trench width from the shore to about the 40-foot depth. The outfall pipe will be buried from the shore to about the 80-foot depth, a distance of approximately 3,500 feet offshore. The subaqueous trench backfill will be designed for maximum wave protection.

From the trench, the outfall sewer will continue seaward along the ocean bottom. Throughout this length, including the diffuser section, the pipe will be ballasted with rock on each side to ensure stability. These measures would be of great assistance also in reducing damage to bottom habitat in the area and will meet the requirements of the State Division of Fish and Game. Underwater excavations will be difficult to control, but will be in accordance with the requirements of the Department of Health and the Army Corps of Engineers. Any disturbance of the ocean bottom will release sediments and increase the turbidity of the water. The overall effect, however, is expected to be small since only a relatively small area will be exposed or be disturbed at any given time. Also, the prevailing currents and dispersal pattern will localize this effect. Excess excavation material from the near shore portion of the outfall sewer will be deposited along the trench. No further handling is anticipated and no nuisances are expected from placing the excess excavated material along the pipeline.

The construction of the Kailua and Kaneohe effluent pump stations will not require additional commitment of lands since both stations will be located within their respective treatment plant sites. The construction of the Kaneohe and Kahaluu EFMs will require

some easements but most of the pipeline will be in the public right-of-way. The entire length of the two force mains will be buried. The construction impact of these projects are described elsewhere and will not be repeated here because they are minor and temporary in nature.

The site needed for the proposed Kahaluu treatment plant will be an irreversible and irretrievable commitment of a land resource. The reduction of the plant site from 20 to 14 acres has minimized the commitment of this valuable resource. Regardless of the location of the proposed plant site, an area of approximately 14 acres would be required within the subdistrict. Hence, the acquisition of the proposed site is not an unreasonable commitment of a necessary ancillary installation. In addition, the acquisition of the proposed site does not deter the feasibility of establishing a regional park within the immediate vicinity.

## VIII. ECONOMIC AND SOCIAL COST ANALYSIS

### A. Definition of Beneficial Uses

The State of Hawaii took positive steps to define, and in some cases to evaluate, the beneficial uses of its waters by holding public hearings for this purpose in 1966 and 1967. These hearings provided the basis upon which the State Water Quality Standards were established. A classification system composed of distinct classes of waters with each of the water classes designed to provide protection for specific beneficial uses was developed (Reference 23). For marine waters, these classes included Class AA waters, established to protect oceanographic research, propagation of shell fish and marine life, conservation of coral reefs and wilderness areas, and aesthetic enjoyment; Class A waters, established to protect recreational, including fishing, swimming, bathing and other water-contact sports, and aesthetic enjoyment; and Class B waters which were to provide protection for small boat harbors, commercial, shipping and industrial activities, bait fishing, and aesthetic enjoyment. All waters around Oahu were placed into these use-based classes.

## B. Beneficial Uses

The coastal and inland waters of Oahu serve a wide variety of uses which provide immeasurable benefits, both economic and social, to the people of Oahu, the State, and to the Nation. These benefits include water-oriented recreation, aquatic life propagation and sustenance, commercial fishing, industrial water supply, ocean-going water transport, and in general, an environment for pleasant living and enjoyment of aesthetic values. All of these benefits depend to some degree upon the maintenance of waters of suitable quality.

The evaluation of beneficial uses is perhaps the more difficult portion of the procedure leading to the establishment of adequate water quality standards to insure the greatest net economical and social return to the people. The easiest and most direct approach is probably an economic evaluation of the obvious uses of a water resource. To the industrialist and agriculturist, the approach is often preferred since their uses of the waters have very specific monetary worths. To the small independent merchant and businessman either directly or indirectly dependent on the water resources of an area, an approach which

only considers large obvious monetary worths could be disastrous. For example, how many fewer gallons of gasoline would be sold by a local independent service station owner if the number of vacationers in an area decline because a section of coral reef had been destroyed by thermal pollution? How much of an economic loss would a sightseeing guide suffer if oil slicks were allowed to develop in boat harbors? These are social-economical questions that are often difficult, if not impossible to answer based on present technology and knowledge. Nevertheless, benefits from and rights to natural resources by all society must be protected in order to insure a continued strong economic growth.

The water areas in Kaneohe and Kailua bays that are affected directly or indirectly by the four existing discharges of Kaneohe, Kailua, Ahuimanu and the KMCAS are listed in Table II-VIII-1 under Geographical Area IV and V. The current uses of these water areas are also indicated in this table.



TABLE X-VIII-1  
BENEFICIAL USES OF THE MARINE WATERS OF OAHU

Geographical Area	Industrial Water Supply	Ship and Boat Harbors	Marine Life Propagation		Coral Reef Conservation	Shellfish Propagation	Battfish Propagation	Recreation		Conservation Areas	Water-fowl	Aesthetics	Water Classification
			Estuarine	Oceanic				Whole Body	Limited Body				
I. Barbers Point to Ahua Point (1) Coastline (2) West Loch, Pearl Harbor (3) Middle Loch, Pearl Harbor (4) East Loch, Pearl Harbor	X X X X	X X X X		X	X	X	X X X X	X				X X X X	A AA, B A, B A, B
II. Ahua Point to Diamond Head (5) Keolu Lagoon (6) Keolu Marinas (7) Hanalei Harbor (8) Kewalo Basin (9) Ala Wai Yacht Harbor (10) Coastline	X X X	X X X	X		X		X X X X	X				X X X X	A B B B B A
III. Diamond Head to Makapuu Point (11) Maunaloa Bay (12) Hanalei Bay (13) Coastline			X		X X X		X X X	X	X			X X X	A AA A
IV. Makapuu Point to Koko Point (14) Maunaloa Bay (15) Kailua Bay		X			X X		X X	X X	X	X	X X	X X	AA, A A
V. Makapu Point to Kailua Point (16a) Kaneohe Bay, Southern Sec. (16b) Kaneohe Bay (16c) Kaneohe Bay (17) Kaneohe Yacht Club Harbor (18) Kaneohe MCAS Harbor and Pier (19) Weeja-Kea Harbor Marinas (20) Coastline	X		X X		X X	X	X X	X X		X	X	X X X	AA AA B
VI. Kailua Point to Kaunaea (21) Kaunaea Bay (22) Coastline			X		X X		X X	X X	X		X	X X	AA A
VII. Kaunaea to Kaena Point (23) Kailua Bay (24) Haleiwa Harbor (25) Coastline			X		X X		X X	X X	X	X		X X X	AA B AA, A
VIII. Kaena Point to Barbers Point (26) Coastline (27) Fokai Harbor (28) Campbell Estate Harbor	X	X			X		X	X	X	X		X X X	AA, A B B

(SOURCE - WQPO)

C. Communities or Areas Which Would Benefit

Communities or areas which will benefit by the diversion of effluents from Kaneohe Bay and off Kapoho Point include Coconut Island, Kaneohe, Kaneohe Yacht Harbor, KMCAS, Ahuimanu, Kahaluu, Kailua, and Kalama Beach. At these communities or areas, the value of the water environment will be enhanced. At Kailua and Kalama beaches where Class A waters of high value exist, elimination of the discharge off Kapoho Point will insure the maintenance of these waters.

In Kaneohe Bay, the research oriented program at Coconut Island will be able to continue. Boating, bait-fishing, fishing and other water related sports would also be benefited.

D. Aesthetics and Recreation

Aesthetics is clearly an important use of all waters. From all available evidence, the social well-being and orderly growth of our society appear to depend to a great extent upon the quality of the environment in which we live. Environmental degradation implies a concomitant social degradation. Protection of aesthetic qualities of all surface water resources is as important as the protection of all other beneficial uses.

Another important use of the waters of Oahu is recreation. People are drawn worldwide to the shores of Oahu to experience and take part in water-based recreational activities. These activities range from swimming through bathing, surfing, SCUBA diving, skin diving, boating and fishing to simple sightseeing. Most of this recreational demand is due to the high quality of most coastal waters together with a warm and constant tropical climate.

The most significant deterrent to the aesthetics and recreational uses of coastal waters appears to be the continued discharge of wastewater effluent into Kaneohe Bay. From all available evidence, the discharges appear to effect directly or indirectly the boating, water skiing, snorkeling, glass bottom boating, and other related water oriented sports and activities in the bay.

#### E. Demographic and Economic Forces

The area served by the Kaneohe-Kailua sewer system is subject to the same major economic forces as are present throughout the State of Hawaii; i.e., defense expenditures, visitor expenditures, sugar production, and pineapple production. Within the area exists Kailua Beach, considered

by some to be the best beach on Oahu, KMCAS, and tuna-bait fishing.

The residents and visitors pay a premium to live in or visit Hawaii. The cost of living in Hawaii is often quoted to be one of the highest in the nation. The compensation for this high cost of living is the high quality of the environment which exists within the State. People choose to live or visit Hawaii in order to enjoy the benefits gained from a clean and healthful natural environment. It should be noted that this is not necessarily the driving force that determines residency throughout the rest of the United States.

A downgrading of the environment, particularly water quality, would result in economic as well as demographic upheaval in Hawaii. Management of wastes from domestic, industrial, agricultural, and natural resources to protect and enhance water quality is vital to insure economic and demographic stability.

A summary of economic and demographic statistic (1962-1973) from an overall State view is shown in Table II-VII-2.

TABLE II-VIII-2

## HAWAII'S ECONOMY — A FORECAST FOR 1973 \*

	1962	Estimated 1972	Projected 1973	Average Annual Change (percent)			
				1962-72	1971-72	1972-73	
<b>POPULATION (As of July 1)</b>							
Total Resident .....	683,513	808,560	828,000	1.7	2.6	2.4	
Civilian .....	541,305	689,800	705,000	2.5	2.1	2.2	
Military Dependents .....	63,231	66,222	68,000	0.5	6.5	2.7	
Armed Forces .....	78,977	52,538	55,000	-4.0	3.5	4.7	
<b>LABOR</b>							
Total Labor Force .....	246,180	370,500	380,000	4.2	2.0	2.6	
Average Civilian Employment .....	234,580	348,300	359,000	4.0	1.0	3.1	
<b>INCOME</b>							
Gross State Product .....	\$ Millions	2,035	4,813	5,340	9.0	8.7	11.0
Total Personal Income .....	\$ Millions	1,676	4,025	4,455	9.2	8.9	10.7
DIVERSIFIED AGRICULTURE .....	\$ Millions	48.3	66.5	69.0	3.3	3.3	3.8
<b>MANUFACTURING SALES</b>							
Sugar .....	\$ Millions	159.5	214.0	223.0	3.0	0.2	4.0
Pineapple .....	\$ Millions	115.0	137.0	135.0	1.8	—	-1.5
Diversified Manufacturing .....	\$ Millions	240.0	465.0	500.0	6.8	5.7	7.5
<b>CONSTRUCTION</b>							
Private Authorizations <sup>1</sup> .....	\$ Millions	198.5	450.0	400.0	8.5	12.6	-11.2
Construction Completed .....	\$ Millions	268.3	685.0	720.0	9.8	-1.8	5.1
Housing Inventory .....	Number	174,383	238,595	247,000	3.2	4.5	3.5
<b>VISITOR INDUSTRY</b>							
Visitor Arrivals .....	Number	362,145	2,280,000	2,650,000	20.0	25.3	16.2
Visitor Expenditures .....	\$ Millions	154.0	724.0	825.0	16.7	12.2	14.0
Hotel Room Inventory .....	Number	10,915	37,264	38,583	13.0	4.1	3.5
<b>TRADE</b>							
Foreign Exports .....	\$ Millions	28.1	62.3	70.0	8.3	34.6	12.4
Foreign Imports .....	\$ Millions	68.3	264.0	316.0	14.5	18.1	19.7
Retail Trade .....	\$ Millions	1,027.6	2,395.0	2,625.0	8.8	7.5	9.6
<b>TRANSPORTATION</b>							
Interisland Air Passenger Trips <sup>2</sup> .....	Thousands	970.0	3,532.7	3,956.0	13.8	19.6	12.0
Interisland Air Cargo <sup>3</sup> .....	Tons-Thousands	14.0	28.8	32.0	7.5	18.0	11.0
Motor Vehicle Registration .....	Number	261,974	456,700	479,500	5.7	4.5	5.0
<b>FINANCE</b>							
Deposits of all Financial Institutions <sup>3</sup> .....	\$ Millions	1,192.2	3,400.0	3,992.0	11.1	12.0	17.4
Loans of all Financial Institutions <sup>3</sup> .....	\$ Millions	891.4	2,900.0	3,422.0	12.5	11.0	18.0
Life Insurance in Force .....	\$ Millions	3,265.9	9,165.0	10,175.0	10.9	11.0	11.0
<b>UTILITIES</b>							
Telephones in Use .....	Thousands	233.7	495.0	535.0	7.8	11.0	8.0
Volume of Electricity Sold .....	KWH Millions	1,693.8	4,622.4	5,175.0	10.5	14.4	12.0
Volume of Gas Sold .....	Therms Millions	22.6	46.0	50.0	7.4	10.8	8.7
Volume of Water Sold .....	Gallons-Billion	23.8	38.0	39.9	4.8	4.1	5.0
<b>GOVERNMENT</b>							
Defense Expenditures .....	\$ Millions	375.8	764.9	820.0	7.4	6.0	7.2
Non-Defense Expenditures .....	\$ Millions	153.9	597.0	705.0	14.5	20.0	18.1
State and Local Revenues <sup>4</sup> .....	\$ Millions	285.9	907.5	1,027.5	12.2	14.6	13.2
State and Local Expenditures <sup>4</sup> .....	\$ Millions	291.5	991.5	1,170.0	13.0	17.2	18.0
ASSESSED VALUE OF REAL PROPERTY .....	\$ Millions	3,630.2	8,564.2	9,948.7	9.0	11.8	16.2
HONOLULU CONSUMER PRICE INDEX .....	1967=100	89.7	123.0	127.0	3.2	3.0	3.3

<sup>1</sup> Private authorizations including some public authorizations on Oahu. <sup>2</sup> Fiscal Year data for all airports. <sup>3</sup> Banks, Savings & Loans, Trust Companies, Industrial Loan companies and Federal Credit Unions. <sup>4</sup> Fiscal year.

\* Source: Bank of Hawaii Monthly Review - Jan 1973

## F. Specific Benefits

The most important commercial fish of the State is the Skipjack tuna (aku) with landing valued at about \$3 million. The nehu of the anchovy species is the primary bait in Hawaii because of their natural tendency to draw the aku toward the tuna boats. Nehu are taken in significant numbers from Kaneohe Bay as well as Keehi Lagoon, Honolulu Harbor, and Pearl Harbor. Since seine fishing for tuna does not appear to be feasible in the Pacific, the nehu and the puha are used solely in the islands. One of the limiting constraints in the growth of the industry has been the availability of the baitfish. Thus, the enhancement of water quality in Kaneohe Bay may directly stimulate the industry by increasing the yield of baitfish.

The Molii Pond near Chinaman's Hat is the only large fishpond in the bay raising mullet. At one time, as much as four thousand pounds of fish were taken monthly from the pond. Mullet raising has been reported at the Kahaluu fishpond as well as the Waikalua-loko ponds. The main problem with raising mullets in the bay is the difficulty in getting the young mullet from the bay with which to stock the ponds.

By improving the water quality in the bay, it may be possible to stimulate the practice and the studies of aquaculture in the State.

A vital part of the economy of Oahu is tourism. It accounts for much of the activities related to construction, air travel, and hotelries which in turn provide employment for a significant part of the population. The lure of the Islands is in part due to salubrious climate, scenic beauty, and its water oriented recreation. Visitor expenditure in Hawaii have steadily increased from about \$154 million in 1962 to about \$724 million in 1972. In order to maintain the growth rate of this vital part of the economy, it appears that enhancement of water quality in Kailua and Kaneohe bays and other areas is essential.

Defense activities in the State of Hawaii are focused in the Pearl Harbor-Hickam areas. An important component of these activities is located at the Kaneohe Marine Corp Air Station. The base is the headquarters of a Marine brigade and employ about a 1000 of the 28,600 civilian defense workers in the State. Defense expenditures rose from \$375.8 million in 1962 to \$764.9 million in

1972, contributing substantially to the economic well-being of the State. The enhancement of water quality in Kailua and Kaneohe bays will certainly enhance the morale and well-being of military personnel, their dependents and civilian workers living and working in the area.



## IX. SECONDARY IMPACT

### A. Public Controversy

As with all public improvement projects, considerable opposition was generated by a small minority, but vocal group. This time, opposition came from a group from Kailua. Information concerning the project was disseminated to the public by means of television, radio, newspaper coverages, and public and professional meetings. The project now appears to have an overwhelming acceptance from the general public. Two public meetings deserve mention here. They are the public informational meetings held at Kailua High School on April 30, 1971, and at Ben Parker School Cafetorium, Kaneohe, on April 5, 1972.

Recommendations for the Kaneohe-Kailua sewer system were presented at the Kailua meeting by the City's Board of Advisors, along with members of the Engineering Consortium working on the project, the Mayor and City's Public Works staff. The recommended system presented was the diversion of sewage effluent from both Kaneohe Bay and Kailua Bay to a deep ocean outfall facility to be located off Mokapu Peninsula. Answers and clarifications were provided in response to the

many questions from the residents attending this meeting.

After the preliminary design of the outfall sewer and diversion line was completed, another public hearing was scheduled at Kaneohe. Attending this meeting was the Managing Director, members of the engineering consultants, and the City's staff. The preliminary findings of the design engineers and scientists were presented using slides. The subjects covered included general design, pump station and force main, ocean outfall, physical oceanography, and oceanographic monitoring. A question and answer period followed.

Another public hearing will be held

this year (1974) after the completion of the final design but before construction begins on any of the components of the disposal system. The hearing will probably be held in Kaneohe.

#### B. Development

The Kaneohe-Kailua sewer system is in agreement with the General Plan (1964). Locations of treatment plants and pumpstations are delineated in the GP and in the Detailed Land Use Maps for Kailua, Lanikai, Maunawili, and Waimanalo; and Kaneohe, Heeia, Kahaluu, Waihee, Kaalaea, Hakipu,

and Kualoa. The designations also include the site for the proposed Kahaluu WWTP. Amendments to the GP and DLUM are anticipated for proposed pump station sites for the sewer collection system in the Kahaluu subdistrict when their specific locations can be established. These changes will follow procedures established by the Department of Planning of the City and County.

### C. Other Factors

The guidelines for the preparation of environmental impact statements published by the Council on Environmental Quality (August 1, 1973) discusses secondary impacts as follows:

...Many major Federal actions, in particular those that involve the construction or licensing of infrastructure investments (e.g. highways, airports, sewer systems, water resource projects, etc.), stimulate or induce secondary effects in the form of associated investments and changed patterns of social and economic activities. Such secondary effects, through their impacts on existing community facilities and activities, through inducing new facilities and activities, or through changes in natural conditions, may often be even more substantial than the primary effects of the original

action itself. For example, the effects of the proposed action on population and growth may be among the more significant secondary effects. Such population and growth impacts should be estimated if expected to be significant...and an assessment made of the effect of any possible change in population patterns or growth upon the resources base, including land use, water, and public services, of the area in question.

(Federal Register, Vol. 38, No. 147 - Wednesday, August 1, 1973, p. 20553)

Two points should be made about the Council's discussion as it relates to the proposed project. The first concern is the specific mention of sewage systems as an infrastructure investment that can induce socioeconomic change. The second concern is the relative importance of secondary vs. primary impacts.

The proposed wastewater treatment system, with an estimated present worth price tag of \$37,000,000 is obviously a substantial public investment. Just as basic, public and private decisions affecting the future development of the project area will be significantly influenced by that investment. It is therefore not necessary to distinguish whether this wastewater treatment system is a cause of an effect of socio-economic change.

In the Kaneohe and Kailua service areas, however, it is far from clear that the project would directly cause growth and development. Sewage treatment has been available since 1962 in Kaneohe and 1965 in Kailua. Growth and development have been tremendous despite the fact that both treatment facility disposal schemes were seriously affecting the receiving waters. It would be difficult under these circumstances to hold that diversion of the effluent is a prerequisite to further growth. Therefore, we contend that the primary or direct impacts, particularly the elimination of the discharges into Kaneohe and Kailua Bays outweigh the secondary impacts in importance.

In the Kahaluu service area that situation is quite different. We will argue that sewage treatment will be a major influence on both the total magnitude of growth in the area and the future pattern of development. For this reason, the secondary impact of Kahaluu is extremely important; more so, we believe, than primary impact.

A critical review of the Oahu population projections made during the past decade was made during WQPO. The data and the methodology used in the several reports were studied and the following general conclusions were reached.

(1) Those projections which relied on local intercensal estimates of resident population and migration as a base for projections overstated the 1970 Oahu population and have unrealistically high projections for future years. This conclusion applies to almost all population projections made locally since 1965. These included projections made by the State DPED in 1966, 1967 and 1969 on the State General Plan Revision and population projection studies.

(2) Those projections which used national projections as a controlling total for local projections provided better short-term projections but should be modified to allow for special local circumstances. These projections were made by the U.S. Bureau of the Census in "Projection of the Population of Metropolitan Areas: 1975" and the report "Looking Ahead" by the National Planning Association.

The two recent population projections for Oahu which appear to be closest to the 1970 census estimates developed the local estimates as elements in a set of national projections. These two reports also illustrate the two general approaches to projecting population for small areas. The first

might be called the demographic approach; the second, the economic base approach.

The U.S. Census Bureau report, "Projections of the Population of Metropolitan Areas: 1975," cited previously, is an example of the demographic approach. The projections in this report depend on standard assumptions about fertility, mortality, and net migration. Births were projected by computing the births per 1,000 women aged 14 to 44 nationally and for each locality in the year 1960. The total number of births in the United States was then projected, using two different assumptions of fertility levels. One--Series B--assumes an increase in fertility over 1967-68 levels, and the other--Series D--assumes no changes in fertility levels. The number of births in each area was calculated by assuming that the difference between the local rate and the national rate would vanish by the year 2010. Deaths were projected for each area using projected national survival rates by age and sex. In- and out-migration was projected by assuming that out-migration, as a percent of total population for each area, would remain constant, and in-migration for each area as a percent of total migration would be constant.

According to this report, the total population in the Honolulu SMSA area in 1975 would range from 675,000 to 646,000. When the 1965-75 annual per cent change is carried out to 2020, projection for the Honolulu SMSA area would range from 1,445,000 to 1,126,000.

The merit of these projections is that since the projection for each area is tied to the national total and has built into it a drift toward the average rate of growth, no area will show an improbable or unrealistically high or low projection. It has the corresponding fault of ignoring some special circumstance in any one area that would affect the projection. For example, the assumption that the ratio of out-migration to total population in each area would remain constant, while fertility rates in each area would tend toward the national average, is a reasonable assumption for most areas, but for Hawaii the assumptions lead to an inconsistency. A large part of Oahu's high birth rate is due to a large military and military dependent population, which also accounts for an abnormally high out-migration rate--as the temporary residents who entered the State two by two leave three by three or four by four. As the birth rate drops



toward the national average, so should the out-migration rate as a percent of the population.

The Census Bureau disclaims any intent to regard these projections as actual predictions but states that they should be regarded as indications of the population distribution that would develop on the basis of the assumptions regarding fertility, mortality, and migration. No assumptions concerning the effect that different economic opportunities might have on inter-area migration were introduced into the projections.

The effect of differential economic opportunity is, however, built into the model of the National Planning Association, "Economic Projection." The population projections are explicitly based on the assumption that population change is primarily related to the change in economic opportunities in the area. That is, the state and metropolitan area population projections were developed by allocating projected national employment in "basic" industries among the states. The estimates of "basic" employment were then used to derive estimates of total employment. Labor participation rates were computed for each area and projected on the assumption that they approach the projected

national levels over time. These rates were then applied to the employment estimates to arrive at estimates of total populations for each area. The sum of the local estimates was, of course, forced into agreement with the national total. The U.S. population projection used was the U.S. Census "C" series--about halfway between the "B" and "D" series.

The economic base approach is fruitful in that economic trends enter the projection explicitly rather than implicitly in the resultant migration trends.

However, the method is open to error in several places unless care is taken to check the assumptions that enter into the calculations. For example, the labor participation rate is a crucial factor in moving from employment to population. Uncritical acceptance of the short-term local trend is dangerous, as is uncritical acceptance of the assumption that the rate will converge on the national rate. Here again, Hawaii's large military and military dependent population has a significant effect on the participation rates.

According to WQPO, the population that Oahu will have in the future will depend primarily upon the volume of employment in our basic industries, the

volume of nonbasic employment generated by basic employment, the labor force participation rates of the working-age population, and the ratio of working-age population to total resident population. To this was added an estimate of the number of temporary visitors present to arrive at the total de facto population.

Basic employment was defined as employment which is supported by demand external to the geographic location under consideration. External demands comes from people outside Oahu who purchase our commodities, from people or firms outside Oahu who purchase services, from tourists, and from the Federal government. Employment related to external demands were calculated and projected for the future. By using the ratio of total employment to basic employment of 2.23 to 1 in 1970 to 2.5 to 1 in 2020, a labor force participation rate about 1.15 persons in the age group 16 to 64 for every one person in the labor force, and a ratio between 1.55-1.60 total population to 1 population age 16-64, the total resident population of 612,721 in 1970 was doubled to 1,135, 147 in the year 2000.

Population projections necessarily involve a "numbers game." The game is often fruitless and misleading. Small differences in fundamental assumptions can yield spectacularly diverse figures when compounded over a

twenty-year period.

This is illustrated by projections of total resident population for all of Oahu made by the State Department of Planning and Economic Development on the one hand, and the Water Quality Program for Oahu on the other. Using "medium assumptions" the Department of Planning and Economic Development predicted a growth of approximately 213,000 on the island between 1971 and 1990 (The Central Oahu Planning Study-A Summary Report, October 1972, State Department of Planning and Economic Development, P. 9). The Water Quality Program for Oahu, over almost exactly the same period (1970-1990), forecasts a population increase of 330,000 with 74,500 in the project area alone. (WQPO as previously cited, Final Report, Table IV-3, p. IV-27). It should be noted that both sources hold military populations constant and neither figure includes tourism in its calculation. The projections are comparable except for their assumptions about growth rate.

If the Department of Planning and Economic Development is correct, the proposed project could be oversized. However, the Department of General Planning of the City and County of Honolulu predicts that the percentage of total population of Windward Oahu,

which encompasses the proposed project area, will increase from 14.6 percent in 1970 to 20.0 percent in 1995. This compares with Central Honolulu decreasing from 49.5 percent in 1970 to 37.8 percent in 1975. (Alternative Policies for Oahu: An example, July 2, 1973, Department of General Planning, City and County of Honolulu, Table 2). Therefore, while the figures are difficult to break down among the Districts of Oahu, it appears that the difference in population will occur in central Honolulu making the projected population of the project area reasonable. The proposed project generally follows the projections of the Water Quality Program for Oahu. In terms of de facto population (resident plus visitor growth) increase, this amounts to 387,000 island-wide and 74,500 in the combined project area. Divided by service area, this means 34,000 for Kailua, 33,000 for Kaneohe, and 7,500 for Kahaluu.

This 7,500 increase in Kahaluu will actually more than double the 1970 population of 7,000. An increase of this magnitude will surely have a big impact on the existing life styles and public facilities of the area. However, is this detrimental? The City's Department of General Planning predicts that the existing General Plan can meet the housing demand

only up to 1985 for a minimum population projection of 924,000 (compared with the Water Quality Programs 960,497). This considers all urban designated land including that in Kahaluu (General Plan Revision Program Study Paper for Workshop #2 - Meeting Housing Needs Within Our Present Urban Boundary, Undated, Department of General Planning, City and County of Honolulu, p. 26).

If Kahaluu is not permitted to be developed, a portion of the housing demand will not be met causing development to occur elsewhere. We honestly believe that this will not happen because of the attractiveness of Kahaluu. Therefore, development will occur whether or not public sewers are available. Private sewerage systems comprised of cesspools and small sewage treatment plants will prevail possibly jeopardizing public health, the ground water supply, and Kaneohe Bay.

There is a general awareness in the State that our natural environment is limited in scale and quantity, and to some extent fragile and unique. These sentiments were expressed in "A Plan For Hawaii's Environment", a report of the Temporary Commission on State-Wide Environmental Planning, dated November 6, 1973. The Temporary Commission made eleven recommendations.

Two of them are repeated here:

"Call for the development of criteria by which the carrying capacity of Hawaii environment can be determined. This would include data on population, pollution, natural resources, community environments, life styles, and the impact for new technology.

Create a mechanism for dealing with and preventing conditions of overload in areas of critical concern where the burden of proof would be on the proponent of growth to show that the action would be of overriding public interest."

An overload is a condition resulting from imbalance between man-made activities and the natural environment. To prevent the occurrence of overload, the carrying capacity of an area must be determined.

The critical areas where present trends toward overload are the Coastal Zone; all of Oahu, agricultural lands, tourist facilities, energy consumption, unique natural and historic sites and social welfare costs.

The 1974 State Legislature, after reviewing the report of the temporary Commission on Statewide Environmental Planning agrees with its findings. Several bills from both the State Senate and House of Representatives have been reported out of committees. To determine

such concept as "carrying capacity", "overload," and "areas of critical concern" for State decision-makers, the State Senate by Senate Concurrent Resolution No. 53, called upon the Hawaii Environmental Simulation Laboratory (HESL) to make a study and submit a report containing its findings and recommendations to the Eighth State Legislature. At this point in time, we cannot hazard what findings HESL will recommend for the Kaneohe-Kailua district.

The effects of the proposed sewerage system on the transportation system is very difficult to assess accurately. Windward Oahu is presently being served by two main transportation corridors, the Pali and the Likelike Highways. The proposed TH-3 Highway, the trans-Koolau arterial is presently mired in controversy. The City and County is advocating a mass transit system utilizing a fixed-rail transit between Hawaii Kai and Pearl City and an express bus system for Windward Oahu and other rural areas on Oahu. The City and County is against the construction of TH-3. On the other hand, the State Administration wishes to continue with the construction of TH-3, contending that both TH-3 and an express bus system are needed for Windward Oahu.



Statistics show that motor vehicles are doubling about every 12 years. There are about 360,000 motor vehicles on Oahu's crowded streets and highways today. We cannot possibly see how 700,000 automobiles can be accomodated by 1985. The transportation controversy between the State and City and County will have to be resolved by the major policy makers of the State and City governments. Insofar, as well can be seen, there will no substantial secondary effects on the transportation system serving Windward Oahu from the implementation of the proposed sewer system.

In conclusion, the proposed project will have negligible secondary impacts on the Kaneohe and Kailua service areas, but will have a substantial secondary effect on the Kahaluu service area. However, this effect is inevitable and the proposed project is only accelerating it.

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APPENDIX A - TRANSCRIPT OF PUBLIC  
HEARING ON KANEOHE-KAILUA SEWER  
SYSTEM

January 16, 1974

1  
2  
3  
4  
5  
6  
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8  
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13  
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16  
17  
18  
19  
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RECORD OF PROCEEDINGS OF A  
PUBLIC HEARING  
FOR THE  
KANEOTE-KAILUA SEWER SYSTEM

held at  
BEN PARKER SCHOOL CAFETORIUM  
KANEOTE, HAWAII

on  
JANUARY 16, 1974  
7:30 P.M.

by the  
CITY AND COUNTY OF HONOLULU  
BOARD OF WATER SUPPLY  
HONOLULU, HAWAII

and  
CHUNG DHO AHN AND ASSOCIATES  
CONSULTING ENGINEERS  
HONOLULU, HAWAII

I N D E X

	<u>SPEAKER</u>	<u>PAGE</u>
1		
2		
3	MR. GEORGE YUEN, Manager & Chief Engineer, Board of Water Supply	4
4		
5	MR. NORMAN WONG, Chief Engineer, Chung Dho & Associates	6
6		
7	MR. PAUL HENNESSEY, Vice President, James M. Montgomery, Inc.	15
8		
9	HON. HIRAM L. FONG, U. S. Senator, State of Hawaii	25
10		
11	MR. MERLE ARNOLD, JR., Soil Conservation Society of America	28
12		
13	MR. LEONARD C. MOFFITT, Kaneohe Bay Task Force	29
14		
15	DR. THOMAS A. BURCH, Hawaii Public Health Association and Malacological Society	31
16		
17	DR. JED HIROTA, Hawaiian Institute of Marine Biology	37
18		
19	MR. OLIN PENDLETON, Kaneohe Community Council	38
20		
21	MS. JULIA CRANE, Lani-Kailua Outdoor Circle	39
22		
23	MS. LOIS FLEMING, Kaneohe Outdoor Circle	42
24		
25	MS. SANDRA BRAUN, Concerned Citizens for Kailua Bay	51
26		
27	MR. BOB NAKATA, Kahaluu Coalition	58
28		
29	COL. RALPH SMALL, Aikahi Park Organization	64
30		
31	MR. DON A. BRENNER, Kailua Community Council	65

I N D E X

	<u>SPEAKER</u>	<u>PAGE</u>
1		
2		
3	MR. GEORGE YUEN, Manager & Chief Engineer, Board of Water Supply	4
4		
5	MR. NORMAN WONG, Chief Engineer, Chung Dho & Associates	6
6		
7	MR. PAUL HENNESSEY, Vice President, James M. Montgomery, Inc.	15
8		
9	HON. HIRAM L. FONG, U. S. Senator, State of Hawaii	25
10		
11	MR. MERLE ARNOLD, JR., Soil Conservation Society of America	26
12		
13	MR. LEONARD C. MOFFITT, Kaneohe Bay Task Force	29
14		
15	DR. THOMAS A. BURCH, Hawaii Public Health Association and Malacological Society	31
16		
17	DR. JED HIROTA, Hawaiian Institute of Marine Biology	32
18		
19	MR. OLIN PENDLETON, Kaneohe Community Council	38
20		
21	MS. JULIA CRANE, Lani-Kailua Outdoor Circle	39
22		
23	MS. LOIS FLEMING, Kaneohe Outdoor Circle	42
24		
25	MS. SANDRA BRAUN, Concerned Citizens for Kailua Bay	51
26		
27	MR. BOB NAKATA, Kahaluu Coalition	50
28		
29	COL. RALPH SMALL, Aikahi Park Organization	64
30		
31	MR. DON A. BRENNER, Kailua Community Council	65



INDEX, (con'd)

	<u>SPEAKER</u>	<u>PAGE</u>
1		
2		
3	MR. PHILIP HELFRICH,	
4	Kaneohe-Bay-In-Crisis	66
5	MS. BEATRICE L. BURCH,	
6	Concerned Citizen	68
7	MS. VALERIE HUMPHRIES,	
8	Windward Action Group	70
9	MR. BANNER,	
10	Marine Life	71
11	CDR. P. K. HARTMAN,	
12	Public Works Officer, Marine Corps Air Station,	
13	Kaneohe (Did not appear; submitted written	
14	testimony)	72
15	MR. ROBERT R. WAY,	
16	Chief Planning Officer, City & County of Honolulu	
17	(Did not appear; submitted written testimony)	73a
18		
19		
20		
21		
22		
23		
24		
25		

1 MR. YUEN: Good evening, everybody. My name is  
2 George Yuen, I'm the Manager and Chief Engineer of the  
3 Honolulu Board of Water Supply of Honolulu City and County,  
4 I will be presiding this evening at this hearing. I hope  
5 all of you are relaxed and comfortable and that the evening  
6 won't be too long for all of us.

7 Before proceeding with the hearing, I would like to  
8 recognize in the audience our good Senator, United States  
9 Senator Hiram Fong. (applause) I'm sure Senator Fong will  
10 have a few comments to make as we proceed along with our  
11 hearing. Are there any other elected officials in the  
12 audience that I have missed? I don't see anyone else. They  
13 probably will show up a little later.

14 I'm sure you all know the subject of tonight's  
15 hearing, the Kaneohe-Kailua sewer system. And the purposes  
16 of this hearing are one, to receive public testimony on the  
17 proposed waste water disposal system and alternatives. And  
18 two, to receive public testimony on the proposed construction  
19 of the ocean outfall through to the shoreline setback area.

20 Before we take public testimony, Mr. Norman Wong,  
21 Chief Engineer of our Engineering Consultant Chung Dho Ahn  
22 and Associates, will present a brief summary of the proposed  
23 sewer system and consideration of the alternatives.

24 After the presentation by Mr. Wong, testimony will  
25 be taken in the following order: One, from Elected Federal,

1 State and City officials in that order. Two, from  
2 representatives of Federal Government Agencies. Three, from  
3 representatives of State Government Agencies. Four, from  
4 representatives of City and County of Honolulu Agencies.  
5 Five, from representatives of private industry and community  
6 organizations. And six, from interested public citizens.

7 We have here a number of organizations and indivi-  
8 duals wishing to speak this evening. I must ask that  
9 individual testimony be limited to no more than 10 minutes.  
10 I think that is plenty of time to present your testimony.  
11 And if you have testimony lasting more than 10 minutes, we  
12 ask that you summarize your testimony. Also, persons with  
13 written testimony need not testify orally, as written  
14 testimony will be received, it will be studied, and placed  
15 upon record. So we would appreciate receiving written copies  
16 of all testimony presented this evening. We expect to end  
17 this hearing at a reasonable hour, and if it appears that  
18 we will be unable to conclude this hearing--say around 11:30  
19 or so tonight-- we will recess the hearing at about 11:00  
20 o'clock. But from all indications, I think we should be  
21 through well before that hour.

22 Further, since this is a public hearing, it is not  
23 intended that this be a question and answer period. What  
24 we are going to do is collect all the relevant facts and  
25 information, and in the interest of time, those presenting

1 testimony are asked not to repeat items and concerns men-  
2 tioned in previous testimony. Questions raised in your  
3 testimony will most certainly be considered, and addressed  
4 in our conclusions. However, as the hearing officer, I will  
5 reserve the right to question those presenting testimony if  
6 I find it necessary.

7 If you wish to speak, please fill out the white  
8 cards which are passed out when you enter the cafetorium.  
9 Further, anyone wishing to speak or give testimony must use  
10 the microphone since this hearing is being recorded, and we  
11 have several microphones here. If you wish to go up to the  
12 podium and use it, you may do so.

13 At this time, I would like to introduce other City  
14 and County officials present at this meeting. On my imme-  
15 diate left is Mr. Francis Aona, Chief of the Division of  
16 Sewers. And on my right is Mr. Chew Lun Lau, Staff Environ-  
17 mental Engineer of the Department of Public Works.

18 I will now ask Mr. Norman Wong, Chief Engineer of  
19 Chung Dho Ahn and Associates to present a brief summary of  
20 plans for the Kaneohe-Kailua Sewer System. Mr. Wong.

21 MR. WONG: Thank you, Mr. Yuen. Good evening,  
22 ladies and gentlemen, Honorable Hiram Fong. We are pleased  
23 to have this opportunity to acquaint you with the planning  
24 for our Kaneohe and Kailua Wastewater system. In order to  
25 more effectively convey the information that we have, a

1 general information handout, which contains much of the in-  
2 formation and items that we will be discussing, was prepared  
3 jointly by the City and County of Honolulu and Chung Dho Ahn  
4 and Associates. Our presentation will be aided, also, by a  
5 series of slides which will be projected on the screen before  
6 you. Before continuing, I would like to define a few words  
7 which we'll be using this evening in order that you can have  
8 a clear understanding of what we are saying. The word "waste-  
9 water" means the spent water of the community. The word  
10 "effluent" means wastewater or other liquids partially or  
11 nearly completely treated, or in its natural state flowing  
12 out of a treatment plant. May we have the light off, please?

13 The development and rapid growth of our islands  
14 during the past decade has created many wastewater disposal  
15 problems. The Windward side of Oahu has not been spared  
16 from this same growth and wastewater disposal problem. The  
17 City and County of Honolulu recognized these problems and  
18 engaged an engineering consortium to develop a comprehensive  
19 water quality program for Oahu with special emphasis on waste  
20 disposal. The consortium studies divided the Island of Oahu  
21 into 7 sewage districts. The Kaneohe-Kailua District is one  
22 of the districts and is shown on this slide. (indicating)

23 The Kaneohe-Kailua wastewater system serves the sub-  
24 districts of Waikane, Waiahole, Kahaluu, Heeia, Kaneohe and  
25 Kailua. The present population in this district is about  
96,000 and it's expected to reach 342,000 in the year 2020.

1 The Kaneohe-Kailua wastewater system encompasses an area of  
 2 approximately 33 square miles or 21,000 acres. The system  
 3 has been designed to provide for wastewater handling capa-  
 4 bility up until the year 2020 or for a period of slightly  
 5 less than 50 years.

6 Sanitary sewers are relatively new in the Kaneohe-  
 7 Kailua system with all sewers constructed within the last  
 8 15 years. This map shows the area which is presently  
 9 sewerred. The Waikane to Kahaluu subdistricts presently use  
 10 cesspools for waste disposal with the exception of the Ahui-  
 11 manu Development which has a tertiary treatment plant. The  
 12 effluent from this plant is discharged into Kaneohe Bay.

13 Upon construction of the proposed Kahaluu Wastewater  
 14 Treatment Plant, flows will be diverted away from the  
 15 Ahuimanu Plant and this plant will be abandoned. Wastewater  
 16 from the Kaneohe District is treated at a trickling filter  
 17 treatment plant situated near the mouth of Kaneohe and Kawa  
 18 streams which is behind the Kaneohe Bay new golf course.  
 19 The effluent from this treatment plant is discharged into  
 20 Kaneohe Bay through a 48" outfall extending approximately  
 21 2,300 feet into the bay to a depth of 26 feet. Wastewater  
 22 is conveyed to the treatment plant by the Kaneohe Bay South  
 23 Interceptor Sewers, the Kaneohe Stream Interceptor Sewer,  
 24 and the Kaneohe Bay East Interceptor Sewer.

25 Facilities at Kaneohe Marine Corps Air Station

1 have recently been updated for a secondary treatment plant  
 2 and the effluent is discharged into Kaneohe Bay through a  
 3 20" outfall approximately 500 feet long into water 15 feet  
 4 deep. Part of the effluent is planned to irrigate the  
 5 Marine Golf Course.

6 The Kailua District contains five treatment plants.  
 7 Four of these plants serve the subdivisions for which they  
 8 were built and are temporary facilities discharging into  
 9 adjacent streams. These streams empty into Kawainui swamp  
 10 which empties into Kailua Bay.

11 The most important plant is the Trickling Filter  
 12 Plant located off Kaneohe Bay Driveway opposite the Aikahi  
 13 development. The effluent from this treatment plant is  
 14 discharged through a 42" outfall into Kailua Bay near Kapoho  
 15 Point 500 feet from the shore into water 13 feet deep. The  
 16 point from which this outfall leaves the shoreline is shown  
 17 on this slide.

18 Because of the tremendous recreational value and  
 19 beauty of both Kaneohe Bay and Kailua Bay, it was seen and  
 20 recommended that the present method of disposal for the  
 21 Kaneohe-Kailua District be changed. The goals for the  
 22 Kaneohe-Kailua Sewer System are one, to abate all sources of  
 23 unsanitary wastewater discharge into Kaneohe Bay which has  
 24 3 treatment plants discharging into it, and two, prevent  
 25 possible degradation of Kailua Bay which has a treatment

1 plant discharging through an outfall and several others  
2 through streams that eventually discharge into Kailua Bay.

3 To accomplish these goals, the Engineering Consor-  
4 tium recommended concepts involve pumping all effluent from  
5 the Treatment Plants to the tip of Mokapu Peninsula for final  
6 disposal into the deep ocean through an outfall. This would  
7 require the following improvements as recommended in the  
8 Consortium's report:

9 One, a wastewater treatment plant and pump station at  
10 Kahaluu;

11 Two, a force main to transport the wastewater from the  
12 proposed Kahaluu wastewater treatment plant to Kaneohe  
13 wastewater treatment plant;

14 Three, a pump station for the Kaneohe wastewater treat-  
15 ment plant;

16 Four, a force main to transport the combined effluent  
17 from the Kaneohe and Kahaluu plants to the Kailua wastewater  
18 treatment plant;

19 Five, a pump station and force main to pump effluent  
20 from the Kaneohe Marine Corps Air Station to the Kailua  
21 wastewater treatment plant;

22 Six, a pump station at the Kailua wastewater treatment  
23 plant;

24 Seven, a force main to transport the combined effluent  
25 from the Kailua, Kaneohe, MCAS, and Kailua plants to the



1 outfall near the tip of the Mokapu Peninsula; and

2 Eight, an ocean outfall.

3 To implement the wastewater management plan for the  
4 Kaneohe-Kailua wastewater system, the City and County of  
5 Honolulu engaged the engineering firm of Chung Dho Ahn &  
6 Associates to prepare an engineering report to design  
7 the first stage facilities.

8 In addition to the guidelines and engineering  
9 report, the design of each of project was based on the recom-  
10 mendations from County, of various Governmental Agencies and  
11 citizens. The latter by means of a public information meet-  
12 ing held at Ben Parker Cafetorium on April 5th, 1972.

13 The final site for the Kahaluu wastewater treatment  
14 plant and pump station has not been selected to date. This  
15 facility would treat the wastewater from Waikane, Waiahole  
16 and Kahaluu subdistricts.

17 The Navy has finalized construction plans for a  
18 pump station and force main to pump effluent from the Kaneohe  
19 Marine Corps Air Station to the Kailua wastewater treatment  
20 plant. The Kahaluu effluent force main would transport  
21 treated effluent from the proposed Kahaluu wastewater  
22 treatment plant to the Kaneohe wastewater treatment plant.  
23 The recommended route for the effluent force main will be  
24 along Kahekili Highway, Keaahala, Anoi Road, Paleka Road,  
25 crossing Kam Highway, along Waikalua Road, crossing Kaneohe

1 Stream and finally to the Kaneohe wastewater treatment plant.

2           During construction, inconveniences are anticipated  
3 to the adjoining neighborhood along portions of Keaahala  
4 Road, Anoi Road, Paleka Road, and Waikalua Road. Every possible  
5 means within reason will be used to minimize the  
6 inconvenience during construction.

7           Views along the Kahaluu effluent force main  
8 alignment are shown on the following slides. This is a  
9 view along Kahakili Highway looking toward Likelike Highway.  
10 This is a view along Paleka Road looking toward the ocean.  
11 This is a view of Paleka Road looking across Kam Highway.  
12 This is a view at the intersection of Waikapoki Road and  
13 Waikalua Road next to the cemetery looking down Waikalua Road.  
14 This is a view from Waikalua Road where the force main will  
15 cross Kaneohe Stream and enter Kaneohe wastewater treatment  
16 plant.

17           The Kaneohe Effluent Pump Station will pump the  
18 combined flows of Kahaluu and Kaneohe to the Kailua wastewater  
19 treatment plant. The pump station is designed for an  
20 initial flow of 4 million gallons a day average dry weather  
21 flow, and an ultimate flow of 18.8 million gallons per day.  
22 The site is located within the Kaneohe wastewater treatment  
23 plant as shown on this slide. A rendering of the building  
24 is shown on this slide. The Kaneohe effluent force main will  
25 transport treated effluent from the Kaneohe wastewater plant

1 to the Kailua wastewater treatment plant. The principal  
2 route for this effluent force main will be along Kaneohe Bay  
3 Drive.

4 Inconveniences to the adjoining neighborhood are  
5 anticipated again during construction along Kaneohe Bay  
6 Drive, particularly along the narrow roadway at certain  
7 places. However, every possible means within reason will be  
8 used to minimize the inconveniences associated with construc-  
9 tion.

10 An alignment across Kaneohe Bay was given serious  
11 consideration; however, construction activities would be  
12 disruptive to the ecology of Kaneohe Bay which is already  
13 under severe ecological stress. Based on comments received  
14 from the public meeting held on April 5, 1972 and other  
15 considerations, the Kaneohe Bay Drive alignment was selected.  
16 Views along the Kaneohe-Kailua Effluent Force Main alignment  
17 are shown in the following slides. This is a view along  
18 Kaneohe Bay Drive near the Mokapu Saddle Road intersection.  
19 This is a view along Kaneohe Bay Drive between Kuono Place  
20 and Malukai Place. This is a view from Aumoana Place. This  
21 is a view along Kaneohe Bay Drive at the intersection of the  
22 H-3 overpass. And this is a view from Kaneohe Bay Drive where  
23 the effluent force main enters the Kailua wastewater treat-  
24 ment plant.

25 The Kailua Effluent Pump Station will pump the flow

1 of the entire district including those of the Marine Corps  
2 base to the outfall. The pump station is designed for an  
3 initial flow of 11 million gallons per day average dry  
4 weather flow and an ultimate flow of 41.2 million gallons  
5 per day. The site is located within the Kailua wastewater  
6 treatment plant as shown on this slide. The pump station  
7 structure was given much consideration because it will be  
8 easily seen from Kaneohe Bay Drive. This slide shows a  
9 rendering of the building. Mechanical pipes and pumps will  
10 be faced away from the Kaneohe Bay side vantage point. The  
11 area around the pump station will be landscaped. Noise  
12 problems were considered in the design of the pump station.

13 The Kailua effluent force main will transport the  
14 effluent of the Kaneohe-Kailua wastewater district to Mokapu  
15 Point for ocean disposal. The alignment is entirely within  
16 the Kaneohe Marine Corps Air Station as shown on this slide.

17 Here at Mokapu Point ends the land portion of the  
18 Kaneohe-Kailua Wastewater System, and again you have some  
19 views along the Kailua effluent force main alignment as shown  
20 on the following slides. This is a view of the shoreline  
21 looking toward Mokapu Point. This is a view of the shoreline  
22 from Mokapu Point looking backwards toward the Kailua waste-  
23 water treatment plant.

24 Ladies and gentlemen, Mr. Yuen, this concludes my  
25 portion of the presentation. Thank you.

1 MR. YUEN: Thank you, Mr. Wong. Before continuing  
2 with our hearing, I understand Representative John Medeiros  
3 has just arrived. Is John here? (applause)

4 Mr. Wong has presented a description of the Kaneohe-  
5 Kailua Sewer System. We have a second major segment com-  
6 prising the entire project and that is the Mokapu ocean  
7 outfall. I would like to, at this time, introduce the second  
8 speaker, Mr. Paul Hennessy, senior Vice-President of James  
9 M. Montgomery, Incorporated, of Pasadena, California, who is  
10 serving as a special consultant to Chung Dho Ahn & Associates,  
11 and he will confine his presentation to the Mokapu ocean  
12 outfall. Mr. Hennessy.

13 MR. HENNESSY: Thank you, George. Ladies and  
14 gentlemen, Senator, most of the material that I'm going to  
15 cover and that I'm going to talk about is covered in the  
16 handout which is available, which in turn was essentially  
17 extracted from the environmental impact statement. Before  
18 I start, I would like to introduce Doctor Karl Bathen of the  
19 University of Hawaii who was director of the studies that  
20 much of our design is based on. There was a one year study  
21 of the circulation of water flow in Kailua Bay itself. Would  
22 you stand up?

23 I would also like to say that this outfall design  
24 was preceded by as much comprehensive information on the  
25 receiving waters as any that I know of that's ever been done.

1 Certainly it's a credit to the City engineering staff and  
2 the people of the City and County of Honolulu's thoroughness  
3 that they were willing to finance studies of the receiving  
4 water to be sure that we, the plumbers that design the pipes  
5 out there, knew what we were getting into.

6 Here is a picture of the site. We were assisted  
7 in the study by Doctor Ed Noda, my neighbor in Pasadena, and  
8 he also is a native of Kailua here. He is an oceanographer  
9 who works for a neighboring company of ours and he came out  
10 here and took some of the pictures we'll be showing.

11 The Mokapu Ocean Outfall will effectively be dis-  
12 posing of the secondary treated effluent for the entire  
13 Kaneohe-Kailua district. This disposal will be by dilution  
14 and dispersion in the waters of the ocean, with ultimate  
15 transport from the area. The location of the outfall is off  
16 of Mokapu Point, and I'm just going to give a slide tour  
17 of the area here.

18 May we have the lights off?

19 The outfall enters the ocean here (indicating).  
20 There's been some misconceptions as to where the outfall is  
21 in the last meeting. This is the Flyers Monoment that you  
22 see underneath, it's a well known landmark, and the outfall  
23 enters the ocean immediately adjacent to the Flyers Monument.  
24 This is the area which will be utilized for a construction  
25 site and staging area during the construction of the outfall.

1 This slide has been put in here so that people will know  
2 that this is a pristine area. It's been utilized for landfill,  
3 adjacent target ranges, and had extensive grading and natural  
4 topography that have been changed extensively over a 20 year  
5 or more period.

6 The contract calls for this area--this is another  
7 view of it--to be regraded, contoured and planted. Now, when  
8 the construction is finished, this will be an improvement.

9 This slide makes a good plate and not a very good  
10 slide. It's in the report. There are the population contri-  
11 butions--flow contributions by the population subdistricts  
12 and the area for 1973, 1983, 1993, and 2020, the green being  
13 Kailua. The orange being Kaneohe. The yellow being Kahaluu,  
14 and the green being a constant figure throughout the Kaneohe  
15 Marine Corps Air Station. This shows the people over the  
16 years of the various sub-districts seen on this slide. It  
17 appears in the plate in the handout.

18 We had the last time so much confusion where the  
19 outfall is, the outfall is clear up here at that point  
20 (indicating). There was some consideration that the original  
21 outfall would be at this location, and there was confusion  
22 that we are going to extend or construct two outfalls there.  
23 The outfall is up on the point. Here it is, the Flyers  
24 Monument. I'm just going to quickly go through the rest  
25 of these. This is the exact point where the outfall goes

1 to sea, right out that way (indicating). Originally, when  
2 the picture was taken, the plan was to go down further, but  
3 it's now been changed and it goes down here (indicating),  
4 its swung farther to the north. These are some construction  
5 pictures. The outfall is a little over 5,000 feet long and  
6 goes to a 105 feet of water depth, and I'll discuss these  
7 a little bit in depth, I just want to go through them. The  
8 diffuser section on the end of this is 960 feet long and  
9 consists of ports of varying size for uniform dispersal  
10 of effluent. I'm going to leave this on and talk about that  
11 later. This has to do with the worst conditions we'll dis-  
12 cuss later.

13 This is a tour of the ocean bottom. 30 foot depth,  
14 45 foot depth, 50 foot depth, 65 foot depth. The bottom is  
15 surprisingly uniform, consisting of dead coral and farther  
16 out, sand pockets, and this is discussed in detail in the  
17 handout and the environmental impact statement. This is the  
18 subject of observation and some fact-finding studies which  
19 are going on now which are being conducted by people from the  
20 University of Hawaii, and they are also under contract to  
21 the City and County of Honolulu, so we'll have something to  
22 measure the net long-term effect of the discharge at this  
23 location against. This is the last picture at the end of  
24 the outfall, not quite, that's about an 80 foot depth. The  
25 outfall actually reaches a 105 foot depth. More in this



1 area (indicating). I think that's all the slides for now.

2 As I said, the Mokapu Outfall has a hydraulic  
3 capacity for the flows anticipated in the year 2020, and the  
4 construction is such that the design life will exceed 50  
5 years. There are some compelling reasons for not making it  
6 smaller, mainly that there are not appreciable savings in  
7 reducing the diameter of the outfall.

8 The Mokapu Outfall will extend approximately one  
9 mile to a water depth of 105 feet. The pipe will be buried  
10 where the effect of wave action is maximum and protected by  
11 armor rock tremie concrete. The outfall terminates in a  
12 diffuser section 960 feet in length, and this diffuser  
13 section is designed to provide an initial mixing of not less  
14 than 100 to 1 under the most adverse conditions, which is  
15 peak wet weather flow at the year 2020.

16 The initial mixing or dilution is created by  
17 controlling the velocity through discharge jets spaced along  
18 the last 960 feet of the pipe, and by the natural effect of  
19 buoyant mixing of the lighter fresh water and the more dense  
20 salt water.

21 The present outfalls into Kaneohe Bay and Kailua Bay  
22 discharges its effluent into shallow water at a 12 foot depth  
23 and 15 foot depth, and the diffusion does not obtain any  
24 appreciable initial dilution. During the final design and  
25 in prior studies, careful attention was paid to the exact

1 location of the outfall. The purpose of studies was to  
 2 select locations with net mass transfer of water away from  
 3 the shore. The consortium and consultants that conceived  
 4 the Kaneohe-Kailua system in the original report entitled  
 5 "Water Quality Program for Oahu" with special emphasis on  
 6 waste disposal, recommended the general area northeast of  
 7 Kailua Bay toward Mokapu Point, and in 1970-71 a one year  
 8 oceanographic study that I have described to you previously  
 9 was conducted by Doctor Karl Bathen of the University of  
 10 Hawaii. This study is entitled "Descriptive Study of Cir-  
 11 culation and Water Quality of Kailua Bay, Hawaii". These  
 12 are on display over there as exhibits and they are available  
 13 at City Hall and other places, if some of you wish to review  
 14 them. This study provided background on nutrient levels,  
 15 density and other physical parameters and established  
 16 circulation patterns under various seasonal and metrological  
 17 regimen. Currents, depths, and on the surface were monitored  
 18 at several critical stations in the area proposed for outfall  
 19 discharge. During the study a current recording meter was  
 20 anchored at the proposed outfall location. In addition, drip  
 21 cards, dyes, and drogues were released at various times at  
 22 the proposed outfall, and other critical points, to determine  
 23 circulation patterns. The study essentially shows that de-  
 24 spite the predominant tradewinds that blow from the ocean to  
 25 the shore at Kailua Bay, the circulation patterns in the bay

1 essentially moves water out of the bay in a northerly  
2 direction when the tides are rising, and southeasterly when  
3 tides are falling. There are abstracts of this study in the  
4 environmental impact statement, and I'm sure there are many  
5 people in this area who are interested enough in the ocean  
6 area that are well versed in this.

7           Because of density differential between fresh water  
8 and ocean, the diluted sewage will mix and rise to the surface,  
9 and an initial dilution of a 100 to 1 or more, will create a  
10 mixture undetectable on the surface by visual observation.

11 The plan selected, which is secondary treatment ocean disposal  
12 for Kaneohe-Kailua, is one of several alternatives that were  
13 studies and mentioned in the initial "Water Quality Study for  
14 Oahu". The rejected alternatives were all found not to be  
15 as reliable or as economically feasible as the one selected.

16 I know there's a lot of interest in other alternatives, so  
17 just abstracted from the impact statement is a brief descrip-  
18 tion of some of the available alternatives that were consider-  
19 ed. First was water reclamation and re-use. Re-use of water  
20 for irrigation is proposed for areas on the Leeward side of  
21 Oahu, principally for sugarcane irrigation. Sugarcane con-  
22 sumes an average of about 10,000 gallons per acre per day or  
23 a 100 acres for every one million gallons a day of sewage.

24 This would require 1,100 acres at the present time, and 4,200  
25 acres for the project projected year 2020 flow. In the

1 Kaneohe-Kailua area, water is plentiful. Areas for proposed  
2 irrigation or at higher elevation requiring pumping, in  
3 periods of continual rainfall will require an alternative  
4 system of disposal when irrigation is impossible or undesir-  
5 able. In addition, the quality of the water, the mineral  
6 quality of the water, is marginal for irrigation because of  
7 infiltration of saline ground water. So because of all the  
8 foregoing, re-use for irrigation was not considered to be  
9 feasible.

10 Direct re-use. We hear these days much of direct  
11 re-use, and I serve on a national committee for wastewater  
12 re-use which just published a policy statement on that.  
13 Except at one location in South Africa, which was used and  
14 now discontinued, and in Chanute, Kansas, for a period of  
15 about 42 days, direct wastewater re-use or direct re-use of  
16 treated wastewater under a controlled environment has not  
17 been tried. Much work on the health effects of wastewater is  
18 needed before direct re-use is possible or recommended by the  
19 medical profession. This will first occur in water short  
20 areas where dilution and blending with available waters is  
21 being practiced, and where the long time storage before re-use  
22 in large lakes or an underground aqueduct is possible, and  
23 such storage is not possible or available on Windward Oahu.

24 One of the other things we hear a lot about and it  
25 was mentioned, is the control of wastewater quantity. Its

1 logical that the problem of Kaneohe Bay is created by runoff  
2 of wastewater and one way to ameliorate the problem is to  
3 control or limit or reduce wastewater. Two approaches were  
4 investigated. First was to minimize flood and ground water  
5 from entering sanitary sewer systems. A program is being  
6 undertaken to accomplish this. The flow forecast used in the  
7 design anticipates reasonable success for this program and  
8 high standards for future construction. However, even if all  
9 infiltration and storm waters were excluded from collection  
10 systems, these waters which would reach Kaneohe Bay being  
11 natural and man-made water courses, the net effect on the Bay  
12 eco. system was virtually identical.

13           The second approach to controlling wastewater  
14 quality is to limit the population to specified areas. I  
15 guess I should say to restrict population moving to specific  
16 areas. At any rate, the control of population in a given  
17 area is a complex Governmental and social problem. For a given  
18 growth rate for Oahu, which has been forecast, land planning  
19 indicates a given population increase in the Kaneohe-Kailua  
20 area, and this population increase is at a greater rate than  
21 the growth rate for Oahu. The population forecast was a  
22 carefully considered part of the water quality program for  
23 Oahu, and the outfall is part of a phased construction pro-  
24 gram to keep pace with the projected population growth.

25           Very small savings are realized in reducing the

1 capacity of the outfall by any substantial percentage. The  
2 sizes are then fixed on population forecasts and growth of  
3 the island as a whole. Ground water injection for effluent  
4 disposal was considered as an alternative to an ocean outfall.  
5 The tentative site for injection would be in the Coconut  
6 Grove district, and here wastewater could be pumped into  
7 saline ground water, and ultimately reach the ocean floor  
8 through strata at the bottom of the ocean. The economics  
9 of this method of disposal are complex. A higher degree of  
10 treatment is required, and provision must be made for storage  
11 and recirculation through the plant of all effluent in the  
12 event of a power outage or other treatment plant malfunction,  
13 and also required would be more land area at the existing  
14 treatment plant and in the disposal area. Economic studies  
15 indicate that well injection for the quantities to be gener-  
16 ated in Kaneohe-Kailua would be more expensive than ocean  
17 disposal, and they would offer no particular advantages.

18 In summary, the proposed project was designed after  
19 a one year detailed study of the receiving waters and will  
20 provide disposal of secondary effluent in the deep ocean at  
21 an area where prevailing currents will keep the effluent  
22 offshore. Dilution, dispersion and bacterial die off rate  
23 in the receiving waters are such that bathing water standards  
24 can be met under the most unfavorable forecast conditions.  
25 The size of outfall was selected that will provide for the

1 year 2020 population. Very little savings would be realized  
2 in constructing a smaller design. Other facilities in the  
3 project would be constructed in phases as the growth increas-  
4 es. Thank you.

5 MR. YUEN: Thank you very much, Paul. I understand  
6 Representative Andrew Poepeo arrived a few minutes ago. Andy,  
7 would you please stand up and be recognized. Thank you.

8 (applause) Thank you for coming, Andy. Is there any other  
9 elected official here that I've neglected to recognize?  
10 Anyone else? Okay. I guess the box score is 3 Republicans  
11 and no Democrats. (audience laughter)

12 We will now proceed with the hearing and we'd like  
13 to hear testimony from the public and various agencies,  
14 but before calling on individuals who have signed up, you  
15 know being a United States Senator carries certain privileges,  
16 and I'd like to call on Senator Hiram Fong to comment, if he  
17 wishes. Hiram, I don't know whether that's a privilege or  
18 not, but I can't think of anyone I'd rather have than you to  
19 kick off the testimony.

20 SENATOR FONG: Thank you, George. I came here  
21 primarily to listen in detail and see for myself what I said  
22 I would back when Dick Martin came to Washington and told me  
23 that the State was going ahead with the sewage system in  
24 the island, and the the State would award the money, and that  
25 they will call upon the Federal Government to reimburse them

1 afterwards. I have said that I would help in any way  
2 possible. And the second reason I'm here is because I'm a  
3 part-time resident of the what shall I call "cesspool leak  
4 Kahaluu area." I want to say that I'm very happy that the  
5 building of the Mokapu Sewer System has now reached the  
6 hearing stage and that the State Government is going ahead to  
7 finance it until the Federal Government sees fit to pay its  
8 share.

9 As a member of the Appropriations Committee, and as  
10 the ranking minority member on a Sub-Committee on Agriculture,  
11 Environmental Protection and Consumer Protection in which  
12 the money will have to come first, I want to say that I will  
13 do everything possible to see that the Federal share will be  
14 given to the City and County, and the State of Hawaii.

15 I want to say that in 1970 I introduced a bill to  
16 have a comprehensive study of the problems of Kaneohe Bay,  
17 and I was able to secure \$25,000 initially for a preliminary  
18 study of the problem. I talked to the engineers just a few  
19 days ago, and they tell me that they are now ready to take  
20 on the big survey which will cost approximately 1.9 million  
21 dollars, and that it may be funded in three ways.

22 First, through the Rivers and Harbor Act; second,  
23 through the Urban Studies Act; and third, through the Water  
24 Resource Survey Act. So I think there will be money forth-  
25 coming to have a very comprehensive study of the problems of



1 Kaneohe Bay relative to pollution, relative to navigation,  
2 siltation, recreation and for other purposes.

3 I want to say, also, that we are working on the  
4 Kailua-Lanikai flood control project, and the engineers told  
5 me that when that gets completed, you will be enjoying  
6 fishing, swimming and other recreation activities in that area.

7 So I want to say that I'm very happy to be here to  
8 listen to the details of what has been presented, as it has  
9 been presented to you, and that I will work very hard to see  
10 that the State will be reimbursed for the Federal share of  
11 the sewer project. Thank you very much. (applause)

12 MR. YUEN: Thank you very much, Hiram, for your  
13 very, very encouraging remarks. As all of you know, Hiram  
14 has been a tremendous force behind the community as well as  
15 the entire State of Hawaii, and has done so much in the way  
16 of helping us realize certain appropriations from the Federal  
17 Government, and we look forward to continued assistance  
18 from Hiram. We are indebted to you, Hiram, for your help.  
19 Thank you.

20 I would like to digress a little bit from the order  
21 of presentation that I mentioned a little while ago this  
22 evening. We have a request from Mr. Merle Arnold, Junior.  
23 Mr. Arnold has another meeting to attend shortly and would  
24 like to make his presentation at this time. Mr. Arnold is  
25 representing the Soil Conservation Society of America. Mr.

1 Arnold.

2 MR. ARNOLD: Thank you, Mr. Yuen. Ladies and  
3 gentlemen: As was mentioned, my name is Merle Arnold and  
4 I'm President of the Soil Conservation Society of America,  
5 Hawaii Chapter, and I'm speaking on behalf of the Chapter.

6 The Soil Conservation Society of America is a non-  
7 profit scientific and educational organization dedicated to  
8 advancing the wise use of land resources. The Hawaii Chapter  
9 is made up of 50 people, primarily professionals working in  
10 resource conservation and management.

11 The Chapter generally favors the improvements pro-  
12 posed for the Kaneohe-Kailua Sewer System. It is our belief  
13 that the proposal would substantially contribute to the much-  
14 needed recovery of Kaneohe Bay from the effects of pollution.

15 However, the Chapter feels additional public assur-  
16 ance should be provided regarding the technology to be used  
17 for the proposed Kahaluu Wastewater Treatment Plant.

18 And I might say here I think a good deal of that  
19 has already been presented here this evening. It looks  
20 pretty good from back in the audience. But according to the  
21 project's environmental impact statement, I'd like to read,  
22 and you'll probably hear more in these proceedings, "the  
23 location of a wastewater treatment plant surrounded by a park  
24 is not new in concept. The 50-acre Sand Island plant is  
25 located adjacent to the State Park. Treatment plants can

1 be compatible with park usage if the plant facilities are  
 2 designed for odor and other controls. Technology is now  
 3 available for odor and pollutant free systems and the Kaha-  
 4 luu plant will be designed accordingly. In addition, the  
 5 plant site will be adequately landscaped." That's the end  
 6 of a quote from the environmental impact statement.

7 It is true that many Mainland treatment plants  
 8 successfully operate adjacent to park locations and even  
 9 within park sites. On the other hand, less careful efforts  
 10 have severely affected adjacent lands for parks and other  
 11 recreational and residential uses.

12 The Soil Conservation Society of America, Hawaii  
 13 Chapter, feels that the Kahaluu Wastewater Treatment Plant  
 14 can be compatible with the recreation uses of the proposed  
 15 park if:

- 16 1. The plant is designed and maintained to be odor-  
 17 and otherwise pollutant-free, and,
- 18 2. All construction is properly designed and landscaped  
 19 to insure it does not become visually objectionable.

20 We have appreciated the opportunity to participate  
 21 in this hearing. I thank you.

22 MR. YUEN: Thank you, Mr. Arnold. Our next speaker  
 23 is Mr. L. C. Moffitt, representing the Kaneohe Bay Task  
 24 Force. Mr. Moffitt.

25 MR. MOFFITT: I'm Leonard Moffitt, normally most of

1 the people know me as the executive director of the  
2 Windward Regional Council, but since Doctor Marlin could  
3 not be here tonight, I was drafted from our executive com-  
4 mittee. We held a meeting today and drafted a statement  
5 which we'd like to present to you.

6 After consulting with knowledgeable scientists and  
7 engineers, the Kaneohe Bay Task Force is persuaded of the  
8 benefit of this system to the waters of Kaneohe Bay, and is  
9 reasonable assured that it will not cause degradation in  
10 other areas. The Executive Committee of the Task Force,  
11 therefore, endorses the plan to construct this outfall and  
12 urges the City and County to move ahead quickly with this  
13 project.

14 Constructing this system does not preclude alterna-  
15 tive uses of wastes in the future. The Task Force urges  
16 that research be continued and intensified, if possible, on  
17 both environmental effects and alternatives to ocean disposal.  
18 Whatever use might some day prove desirable would still re-  
19 quire this presently planned disposal system as a back-up  
20 system. Thank you.

21 MR. YUEN: Thank you, Mr. Moffitt. Our next speaker  
22 is Doctor Thomas A. Burch. He's representing the Hawaii  
23 Public Health Association and also the University of Hawaii  
24 School of Public Health. I understand Doctor Burch is also  
25 a member of the Hawaii Malacological Society. How many of

1 you know what that means? (A number of hands were shown  
2 from the audience)

3 Well, this is an intelligent group here. Doctor  
4 Burch.

5 DR. BURCH: The Malacological Society is a group  
6 of people who study shells--sea shells, and one of the problems  
7 that we have in Kaneohe Bay is that they have been disappear-  
8 ing. So that they aren't there anymore, or very few of  
9 them, and this has been of concern to the Malacological  
10 Society and they, having reviewed the impact statement, feel  
11 that the proposed Kaneohe-Kailua System would help to bring  
12 Kaneohe Bay back to--or at least tend to bring it back to  
13 the way it was--so that hopefully we would again have mollusks,  
14 shells and other animals of the type that do not thrive on  
15 pollution.

16 Actually, I'm here as a member of the Board of Dir-  
17 ectors of the Hawaii Public Health Association and as a  
18 Clinical Professor of the University of Hawaii School of Public  
19 Health. The Public Health Association submitted a written  
20 statement, and in keeping with your instructions, I will not  
21 read that, but to briefly summarize it, I think one of the  
22 significant things in this is that the Department of Health  
23 has a health surveillance program which is based upon a random  
24 sampling of the households--in fact now in the entire State--  
25 but in 1964 to '67 limited to Oahu. This is based upon the

1 national health survey which is conducted on interviews,  
 2 and in this survey which was conducted, '64 to '67, and then  
 3 starting again in '69 to '71 and has been continuing the  
 4 data for the years around 1965 to 1970 have showed that the  
 5 types of infection and conditions which have been reported  
 6 to be associated with swimming and other exposures to polluted  
 7 waters has increased in the entire Island of Oahu. This is  
 8 an indication that one of the cornerstones of Public Health,  
 9 which is mainly sewage treatment, is something that we can-  
 10 not become complacent with. We must keep striving to improve  
 11 it, and we members of the Public Health Association have  
 12 reviewed the impact statement and believe that this should  
 13 definitely cause an improvement, at least in this area and  
 14 support it. Mr. Jerrold Michael, who is the Dean of the  
 15 School of Public Health at the University of Hawaii, asked  
 16 me to also say that he and other members of his staff have  
 17 also checked into this and that they are in complete agree-  
 18 ment with the recommendations of the Public Health Association.  
 19 Incidentally, he is also the President of the Public Health  
 20 Association. Thank you.

21 WRITTEN TESTIMONY BY THE HAWAII PUBLIC HEALTH ASSOCIATION

22           The Hawaii Public Health Association (HPHA) is made  
 23 up of over 300 health professional workers employed by Federal,  
 24 State, County and various private health agencies and corpor-  
 25 ations. All are committed to improving the health and quality

1 of life in Hawaii.

2           The Association supports plans to supplement the  
3 sewage systems in Hawaii. Improvement of sewage systems has  
4 long been one of the cornerstones of health protection and a  
5 public service not to be complacent about. This notion is  
6 supported by the Health Surveillance Program of the State  
7 Department of Health which recorded an increase of 78.9%  
8 between 1965 and 1970 in the frequency of acute illness  
9 conditions that have been associated with contact with  
10 polluted water, including swimming (see attached). These  
11 data are based on household interviews conducted on a random  
12 sample of population of Oahu residents, excluding those in  
13 institutions and group quarters. During that same interval  
14 of time, the base population (excluding the same persons)  
15 increased by only 15%.

16           The Kaneohe Bay area, a popular recreational area,  
17 has three sewage plants (Ahaimanu, Kaneohe, and Kaneohe  
18 Marine Corps Air Station) discharging into the Bay and may  
19 well be responsible in part to the increased incidence of  
20 acute conditions and constitute a potential health hazard.

21           We have reviewed the November 1973 draft of the  
22 "Environmental Impact State for Kaneohe-Kailua Sewer System"  
23 prepared by your office, with particular reference to the  
24 possible positive impact on Kailua Bay and are convinced  
25 that the approach advocated in the report could ameliorate

1 the present undesirable situation in Kaneohe Bay.

2 We are pleased the plan proposes to incorporate  
3 the effluent from the Kailua sewage treatment facilities  
4 since we believe that outfall is too close to shore and to  
5 recreational areas. If this is not altered, it would pro-  
6 bably only be a matter of time before the recreational waters  
7 of Kailua Bay become fouled with the sewage of its own  
8 citizens.

9 The HPHA considers that the proposed system is a wise  
10 move and urges its implementation at the earliest possible  
11 time.

12 SELECTED ACUTE ILLNESS CONDITIONS  
13 POSSIBLY ASSOCIATED WITH POLLUTED WATER

14 Typhoid and paratyphoid fever

15 Dysentery, all forms, not elsewhere classified (NEC)

16 Other infectious diseases, intestinal tract, NEC

17 Streptococcal sore throat

18 Hepatitis (infectious)

19 "Virus" (infection) ill defined or not otherwise stated (NEC)

20 Other diseases due to viruses, NEC

21 Dermotophytosis (athlete's foot)

22 Conjunctivitis and ophthalmia

23 Stye

24 Other inflammatory diseases of eye

25 Inflammatory diseases of ear



- 1 Other acute upper respiratory infections
- 2 Influenza with digestive manifestations
- 3 Gastro-enteritis, acute, NEC
- 4 Boil and carbuncle, NEC
- 5 Jaundice, NOS

6 WRITTEN TESTIMONY OF THE HAWAIIAN MALACOLOGICAL SOCIETY

7 The Hawaiian Malacological Society was established  
8 in 1941 for the purpose of furthering the collecting and  
9 study of mollusks in Hawaii. The organization has approxi-  
10 mately 300 members in Hawaii, mostly on Oahu, and some 1000  
11 living elsewhere in the United States and many other parts  
12 of the world. It is, we believe, the largest shell-study  
13 group in the world.

14 Members of our organization have watched with  
15 dismay while the numerous species of mollusks once present  
16 in Kaneohe Bay have become increasingly scarce or have  
17 disappeared completely. We believe this trend has been  
18 the result of two factors: (1) the great amount of silt  
19 that has washed into the Bay from the many real estate de-  
20 velopments on the hillsides, and (2) an enormous increase  
21 in the organic matter, including phosphates and nitrates,  
22 poured in by three separate sewage treatment plants.

23 Either factor, alone, would seriously damage the  
24 marine life of the Bay. Observations by our members, how-  
25 ever, convince us that the sewage has had a particularly

1 drastic effect on the environment by triggering and sustain-  
2 ing an explosion of certain species of algae that have  
3 completely upset the ecological balance. We believe,  
4 furthermore, that the molluskan life of Kaneohe Bay will  
5 continue to deteriorate-- and pre-existing marine animals  
6 probably will disappear--if the sewer effluent continues to  
7 be dumped there.

8           The Society's Committee on Environment and Ecology  
9 has studied the November 1973 draft of the Environmental  
10 Impact Statement for Kaneohe-Kailua Sewer System prepared  
11 by the Department of Public Works, City and County of  
12 Honolulu. It noted the proposal to divert the sewer effluent  
13 from Kaneohe Bay into deep water off Mokapu Point, and the  
14 reported indication that this action would have no adverse  
15 effect on the environment and ecology of Kailua Bay.

16           On the basis of these assurances, and in the light  
17 of members' own observations, the Hawaiian Malacological  
18 Society considers the reference project desirable as a step  
19 to preserve and restore the marine life--particularly the  
20 molluskan fauna--of Windward Oahu. We urge its adoption.

21           MR. YUEN: Thank you, Doctor Burch. Our next  
22 speaker is Doctor Jed Hirota who is representing the  
23 Hawaiian Institute of Marine Biology, and someone attached  
24 a note to this card indicating that Doctor Hirota is a  
25 graduate of the Scripps Institute of Oceanography and is

1 the first real genuine Hawaiian Oceanographer. Doctor Hirota.

2 DR. HIROTA: Thank you, Mr. Yuen, Honorable Senator,  
3 ladies and gentlemen: I'm here this evening to represent  
4 the Hawaii Institute on behalf of the Director, Doctor  
5 John Bardach, who is sitting next to Doctor Bathen there,  
6 and members of the staff.

7 We have evaluated the draft impact statement which  
8 is the subject of this evening's hearing, and the following  
9 is the evaluation and opinions of the professional staff  
10 members.

11 First, we would like to state that the damage has  
12 been severe to Kaneohe Bay. That conditions are deteriora-  
13 ating and it has been repeatedly mentioned to the citizens  
14 of Hawaii in an open letter on 8 March, 1973.

15 It was noted the Draft Impact Statement that there's  
16 been projected a doubling of the average sewage outfall to  
17 be discharged by the year 1990. We know that Kaneohe Bay  
18 will be faced with a potential ecological disaster if the  
19 continued discharge were to be added to the bay, and we  
20 therefore endorse the outfall proposal for the deep ocean  
21 for four principal reasons.

22 Firstly, that the removal of the discharge will  
23 be necessary to restore normal ecological balance to Kaneohe  
24 Bay, and that the outfall construction disturbance will be  
25 transitory in nature.

1 Thirdly, the discharge should have a minor effect  
2 on marine life, and if so only in the immediate vicinity  
3 of the discharge or outfall area.

4 Lastly, the new outfall will not risk greater  
5 pollution to Kailua Bay and in fact will actually improve  
6 existing conditions.

7 In summary therefore, we favor the project, we  
8 urge that it be given the highest priority, and we'd like  
9 to see the work be completed as soon as possible.

10 Thank you.

11 MR. YUEN: Thank you, Doctor Hirota, and again our  
12 congratulations to you for the distinction of being the  
13 first Hawaii born oceanographer. Our next speaker is Olin  
14 Pendleton, and Mr. Pendleton is representing the Kaneohe  
15 Community Council.

16 MR. PENDLETON: Following Jed's remarks and the  
17 feeling that I come across with in addition to what I've  
18 put on paper here, I'd like to speak, if I might for a  
19 minute, for the children, the future generations for whom  
20 we've been battling in the Kaneohe Community Council a long  
21 time on this concern for Kaneohe Bay. And for those who  
22 have been working on the crisis force there, this comes as  
23 a real fresh breeze and a real joy to all of us, and we  
24 really thank everyone who's put this tremendous effort into it.  
25 to do it before the patient died, and we were awfully afraid

1 that the rescue operation wasn't going to come in time.  
2 It looks hopeful now and we're encouraged. And we thank  
3 you all very much and all speed forward.

4 WRITTEN TESTIMONY BY THE KANEOHE COMMUNITY COUNCIL

5 The Kaneohe Community Council would like to take  
6 this opportunity to state again its support for the proposed  
7 Mokapu Sewage Outfall.

8 Kaneohe Bay is a precious resource not only for its  
9 natural value, but also for its future potential as a  
10 developable resource to benefit the residents of the Windward  
11 Side.

12 We are most pleased to now have this long awaited  
13 project finally reaching the point of reality.

14 MR. YUEN: Thank you, Mr. Pendleton. Next we have  
15 Julia Crane representing the Lani-Kailua Outdoor Circle.

16 MS. CRANE: Mr. Yuen, distinguished guests and the  
17 assembled audience. I would like to present the testimony  
18 of the Lani-Kailua Outdoor Circle.

19 We welcome this opportunity to comment on the pro-  
20 posed Kaneohe-Kailua waste disposal system and alternatives  
21 as part of our continuing participation in the attempt to  
22 solve our Windward waste management problems. The Lani-  
23 Kailua Outdoor Circle is concerned about clean waters and  
24 a healthy environment for Hawaii. Kaneohe Bay's environment  
25 should show positive improvement after the removal of the

1 sewage disposal through the municipal outfall. For possible  
2 long term detrimental effects of the proposed outfall, we  
3 must look to its predicted effects on the marine ecosystem  
4 in the vicinity of the outfall and its possible effects on  
5 the water quality of Kailua Bay.

6 As dilution and dispersal of the effluent is the  
7 main basis of the system, the direction and behavior of  
8 currents is of primary importance. Although the net trans-  
9 port of water has been shown to be roughly parallel to the  
10 shore, reversing direction seasonally, in Kailua Bay the  
11 direction of flow on the surface is strongly influenced by  
12 the prevailing winds which are predominantly shoreward  
13 trades (contrary to Honolulu's situation in Sand Island).  
14 In addition, changes due to tides are essentially always  
15 in a shoreward direction. Since we do not have a thermo-  
16 cline structure that would keep the sewage field submerged,  
17 as they do in California, for example, the effluent will  
18 surface. Thus, any effluent which does come shoreward from  
19 the outfall discharge area may be trapped in the shallow,  
20 nearshore waters, which move back and forth with insufficient  
21 mixing with deep ocean waters. In this connection, bacter-  
22 iological and viral dangers are an area of concern. We  
23 wholeheartedly support additional study of this problem,  
24 including a more thorough examination of the effects of  
25 chlorination.

1           Several questions occur in relation to alternatives.  
2 Will the proposed outfall be far enough out into deep water?  
3 Is there any discharge point that would be better? (At what  
4 cost)? Will it be possible to extend the outfall if it  
5 proves advisable to do so.

6           We know that the present outfall has had certain  
7 effects on the ecosystem and water quality of Kailua Bay  
8 and we know that the proposed outfall would have its effects.  
9 It would be a good idea if the EIS would spell this out.  
10 The general type of statement contained in the EIS that the  
11 proposed outfall will be less detrimental than the present  
12 shallow nearshore outfall would not seem to be sufficient.

13           According to the EIS, "ecological disaster" occurred  
14 in Kaneohe Bay without a concomitant deterioration of con-  
15 ventionally monitored water quality parameters. To avert  
16 this in Kailua Bay, it will be necessary to use new indi-  
17 cators. Changes in the biota near the outfall and in the  
18 entire Kailua Bay area may serve this purpose and should be  
19 watched for systematically. Baseline studies have been made  
20 which should make monitoring and surveillance the next  
21 logical step.

22           As Dr. Bathen said, it would be tragic if we did  
23 not use the time bought with this solution to work out a  
24 better way to dispose of our wastes, especially in the light  
25 of the projected population growth of the Windward Side.

1 In conclusion, we realize that during the construc-  
2 tion process some damage to the marine and terrestrial life  
3 will occur, but we hope that such destruction will be kept  
4 to an absolute minimum.

5 Thank you for your kind attention.

6 MR. YUEN: Thank you for your testimony, Mrs. Crane.  
7 Our next speaker is Lois Fleming representing the Kaneohe  
8 Outdoor Circle. Lois Fleming.

9 MS. FLEMING: Mr. Chairman, ladies and gentlemen:  
10 Actually it was the President of the Kaneohe Outdoor Circle  
11 who was supposed to give this. I'm no longer the President.

12 The Kaneohe Outdoor Circle, a Branch of the State-  
13 wide organization, appreciates the opportunity to support  
14 construction of the Kaneohe-Kailua Sewer System including the  
15 Mokapu deep ocean outfall. The primary goal of the Kaneohe  
16 Outdoor Circle for the past four years has been to support  
17 all efforts to reverse the threatening influence of sewage,  
18 pesticide and fertilizer run-off, erosion, and adverse  
19 thermal, salinity, and sedimental effects on Kaneohe Bay.

20 We realize one of the primary purpose of this  
21 hearing is to comply with the State law regarding the 40-  
22 foot Shoreline Set Back Rules and Regulations. On past  
23 occasions, our Branch Circle has opposed requests for  
24 variances to these Regulations when housing developments  
25 along the shoreline with their needed drainage lines,



1 sewerage connections or cesspools within the 40-foot set-  
2 back area would add further to the pollution of Kaneohe Bay.  
3 However, construction of the Mokapu Sewage Outfall and con-  
4 necting facilities would be in the public interest, there-  
5 fore, we do not oppose the use of land within the 40-foot  
6 set-back from the shoreline for this purpose.

7           One of the recommendations made by the Kaneohe Out-  
8 door Circle in a Policy Statement Relating to Development in  
9 the Kaneohe Bay Watershed Area, dated April 26, 1973, was that  
10 there should be no more sewer hook-ups to the existing treat-  
11 ment plants discharging into Kaneohe Bay until the deep ocean  
12 outfall at Mokapu and the necessary diversion lines are com-  
13 pleted. We made this recommendation because the increase in  
14 population predicted from the number of applications for new  
15 housing and commercial developments being processed by the City  
16 and County Planning Department would more than double the  
17 sewage discharged into Kaneohe Bay. We concur with the Marine  
18 Biologists at the Hawaii Institute of Marine Biology at Coconut  
19 Island that Kaneohe Bay has already exceeded its sewage capacity.

20           In June, 1973, completion of the Mokapu Sewage  
21 Outfall and related projects was predicted for 1975. Now  
22 the schedule has been altered so that "contingent upon no  
23 further delays", the project will be completed in August of  
24 1976--already one year behind last year's goal. The Kaneohe  
25 Outdoor Circle therefore urges the Board of Water Supply to

1 do everything within its power to move the Kaneohe-Kailua  
2 Sewer System project ahead without further delays. Thank  
3 you.

4 WRITTEN TESTIMONY SUBMITTED BY KANEOHE OUTDOOR CIRCLE

5 POLICY STATEMENT RELATING TO DEVELOPMENT  
6 IN THE KANEOHE BAY WATERSHED AREA

7 The Kaneohe Outdoor Circle believes private develop-  
8 ment should proceed only at the rate public--State and  
9 County--facilities and services are adequate to protect the  
10 environment from degradation created by further urbanization  
11 in the Kaneohe Bay Watershed Area.

12 The principal goal of the Kaneohe Outdoor Circle  
13 for the past three years has been to support all efforts to  
14 reverse the threatening influence of sewage, pesticide and  
15 fertilizer run-off, erosion, and adverse thermal, salinity  
16 and sedimental effects on Kaneohe Bay.

17 Kaneohe Bay is a valuable State resource and the  
18 property of all the citizens of Hawaii. The serious  
19 condition of the Bay is caused primarily by sewage and  
20 siltation--the result of increased urbanization of the land  
21 surrounding it. This crisis condition has been called to the  
22 attention of the citizens of Hawaii by marine scientists,  
23 local fishermen's groups, and water-oriented recreation  
24 organizations.\*

25 We believe it is the cumulative effect of changes--  
small though they may be when considered one development at

1 a time--that has brought Kaneohe Bay to its present condition  
2 of degradation. The conservation of water quality and  
3 associated environmental resources requires that incremental  
4 change not be permitted to gradually and irreversibly destroy  
5 the common property of the people of Hawaii.

6 Therefore, the Kaneohe Outdoor Circle calls on all  
7 government agencies responsible for approval of development  
8 plans in the Kaneohe Bay Watershed Area to consider the  
9 public cost to reclaim this precious natural resource and  
10 recreational asset to our community. If action is not taken  
11 now to provide adequate safeguards to protect the Bay from  
12 further pollution from sewage and siltation, the task may  
13 become impossible, and the cost prohibitive, even three years  
14 from now.

15 References: March 8, 1973 letter from 16 marine scientists  
16 at the Hawaii Institute of Marine Biology at  
17 Coconut Island, Kaneohe Bay:  
18 January 1973 Ka Lama article on the Kapuku Plan  
19 Controversy by Hui Malama Kai (Fishermens' Group):  
20 March 23, 1973 Open Letter from Kokokahi YWCA  
21 concerning Kaneohe Bay's pollution problems

22 SEWAGE

23 The existing sewerage system of Kaneohe town pres-  
24 ently discharges directly into the southern end of Kaneohe  
25 Bay. The Sewer Division of the City Public Works Department

1 estimates approximately 100 gallons of sewage per person  
 2 per day. At the present time, 3.12 millions of gallons of  
 3 sewage per day are being discharged into the restricted  
 4 confines of the Bay.

5 As of February, 1973, the City and County Planning  
 6 Department had records of 10,700 projected housing units in  
 7 the Kaneohe Bay Watershed Area that developers hope to erect  
 8 as soon as changes in zoning are approved and plans processed.  
 9 Using the figure 4.2 as an average number of persons to be  
 10 house in each unit, these 10,700 units alone could add  
 11 approximately 45,000 people, resulting in a total population  
 12 of approximately 91,300.

13 If the population increases by 45,000 prior to the  
 14 completion of the deep ocean outfall at Mokapu, instead of  
 15 3.12 millions of gallons of sewage per day being discharged  
 16 into Kaneohe Bay as there is now, there would be double that  
 17 amount or about six and a quarter million gallons per day.

18 Since the capacity for sewage has already been  
 19 exceeded in Kaneohe Bay, the Kaneohe Outdoor Circle recommends  
 20 that all new sewer hook-ups on developments not already under  
 21 construction be postponed until the deep ocean outfall at  
 22 Mokapu and the necessary diversion lines to connect the  
 23 community's sewerage system are completed.

24 Therefore, we urge that planning, engineering, and  
 25 construction begin st once on the Mokapu deep ocean sewage

1 outfall, so that it will not be necessary to postpone new  
2 sewer hook-ups an unreasonably long time.

3 SILTATION AND SEDIMENTATION

4 There always has been, and always will be, some  
5 natural erosion and siltation from the Ko'olau mountain  
6 slopes into the Bay. However, there has been a tremendous  
7 increase in the rate of erosion in areas undergoing develop-  
8 ment.

9 "Soil erosion and its effects are damaging many times  
10 over. First, there is the irreplaceable loss of soil that  
11 usually has taken thousands of years to form. Second, sedi-  
12 ments not only contribute heavily to suspended solids  
13 pollution problem. Third, sediment frequently damages the  
14 area where it comes to rest; for example, dangerously reducing  
15 the capacity of flood control channels and natural streams,  
16 destroying marine life such as shellfish and/or delicate  
17 coral ecosystems, as in Kaneohe Bay."\*

18 "The presence of numerous coral reef areas around  
19 Oahu indicates that in the past a natural balance had been  
20 achieved, and the delicate organisms in the reef structures  
21 had been able to re-establish themselves after periodic  
22 slight damage by natural sediments. Now, there are many  
23 areas in Kaneohe Bay where the reefs are dead, and other  
24 areas where the reefs are dying because of greatly increased  
25 sediment loads. For example, sediment yields in areas under-

1 going suburban development can be as much as 5 to 500 times  
2 greater than in rural areas.<sup>1</sup> The sediment yield for a storm  
3 from highway construction areas was found to be about 10 times  
4 greater than from cultivated land, 200 times greater than  
5 that from grassed areas, and 2,000 times greater than from  
6 forested areas.<sup>2\*\*</sup>

7 Removing trees and other natural ground cover and  
8 replacing them with impermeable materials for houses, drive-  
9 ways, patios, and streets increases the runoff of surface  
10 water. Also, the surface water runoff from developed areas  
11 usually contains fertilizers, pesticides, and other chemicals  
12 dangerous to the marine life of receiving waters.

13 Even the best erosion control measures are going to  
14 result in some silting. The revised Grading Ordinance passed  
15 by the City Council in July of 1972 was a first step toward  
16 the objective of protecting the environment and assuring in-  
17 telligent and controlled development. A second step would  
18 be the adoption by the City and the State of a set of engi-  
19 neering standards for erosion and sediment control on Oahu to  
20 accompany the new Grading Ordinance. At the present time,  
21 the City engineers have no guidelines for erosion control  
22 standards to use as a basis of comparison with plans sub-  
23 mitted by developers. Therefore, efficient and stringent  
24 enforcement of the Grading Ordinance, which is necessary for  
25 the protection of Kaneohe Bay, is very difficult to attain.

1           The State Water Quality Act forbids sedimentation  
 2 in receiving waters, regardless of category or classification.  
 3 Yet, the State Health Department routinely approves variances  
 4 requested by developers to run drainage pipes from subdivisions  
 5 into Kaneohe Bay, saying--"it is in the public interest,"  
 6 and the department "would not anticipate any adverse water  
 7 pollution problem from this development."\*

8 <sup>1</sup>Page G3, Community Action Guidebook for soil Erosion and  
 9 Sediment Control--Powell, Winter, and Bodwitch NACORF  
 10 National Association of Counties Research Foundation.

11 <sup>2</sup>Senator Jennings Randolph - Proceedings of the National  
 12 Conference on Sediment Control, Washington, D.C. September  
 13 14-16, 1969.

14 \*Reference; Report of W.C.P.C. Grading Ordinance Committee  
 15 to City Council.

16 COORDINATION NEEDED

17           Under the Federal Coastal Zone Management Act, the  
 18 State must plan for Hawaii's shoreline in order to qualify  
 19 for Federal monies--if and when available. Therefore, the  
 20 Kaneohe Outdoor Circle believes that coordination among  
 21 Federal, State, and City agencies, Commissions and Boards is  
 22 necessary in order to protect Kaneohe Bay from further pollu-  
 23 tion and to serve the public interest to the fullest extent.

24           The Kaneohe Outdoor Circle believes the State Health  
 25 Department and the City and County Public Works Department

1 should take a firmer position to enforce existing regulations  
2 rather than allow these laws to be weakened by permitting  
3 incremental changes--the cumulative effect of such changes  
4 having a degrading effect on the water quality of Kaneohe Bay.

5 SUMMARY

6 The Kaneohe Outdoor Circle recommends:

7 1. All new sewer hook-ups on developments not already  
8 under construction be postponed until the deep ocean outfall  
9 at Mokapu and the necessary diversion lines to connect the  
10 community's sewerage system are completed.

11 2. Planning, engineering, and construction begin at  
12 once on the Mokapu deep ocean outfall.

13 3. Adoption by City and State of a set of engineering  
14 standards for erosion and sediment control on Oahu to accom-  
15 pany the revised Grading Ordinance.

16 4. State Health Department and County Public Works  
17 Department take firmer position to enforce existing regula-  
18 tions.

19 5. Federal, State, City and County coordinate efforts  
20 to protect Kaneohe Bay from further pollution.

21 Reference: Staff Report of the Zoning Board of Appeals,  
22 Item No. 11, April 12, 1973--Request for a  
23 variance from Rule 13.3, regarding structures not  
24 permitted within the shoreline setback, of the  
25 Shoreline Setback Rules and Regulations.



1 MR. YUEN: Thank you, Lois. We also have a speaker  
2 from the Kaneohe Outdoor Circle, Marcia Rice.

3 MS. RICE: I think that would be duplication.

4 MR. YUEN: Are you here to give moral support to  
5 Lois?

6 MS. FLEMING: I just read the testimony.

7 MR. YUEN: Oh, I see. The next speaker is Sandra  
8 Braun. Sandra is representing the Concerned Citizens for  
9 Kailua Bay.

10 MS. BRAUN: My name is Sandra Braun and I'm test-  
11 ifying in behalf of the Concerned Citizens for Kailua Bay  
12 and myself.

13 The value placed upon true public input by officials  
14 of the City and County and State could be questioned as  
15 evidenced by this public hearing being held after completion  
16 of the planning period and after funds have been released  
17 for the project.

18 Broad public participation often reveals those areas  
19 of concern affecting the general public which are so often  
20 missed by public officials. Therefore it is hoped, even at  
21 this late date, that the testimony submitted by an ad hoc  
22 broadly based group will in some way contribute constructive-  
23 ly to a sewage management system for Windward Oahu which will  
24 protect and enhance both Kaneohe and Kailua for the future.

25 The following concerns are based upon continued

1 questioning and information gathering on the part of the  
2 group of concerned citizens and expressed by them to officials  
3 since the planning of this project was brought to public  
4 attention several years ago.

5           According to George Jensen of the U.S. Environmental  
6 Protection Agency, the method of sewage disposal on which  
7 this project is based is antiquated and has not proven it-  
8 self over time to be effective. Further, he states that  
9 technology is available which is proven effective and in-  
10 creasingly economical in contrast to the outmoded method  
11 under consideration.

12           One might ask then why does the inferior method  
13 continue to be planned. Mr. Jensen suggests that it's  
14 simply because engineers responsible to develop the system  
15 understand this system the best. Locally many of those  
16 supporting the planning and approval of the project point to  
17 the pollution of the southern sector of Kaneohe Bay as a  
18 result of the use of this method by the present Kaneohe system.  
19 Yet the project which has been proposed will also depend upon  
20 the discharge of effluent treated to the secondary level into  
21 a shallow outfall. The shallow outfall is defined as such  
22 in the environmental impact statement itself prepared by the  
23 City in contrast to the use of deep ocean outfall which is  
24 most frequently heard.

25           Eight to ten years ago officials did not heed the

53

1 warnings that there was poor water circulation in the dis-  
2 charge area of Kaneohe Bay. Likewise today, studies have  
3 revealed that the natural conditions relevant to the proposed  
4 new outfall are far from ideal. The currents running  
5 roughly parallel to the shore on which the system would de-  
6 pend are not characterized as strong. One of the principal  
7 investigators expressed concern that a harmful buildup could  
8 occur against Mokapu Peninsula during the period of a norther-  
9 ly direction of the current, since the effluent will not, in  
10 fact, go out into the open ocean beyond the Mokapu Outfall on  
11 the Mokapu Point.

12 In addition, no reliable thermocline exists to trap  
13 the water beneath the surface, and therefore the prevailing  
14 winds and the on-shore surface current are of concern. As a  
15 consequence of these conditions, officials have not been able  
16 to preclude the possibility of the effluent returning to the  
17 inshore waters and beach areas of Kailua Bay. This has been  
18 indicated by the Kaneohe Task Force's testimony when they  
19 said that they were only reasonably assured, not sufficiently  
20 assured.

21 Of further concern in connection with the above is  
22 that contrary to what might be assumed through lay observa-  
23 tion, the exchange of Kailua and open ocean water is charact-  
24 erized as slow. Therefore, the removal from onshore waters  
25 of the undesirable elements of the effluent would be slow.

1 Flexibility in the system has been offered by many supporting 54  
2 the project as a safety factor for correction of this system  
3 which has been programmed for a 50 year life to serve an  
4 additional several hundred thousand people. Flexibility is  
5 one of the objectives to be built into the project according  
6 to the EIS. However, in talking with City officials regarding  
7 the extension of the outfall, it was made very clear that they  
8 would not consider this a significant improvement to the  
9 system.

10 In discussing the possibility of additional treat-  
11 ment to the effluent being applied at a later date, City  
12 officials and scientists have indicated that since it is not  
13 known what is in the effluent that causes pollution, this is  
14 not a valid means of altering the effluent, short of full  
15 tertiary treatment, a method which the City has turned down  
16 in favor of this project.

17 In addition, monitoring as an early warning device  
18 has not been sufficiently provided for in completing the  
19 baseline studies of the area nor has funding been built into  
20 the city operational budget for the monitoring project.

21 The State has previously demonstrated it is not able  
22 to carry out such monitoring due to lack of funding. In  
23 contrast to stated commitment by city officials to this  
24 system, as presently planned, private conversations and  
25 public hints by those involved in evaluating and supporting

1 the project have acknowledged that the system cannot have but 50  
2 a tenth to a fifth of the 50-year life plan. With slow re-  
3 sponse demonstrated by governmental officials in response to  
4 the ravaging of Kaneohe Bay, this contradiction should be  
5 resolved concerning a project estimated to cost in excess of  
6 12 million dollars.

7 In addition, we may suffer from a loss of opportunity  
8 for a truly effective system. The question regarding the  
9 profile of the effluent to be discharged from the Kaneohe  
10 Marine Corps Air Station sewer treatment plant and the unknown  
11 potential of the effect of viruses should be also more fully  
12 considered.

13 In summary I wish to call attention to the value of  
14 Kailua Bay as a public resource in addition to the value  
15 widely recognized of Kaneohe Bay. A recent study carried out  
16 by James Montfer of the University of Hawaii Economics De-  
17 partment has quantified the value in millions of dollars of  
18 the bay, and has identified it as the beach and recreational  
19 waters most valued on all Oahu by its residents.

20 Thus an objective, independent, thorough review of  
21 this project and the alternatives in terms of long range  
22 economic considerations and broadened concern is needed. With  
23 the trade-off made only subsequent to this review. Thank you.

24 MR. YUEN: Thank you very much Sandra. Our next  
25 speaker is Bob Nakata. Bob is representing an organization

1 called Kahaluu Coalition. Bob.

2 MR. NAKATA: Mr. Yuen, ladies and gentlemen: The  
3 Kahaluu Coalition endorses the concept of the ocean outfall.  
4 Our comments this evening are directed mainly at the location  
5 of the wastewater treatment plant in Kahaluu itself. Now, we  
6 were glad to hear earlier this evening that the city has not  
7 yet settled on the site. Up to about a year and a half ago,  
8 we were under the impression that the city was not considering  
9 a treatment plant in Kahaluu. We were surprised four months  
10 ago to learn that the city was moving ahead to acquire land  
11 which was already designated for a sewage treatment plant,  
12 and that this plant was scheduled for completion in 1977.

13 At about the same time we were considering the flood  
14 control project, which is scheduled for Kahaluu, and the waste-  
15 water treatment site which was designated on the DLUM is located  
16 very close to the flood control system. So one of the issues  
17 we considered was whether the wastewater system plant should  
18 be located at that site. And this was the only issue on which  
19 there was unanimity. The community groups were all opposed to  
20 the location of the wastewater treatment plant at that site.

21 The site is located within about 900 feet of the  
22 Kahaluu Elementary School. It would disrupt the land green-  
23 belt leading from the flood control lagoon to the forest  
24 reserve line. These would be green strips which would pre-  
25 serve public access from the ocean to the mountains.

1           Its also located very centrally in Kahaluu. Right  
 2 now our landmarks are the Hygienic Store and Lau's Drive-In,  
 3 but both Hygienic Store and Lau's Drive-In are threatened by  
 4 highway expansion, and we would very definitely not like to  
 5 be identified by the sewage treatment plant.

6           Now one of the things we'd like to see the city  
 7 consider more than they did in the Environmental Impact  
 8 Statement is possibly the retention of the Ahuimanu Sewage  
 9 Treatment Plant. Its capacity is about 1.1 million gallons  
 10 daily, which would handle the projected population up to 1990  
 11 or 1995. Now if the wastewater treatment plant that the city  
 12 is considering is built by 1977, the Ahuimanu Plant would be  
 13 phased out before reaching anywhere near its designed capacity.  
 14 We also have some fear that because of the pressures for  
 15 development in the Kahaluu area upon the completion of the  
 16 city's wastewater treatment plant the Ahuimanu Plant itself  
 17 may indeed not be phased out because more people could then  
 18 be accomodated there. We're not accusing the city of, you  
 19 know, double-dealing with us, but rather that the pressures  
 20 that we are feeling now are such that we feel the possibility  
 21 is there, that the city may change its mind at a later date.

22           We also know that the city is in the process of a  
 23 general plan revision. We feel that the selection of the  
 24 sewage treatment site in Kahaluu should be considered within  
 25 the context of that general plan review rather than being

1 done separately and have the plant site designated and the  
2 community planned around that. We believe that under good  
3 planning the site selection should fit into the revision  
4 process rather than precede it. Thank you.

5 WRITTEN TESTIMONY OF THE KAHALUU COALITION OF COMMUNITY  
6 ORGANIZATIONS

7 The Kahaluu Coalition of Community Organizations  
8 endorses the concept of the ocean outfall sewage disposal  
9 system to serve the Kailua, Kaneohe, Kahaluu region. The  
10 deterioration of Kaneohe Bay is of great concern to us. The  
11 ocean outfall system will eliminate pollution of the Bay by  
12 sewage. Overall, we endorse the ocean outfall because the  
13 present level of sewage is already threatening the Bay with  
14 irreparable damage.

15 While endorsing the system as a whole, we would like  
16 to voice our objections to the selection of the site for the  
17 Kahaluu sewage treatment plant. The original designation of  
18 twenty acres in the middle of the Kahaluu flood plain in  
19 1964 for a sewage treatment plant and the preparation of the  
20 EIS were done without consultation with Kahaluu residents.  
21 In fact, the Public Facilities Committee of Hui Koolau (before  
22 the formation of the Coalition) was led to believe that the  
23 City had no intention of using the designated site for a  
24 treatment plant. It was led to believe, until a year and a  
25 half ago, that sewage from Kahaluu would be treated at Kualoa  
or at an expanded Kaneohe treatment plant. The Kahaluu



1 community has always been opposed to the DLUM designated  
 2 site and anticipated that in the City's general plan revision  
 3 process now in motion, the views of the community would be  
 4 heard.

5           It was with a sense of shock that the eighteen  
 6 member organizations of the Coalition learned that the City  
 7 has recently decided to move ahead with the acquisition of  
 8 site. We were not notified that the City's thinking had  
 9 changed in regard to this site. This is particularly galling  
 10 because the City has been participating in the development  
 11 of a flood control-park complex which is in direct conflict  
 12 with the DLUM designated site. The flood control-park  
 13 complex envisioned a lagoon-settling basin surrounded by a  
 14 park. Radiating from the park would be green strips along  
 15 the flood control channels and natural streams. These would  
 16 extend to the forest reserve line, preserving public access  
 17 to the mountains. The sewage treatment plant would sit in  
 18 the middle of the park, disrupt the green strips, and two of  
 19 the flood control channels would cut through the site. In  
 20 a recent poll of the Coalition member organizations on  
 21 various recommendations on the proposed flood control project,  
 22 the only issue on which there was unanimity was the opposit-  
 23 ion to the DLUM designated site for the sewage treatment plant.  
 24 The Kahaluu Coalition is unanimously opposed to that site, and  
 25 believes that the flood control-park complex should have

1 precedence over the treatment plant.

2           There has emerged a sharp contrast between the City's  
3 handling of the flood control plans and its handling of the  
4 sewage treatment plant site. The community has been vitally  
5 involved in the planning of the flood control system. It  
6 has hardly been consulted in the decisions concerning the  
7 original selection of the site, the drafting of the environ-  
8 mental impact statement, or the decision to move ahead on  
9 land acquisition.

10           The City is presently in the process of revising its  
11 general plan. There is a great need for the revision process  
12 in Kahaluu where the DLUM is obsolete. The flood control  
13 project cannot get under way until some major changes are  
14 made in the Details Land Use Map for the area. It would  
15 appear to us that the selection of a site for the sewage  
16 treatment plant should be a part of the general plan revision  
17 process. As things stand now, the community will be planned  
18 around the sewage treatment plant, rather than the community  
19 being planned first and the sewage treatment plant then placed  
20 in the least obnoxious location. The DLUM designated site  
21 is in the geographical and symbolic center of Kahaluu proper.  
22 It could easily become the identifying landmark for Kahaluu,  
23 replacing the Hygienic Store in this regard. Needless to say,  
24 this is not an uplifting idea for Kahaluu residents.

25           The Coalition does not feel that the environmental

1 impact statement adequately addressed itself to the socio-  
2 economic implications of placing a sewage treatment plant  
3 in Kahaluu. Such a step would make Kahaluu even more desir-  
4 able for development than it is now. This means higher land  
5 values, higher taxes, higher costs of housing. What does  
6 this mean for the present residents of Kahaluu?

7           The "H-3 Socio-Economic Study" done by Eckbo, Dean,  
8 Austin, and Williams says that H-3 will double the rate of  
9 development in Kahaluu. It also says that the population  
10 of Kahaluu will be 40,000 by 1995 if H-3 is built. Without  
11 H-3 it would be 20,000. The study lists the social ills,  
12 such as increased crime and mental illness which would result.  
13 The sewage treatment plant will also encourage development.  
14 Why haven't the same kinds of considerations been taken into  
15 account in the decision to locate a plant in Kahaluu?

16           Specific comments on the five alternative sites  
17 considered in the EIS follow.

18           Alternative 1 is the DLUM designated site. We are  
19 opposed to this site. It is located within 1000 feet of the  
20 Kahaluu Elementary School. Winds would take odors in that  
21 direction 15% of the time. It is located in the geographical  
22 and symbolic center of Kahaluu, as mentioned earlier. There-  
23 fore, it could become the identifying landmark for Kahaluu.  
24 It interferes with and disrupts the park-flood control complex.  
25 It is badly placed, even in the 1964 DLUM which shows the site

1 surrounded by commercial, residential, and park areas.  
2 Nothing has yet been done to change that situation.

3 Alternative 2 is the existing Ahuimanu treatment  
4 plant. This plant has a capacity of 1.4 mgd and present  
5 flows average .3 mgd. It therefore has over a million  
6 gallons of capacity remaining. Although the site is too small  
7 to handle the projected population of the area by 2020, it is  
8 adequate to handle the projected population until at least  
9 1990, and maybe as far as 2000. (See Table I-VI-3) If this  
10 plant is retained instead of phased out, three advantages  
11 are realized. First, a new plant will not be needed for  
12 nearly 20 years. Second, a smaller plant and therefore a  
13 smaller site will be needed to serve the expected 2020 popu-  
14 lation. Rather than two phases on the DLUM site, the Ahui-  
15 manu plant could be retained as the first phase. Greater  
16 flexibility would then be gained for the location of the  
17 second phase, since it will be smaller than that which is  
18 needed under the present plan. Third, the capital outlay  
19 has already been made for this plant. This would compensate  
20 for the expense of pumping sewage to this site.

21 We have no comments beyond those already contained  
22 in the EIS regarding alternative 3, the Kualoa site.<sup>1</sup>

23 Alternative 4 has the same problems as the DLUM  
24 site. In addition, prevailing winds are towards the school  
25 and the industrial area may be needed to provide employment

1 in the Kahaluu community.

2 Alternative 5, the Waiahole site, may help open  
3 that area to development. Such an eventuality would further  
4 degrade the natural environment of the Windward Side, es-  
5 pecially Kaneohe Bay. No development has taken place there  
6 yet, one of the few areas of Oahu which can make that claim.

7 We question whether the Ahuimanu plant has been  
8 adequately studied as the treatment facility for Kahaluu over  
9 the next 15 to 20 years. A second facility could be constructed  
10 somewhere else when this plant's capacity is reached. Such  
11 a course would allow the City time to update its general plan  
12 for the area and select the site for the second facility with-  
13 in the context of this updating. This course would also allow  
14 greater flexibility in site selection because a smaller area  
15 than 14 acres would be needed for the second facility. The  
16 recommended phasing out of the Ahuimanu plant makes it more  
17 urgent and also more difficult to find an acceptable site in  
18 the Kahaluu area. We are also afraid that this plant will not  
19 be phased out when the first increment of the proposed plant  
20 is built. If it is retained under such conditions, the popu-  
21 lation of 40,000 anticipated by Eckbo, Dean, Austin and  
22 Williams by 1995 will be possible. If the second increment  
23 is then built, Kahaluu could have a population of nearly  
24 60,000 rather than 40,000 by 2020. We urge that the reten-  
25 tion of the Ahuimanu plant be investigated along with another

1 site for a second sewage treatment plant in Kahaluu, if it  
2 is needed.

3 In summary, we feel that the location of the Kahaluu  
4 sewage treatment plant, if it is at all necessary, should be  
5 considered within the context of a revised general plan for  
6 Kahaluu. To place it in the focal point of the community  
7 does not make good planning sense and does nothing for the  
8 community's self image. The Kahaluu community is appalled at  
9 the prospect of a sewage treatment plant in such a location.  
10 It would be difficult to imagine a proposed development in any  
11 community that would have such a negative impact upon the  
12 environment as a sewage treatment plant complex in the pro-  
13 posed location. Thank you.

14 MR. YUEN: Thank you very much, Bob. Our next  
15 speaker is Colonel Ralph Small, and Colonel Small is repre-  
16 senting the Aikahi Park Organization.

17 COL. SMALL: I'd like to congratulate the Board on  
18 such a fine public hearing. I have been to many on this sub-  
19 ject and this is the finest one, I think, I've ever attended.  
20 It's well presented and a beautiful job.

21 I'm not going to repeat testimony that has been  
22 given, but I would suggest to the Kahaluu people that they come  
23 over to the Kailua Sewage Treatment Plant and talk to the  
24 school authorities just across the fence from the Kailua  
25 Sewage Treatment Plant, and see if that plant has bothered

1 the elementary school. I think they will find that there  
 2 has been no conflict of any nature. I live right near there;  
 3 I have never heard any complaint about a conflict between the  
 4 Kailua Sewage Treatment Plant and the elementary school which  
 5 adjoins it just across a fence.

6 I'm happy with what I have heard here tonight. I  
 7 don't think we can expect complete unanimity on any subject  
 8 this large, but it looks like it's pretty close and I'm all  
 9 in favor of this plan. And I'd say, let's go, go, go.  
 10 Thank you.

11 MR. YUEN: Thank you very much, Colonel. You might  
 12 say we're on the 10 yard line right now. Okay, our next  
 13 speaker is Mr. D. A. Brenner, and Mr. Brenner is representing  
 14 the Kailua Community Council.

15 MR. BRENNER: Thank you, Mr. Yuen. I'm Don Brenner,  
 16 the President of the Kailua Community Council representing  
 17 that group this evening.

18 We have discussed this project on a couple of occa-  
 19 sions in the past year and a half or so, each time coming to  
 20 the conclusion and/or official position that on the overall  
 21 considerations, the project is justified, necessary and de-  
 22 sireable from the standpoint of the entire community. On the  
 23 surface of it, you should have expected some concern from  
 24 Kailua since it could be, and indeed it has been argued by  
 25 some, that you are merely switching sewage treatment effluent

1 from one bay to another. However, in objectively analyzing  
2 the situation, the difference in the nature of the two bays,  
3 the location and the design of the outfall, and the fact that  
4 we are dealing with treated effluent, indicates to us that  
5 the probability of creating a problem in Kailua Bay by solving  
6 one in Kaheohe is small.

7 In addition, the direct advantages and improvements  
8 to Kailua have been mentioned this evening. We do suggest,  
9 however, that a monitoring system be incorporated into the  
10 overall project plan so that any unanticipated change in the  
11 water quality of Kailua Bay can be detected and remedied early  
12 through contingency plans that we hope that you will develop  
13 if you do not have already.

14 In our attempts to stretch the benefits to Kailua  
15 from this project, we are hoping to -- that it might to do  
16 something to eliminate the odor at the Kailua Wastewater  
17 Treatment Plant. Thank you.

18 MR. YUEN: Thank you, Mr. Brenner. Our next speaker  
19 is Philip Helfrich, who is representing the Kaneohe-Bay-In-  
20 Crisis organization.

21 MR. HELFRICH: Mr. Chairman, ladies and gentlemen:  
22 I represent Kaneohe-Bay-In-Crisis, which is a consortium of  
23 civic organizations that was sort of formed spontaneously  
24 several years ago as the result of concern about the rapid  
25 deterioration of the water quality in Kaneohe Bay. You might



1 say that probably our hope would--to eliminate our reason to  
2 be, certainly our first objective, our major goal, was the re-  
3 moval of all sewage from Kaneohe Bay.

4 Now we see this about to happen; if you'll excuse the  
5 pun, we see the light at the end of the pipeline. But we still  
6 have a lot of concern. To use Olin Pendleton's analogy, we  
7 were afraid the patient was going to die. I would like to say  
8 that the patient is still in intensive care. The biologists,  
9 my fellow biologists at the Institute of Marine Biology on  
10 Coconut Island have voiced a warning several times. We can't  
11 predict the exact moment, the exact amount of nutrients and so  
12 forth, but we are in a very delicate situation. The system is  
13 not out of balance when we speak of the animal-plant nutrients  
14 cycle, but it can easily be thrown out of balance; it can be-  
15 come anaerobic, in which case we'd have very serious problems.

16 So what I'm saying is that we endorse wholeheartedly  
17 the concept of the deep ocean outfall as presented here. We  
18 recognize that there are some minor stresses and problems that  
19 relate to the construction of this outfall and to its opera-  
20 tion, but we are particularly concerned at this time that be-  
21 tween now and the time the effluent begins to flow out of the  
22 deep ocean outfall that we don't have a disaster.

23 So I would add my voice to Lois Fleming in caution-  
24 ing against further loading Kaneohe Bay before we can elimi-  
25 nate this. A specific case in point. We may not, although

1 I'd like to think we could, stop new construction. However,  
2 there are cases where people who are not shoreside residents  
3 who are presently using cesspools in the Kaneohe area, but  
4 are on existing sewer lines, who are being required to hook  
5 up to these sewer lines. Now, I'd seriously question this  
6 practice in view of the stresses that we recognize in Kaneohe  
7 Bay at this time.

8 So, in conclusion, we endorse the deep ocean out-  
9 fall, we urge its rapid completion and we seriously caution  
10 of further loading of Kaneohe Bay with sewage effluent. Thank  
11 you.

12 MR. YUEN: Thank you very much, Mr. Helfrich. That  
13 is the last of our signed up speakers. Is there anyone else  
14 in the audience that would like to make a comment at this  
15 time? Yes. Would you give us your name and the organization  
16 you're representing?

17 MS. BURCH: My name is Beatrice L. Burch and I  
18 represent no organization, purely as a third generation  
19 Californiana who has lived here for only three years. How-  
20 ever, my query is perhaps to Mr. Hennessy, would could help  
21 me out a little bit.

22 I did not note what precautions were made about  
23 earthquakes and puncturing or shift of the pipe, what type of  
24 monitoring was being done by the engineering type of personnel.  
25 Having lived in Southern California, growing up at -- near

1 Hyperian at El Segundo, the effect of a punctured sewer line  
2 to me is a rather interesting thought.

3 MR. YUEN: Paul, would you like to take about 30  
4 seconds to answer that question?

5 MR. HENNESSY: Yes. These are engineering problems.  
6 You know, if you look at the Grand Canyon, you can find rocks  
7 folded back on theirselves and nobody is going to design any-  
8 thing that's structured that will survive that. If it will  
9 make you feel better, we designed the San Diego Ocean outfall,  
10 my firm, and the Laguna Beach Ocean outfall, and the Catalina  
11 one, and they've been through a few earthquakes -- minor ones  
12 and some bigger ones.

13 There are two alternatives to the pipe. One is  
14 a flexible design called double rubber gasket reinforced  
15 concrete pipe; the other is a steel alternative, which is  
16 mortar lined and gunite coated. Both of these are highly  
17 resistant to shearing stress. And I think that's been one  
18 of the minor design problems. We had the wave forces -- the  
19 hurricane wave forces for the design wave exert forces on  
20 the pipe of a magnitude of several times the expected ex-  
21 periences of a seismic zone two earthquake.

22 The monitoring, I can't speak to, George. You would  
23 have to talk to somebody else on that.

24 MR. YUEN: In other words, his answer is yes.

25 MS. BURCH: No. I want to know what happens. We

1 haven't heard about the monitoring.

2 MR. HENNESSY: Are we talking about sizing monitors?

3 MS. BURCH: No, zone. Actually, what I mean is  
4 just regular routine type of checking.

5 MR. HENNESSY: Alright, George.

6 MR. YUEN: Well, I'm sure that will be done, Paul.

7 I'm sure that will be taken into consideration. Is there  
8 anyone else who would like to testify at this time?

9 MS. HUMPHRIES: May I speak?

10 MR. YUEN: Sure.

11 MS. HUMPHRIES: Mr. Yuen, ladies and gentlemen:  
12 I'm Valerie Humphries, President of the Windward Action Group.  
13 And I had a card with me, but I didn't get it in.

14 I wanted to concur with the Outdoor Circle and Dr.  
15 Helfrich and the rest of us who have worked for a long time  
16 to see this come about, and we're pleased to see it on its  
17 way.

18 However, there is one question. And I understood  
19 that you said we couldn't have questions and answers, but  
20 perhaps I can direct it to -- I can't help but put it in the  
21 form of a question. I don't know where I can phrase it as a  
22 comment and ask you to think of the alternatives. I don't  
23 understand what will we do in view of the current energy crisis  
24 which issue has not been raised, when we are talking about use  
25 of either diesel electric or electric, and we obviously have

1 to have power. So I'm asking that we understand what our  
2 priority is going to be and how this will be met in the face  
3 of today's crisis and the future problems that we will be  
4 having in this area.

5 MR. YUEN: Well, I'm sure that's a very important  
6 consideration, but for the purpose of this hearing, I think  
7 it's just beyond application insofar as the hearing is con-  
8 cerned. But I'm sure that will be a major item of considera-  
9 tion.

10 MS. HUMPHRIES: I know, but under our tentative  
11 plans, and these are some of the things which you are suggest-  
12 ing, that this is the way that the plant will be built and  
13 this is the way it will be powered, and this is something  
14 that will have to be thought through by the committee, and you  
15 will have to pay some attention to this area. I'm not expect-  
16 ing you to give me some answers right now. I'm just suggest-  
17 ing that this be given some thought in depth because it is  
18 important. We might find out that we've been put at the end  
19 of the list because of the energy crisis, and to stay at the  
20 top of the list, we have to plan for that now. Thank you.

21 MR. YUEN: Alright. We'll give it the serious  
22 thought it really deserves. Okay, is there anyone else that  
23 would like to testify at this time? Yes, sir.

24 MR. BANNER: I've spoken to this group several  
25 times before, or substantially groups like this, on the

1 pollution of Kaneohe Bay. My name is Banner; I'm with Marine  
2 Life, and I just want to really reinforce the point that was  
3 brought across by Dr. Helfrich and the others that it is still  
4 far in the future and we still have an increasing crisis in  
5 Kaneohe Bay, and we should by every means possible decrease  
6 -- no, wait, prevent the increase of sewage going into the  
7 bay until such as a time the sewage outfall is made. The  
8 bottom life, the plankton in the bay, is in a very bad fix  
9 and we should, the people in the area, should try to keep more  
10 effluent from going into the bay until such time as we can  
11 get the deep water outfall. Thank you.

12 MR. YUEN: Is there anyone else who wishes to testi-  
13 fy at this time? If not, I would like to mention that we  
14 have received communications from the Public Works office at  
15 Kaneohe Marine Corps Air Station and also Mr. Robert R. Way,  
16 Chief Planning Officer of the City and County of Honolulu,  
17 both supporting the project.

18 WRITTEN TESTIMONY OF THE PUBLIC WORKS OFFICE  
19 KANEOHE MARINE CORPS AIR STATION

20 Thank you for your letter of December 27, 1973 ad-  
21 vising of the upcoming Public Hearing on the Kaneohe-Kailua  
22 Sewage System. We are vitally interested in preserving Kaneohe  
23 Bay and as noted in the enclosed letter, fully support the  
24 proposed comprehensive sewage program.

25 I or my representative will attend your hearing and

1 would be pleased to answer questions which may arise with  
2 respect to our pump station and connecting force main or  
3 other pertinent items. In the interim, please feel free to  
4 call on me should the need arise.

5 COPY OF LETTER APPENDED TO WRITTEN TESTIMONY OF THE  
6 PUBLIC WORKS OFFICER, KANEHOHE MARINE CORPS AIR STATION

- 7 1. Enclosure (1), a Public Notice pertaining to proposed  
8 construction of an ocean outfall sewer at Mokapu Point, Oahu,  
9 has recently been received and reviewed. Enclosure (1)  
10 solicits comments from interested parties so that a decision  
11 can be made on whether to award a permit for construction of  
12 the outfall sewer.
- 13 2. The project, as proposed, appears to be the most effective  
14 means for meeting State water quality standards. The City has  
15 assured us that discharges from the proposed outfall sewer  
16 will not creat any significant adverse environmental impact  
17 on Kailua Bay.
- 18 3. Joint use of the proposed outfall sewer by the City and  
19 this Station is of particular significance. This sharing is  
20 in accordance with direction provided by the President of the  
21 United States in Executive Order 11507. This Station current-  
22 ly has funded VY'73 MILCON Project P-146, "Municipal Sewer  
23 Connection" to effect connection of Station sewage to the  
24 proposed City project. We have actively supported the Mokapu  
25 Outfall Sewer since its inception, have worked with the City

1 and its consultants on planning and real estate matters to  
2 date, and will continue to provide necessary support and  
3 assistance as we believe that the outfall is a valid require-  
4 ment, vital to the public interest.

5 4. Accordingly, it is requested that our support for the  
6 proposed project be conveyed to the Corps of Engineers in  
7 accordance with the provisions of enclosure (1).

8  
9 WRITTEN TESTIMONY OF THE CHIEF PLANNING OFFICER,  
CITY AND COUNTY OF HONOLULU

10 This is in response to the public hearing notice  
11 issued by Mayor Frank P. Fasi concerning the Kaneohe-Kailua  
12 Sewer System.

13 The proposed system is generally consistent with  
14 the intent and objectives of the General Plan, which states  
15 that "sewage facilities are required ancillary public utili-  
16 ties for urbanizing communities."

17 However, as anticipated in your Draft Environmental  
18 Impact Statement, there will be a need to amend the General  
19 Plan for certain sewer system facilities such as pump stations  
20 when specific site locations are identified.

21 Please contact Mr. Charles Prentiss of my staff at  
22 546-8048 if you have any further questions concerning this  
23 matter.

24 MR. YUEN: I might mention at this time that these  
25 letters and others which we expect may be received within the



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next few days will be considered and included in the proceedings of this hearing.

I want to thank all of you for coming this evening and particularly those of you who testified, and I would like to especially commend this audience for being courteous and orderly and very thoughtful. I think it's very refreshing to see an audience like this at a public hearing. We accomplished very much in the short time that we have spent on this hearing, and I would like to assure you that all of your comments will be considered before we make our final determination. So at this time, I would like to declare this hearing closed. Thank you very much and good night.

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C E R T I F I C A T E

I, Ray P. Russell, Certified Shorthand Reporter, do hereby certify:

That I reported in machine shorthand the proceedings had in the matter entitled as upon the first page hereof; that I thereafter caused the same to be reduced to type-writing; that the foregoing pages contain a full, true, and correct statement of the proceedings had in said matter and a true, full, and correct transcript of my machine stenographic notes taken of the proceedings had thereat.

DATED: 29 Jan 1974

Ray P. Russell

APPENDIX B - COMMENTS  
ON THE DRAFT STATEMENT

CONTENTS OF APPENDIX B: COMMENT LETTERS

<u>City and County</u>	<u>Page</u>
Board of Water Supply	B-1
Department of Land Utilization	B-2
Department of General Planning	B-3
Department of Transportation Services	B-4
<u>State of Hawaii</u>	
Department of Agriculture	B-5
Department of Planning and Economic Development	B-6
Department of Transportation	B-7
<u>Federal Agencies</u>	
Department of Agriculture	B-8
Department of the Air Force	B-9
Department of Commerce	B-10
Army Corp of Engineers	B-12
Fourteenth Naval District Headquarters	B-15
<u>Others</u>	
Environmental Center, University of Hawaii	B-17
Hawaii Public Health Association	B-21
Hawaii Section-American Society of Civil Engineers	B-24
Kahaluu Coalition	B-25
The Outdoor Circle	B-28
Windward Regional Council	B-30

DEPARTMENT OF WATER SUPPLY

TERMINAL AND COUNTY OF HONOLULU

630 SOUTH BERETANIA

POST OFFICE BOX 3410  
96843  
HONOLULU, HAWAII 96801



STANLEY W. DEAN  
GEORGE A. YUEN  
EDWARD T. OHATA  
WALTER D. WARD  
ROBERT H. RUTZ  
E. ALVIN WRIGHT  
GEORGE A. YUEN  
Manager and Chief Engineer

December 6, 1973

Dr. Richard E. Marland  
Interim Director  
Office of Environmental Quality Control  
550 Halekauwila Street  
Honolulu, Hawaii 96813

Dear Dr. Marland:

Thank you for sending us the "Draft Environmental Impact Statement for Kaneohe - Kailua Sewer System" for our review and comments.

The proposed project is not anticipated to adversely affect our present and future potable water resources. However, we recommend close coordination between agencies during the planning and construction phases of the project to insure protection of our existing mains.

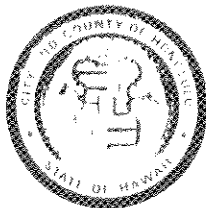
Please contact us for any further information required on this matter.

Very truly yours,

John Y. C. Chang  
Acting Chief - Planning, Resources  
and Research Division

629 POHIKAINA STREET  
HONOLULU, HAWAII 96813

FRANK F. FASI  
MAYOR



GEORGE S. MORIGUCHI  
DIRECTOR

WILLIAM E. WANKET  
DEPUTY DIRECTOR

LU11/16-1480  
(WEW)

November 20, 1973

MEMORANDUM


TO : RICHARD E. MARLAND, INTERIM DIRECTOR

FROM : GEORGE S. MORIGUCHI  
DIRECTOR OF LAND UTILIZATION

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT  
FOR KANEOHE-KAILUA SEWER SYSTEM

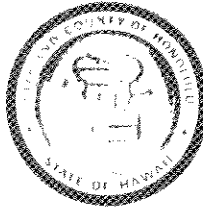
It appears that the implementation of this system will involve work within the shoreline setback area as well as subdivision activity. Compliance with the Subdivision Rules and Regulations and the Shoreline Rules and Regulations will be required.

GSM:dc

  
GEORGE S. MORIGUCHI  
Director of Land Utilization

29 POHUKAINA STREET  
HONOLULU, HAWAII 96813

FRANK F. FASI  
MAYOR



ROBERT R. WAY  
CHIEF PLANNING OFFICER

DONALD A. CLEGG  
DEPUTY CHIEF PLANNING OFFICER

DGP11/73-931 (MM/CT)

December 27, 1973

MEMORANDUM

TO : DR. RICHARD E. MARLAND, INTERIM DIRECTOR  
OFFICE OF ENVIRONMENTAL QUALITY CONTROL

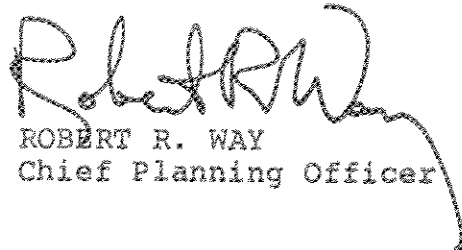
FROM : ROBERT R. WAY, CHIEF PLANNING OFFICER

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE  
KANEHOHE-KAILUA SEWER SYSTEM

We have reviewed the draft report in the context of the objectives of the General Plan of the City and County of Honolulu and find no apparent conflicts. This proposed system is an element of the officially-approved comprehensive Sewer Functional Plan of the City and County of Honolulu and is in accord with the objectives for the elimination and abatement of water pollution in the City and County of Honolulu. The proposed system is also an element of the State's Water Quality Management Program.

A generalized delineation of the proposed service areas on Figure I-12, showing how the population projected in Table I-VI-3 is expected to be distributed, would be helpful in providing an understanding of the relationship of the sewerage system to the officially-adopted plans for the area. It is indicated in the draft EIS that amendments to the General Plan and Detailed Land Use Maps will be necessary for some elements of the proposed sewerage system.

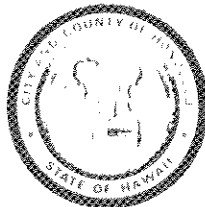
Thank you for the opportunity to comment on the subject draft EIS.

  
ROBERT R. WAY  
Chief Planning Officer

RRW:et

DEPARTMENT OF TRANSPORTATION SERVICES  
**CITY AND COUNTY OF HONOLULU**

CITY HALL ANNEX  
HONOLULU HAWAII 96813



FRANK P. FABI  
MAYOR

PAUL DE VENS  
MANAGING DIRECTOR

GEORGE C. VILLEGAS  
DIRECTOR

ROY A. PARKER  
DEPUTY DIRECTOR

December 10, 1973

Dr. Richard E. Marland  
Interim Director  
Office of Environmental  
Quality Control  
State of Hawaii  
550 Halekauwila St., Rm. 301  
Honolulu, Hawaii 96813


Dear Dr. Marland:

Subject: Draft Environmental Impact Statement for  
Kaneohe-Kailua Sewer System

When the plans for the above project were first submitted to this office by the design engineers, we found no objection to the closure of streets affecting Kaneohe Bay Drive. However, upon reviewing the contents of the Draft Environmental Impact Statement (pages II-64-65), we find it involves our City bus route.

Being that Kaneohe Bay Drive is one of the major routes, we request that one lane be kept opened or other provisions be made to permit buses through passage. Should the roadway be closed for the convenience of construction in short increments (as stated), the only bypass is via the Mokapu Saddle Road. Utilizing the bypass will inconvenience the Kaneohe Bay Drive passengers and/or defeat continued service until the entire narrow segments of Kaneohe Bay Drive is completed.

Sincerely,

  
GEORGE C. VILLEGAS  
Director

JM:fhe



JOHN A. BURNS  
GOVERNOR



FREDERICK C. ERSKINE  
CHAIRMAN, BOARD OF AGRICULTURE

WILLIAM E. FERNANDES  
DEPUTY TO THE CHAIRMAN

STATE OF HAWAII  
DEPARTMENT OF AGRICULTURE  
1428 SO KING STREET  
HONOLULU, HAWAII 96814

November 29, 1973

MEMORANDUM

TO: Dr. Richard E. Marland, Interim Director  
Office of Environmental Quality Control

SUBJECT: Draft Environmental Impact Statement for  
Kaneohe-Kailua Sewer System

The basic goal is to achieve and maintain a high level of marine water quality in Kaneohe Bay and its nearshore waters. The consequences of diverting fresh water from the inshore boundaries are only partially addressed. Biological effects of nutrients and silt loads are recognized, but the importance of maintaining a brackish water breeding and nursery zone is not even mentioned.

Effects of coral are thoroughly documented leaving the implication that viable coral within the fringe is a desirable attribute. Documentation and survey data on fish populations are sketchy.

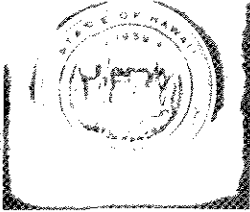
The consequence of this proposed diversion of waste water may well be restoration of coral, protection of water contact activities, but at a loss of our already limited nursery areas. The option of recharge of treated waste water into the salt water margin is dismissed without considering its environmental effect. The emphasis is directed to sole the goal of offshore dispersion and how to achieve this at a minimum cost. The present level of total waste water diversion from the shoreline zone is estimated at about 8 mgd of a total flow estimated runoff 75 mgd.

There are no immediate effects of the proposed system on agricultural activities. However, the long-range effect will be to favor urban development with more "waterproofing" of the infiltration zones now provided by agricultural activities. The long-range effects of the plan may well be elimination of the productive zones suitable for bananas. This effect may be of minor consequence when contrasted with the elimination of natural marine productivity associated with commercial and recreational fisheries.

The effect of the system on the livestock liquid wastes is noted. These wastes are presently managed to achieve productive controlled recycling of the waste water. These activities are mentioned briefly and probably adequately.

Thank you for the opportunity to comment on this matter.

*Frederick C. Erskine*  
FREDERICK C. ERSKINE  
Chairman, Board of Agriculture



DEPARTMENT OF PLANNING  
AND ECONOMIC DEVELOPMENT

P. O. BOX 2359 • HONOLULU, HAWAII 96804

STATE OF  
HAWAII

December 10, 1973

JOHN A. BURNS  
Governor

SHELLEY M. MARK  
Director

EDWARD J. GREANEY, JR.  
Deputy Director

Ref. No. 007t

MEMORANDUM

TO: Dr. Richard E. Marland, Interim Director  
Office of Environmental Quality Control

FROM: Shelley M. Mark, Director *SM*

SUBJECT: Draft EIS for Kaneohe-Kailua Sewer System

We have reviewed the above subject draft and have no major changes or additions to suggest at this time. The draft appears to fulfill the paramount purpose of being a "full-disclosure" document and the preferred alternatives are supported by data.

We concur with the urgency to relieve, as much as possible, the nutrient and sediment load which is contributing to the continued deterioration of water quality and ecosystem equilibrium in Kaneohe Bay.

We might mention that in regard to noise from construction due to the use of piles, that there are techniques which might be applicable which are able to solve the load-bearing problems without piles.

Please keep us informed of the construction schedule for this project as information becomes available.



DIRECTOR

LAWRENCE F. O'NEILL  
DEPUTY DIRECTOR

MUNNY Y. M. LEE  
DEPUTY DIRECTOR

DOUGLAS S. SAKAM  
DEPUTY DIRECTOR

## STATE OF HAWAII

### DEPARTMENT OF TRANSPORTATION

869 PUNCHBOWL STREET  
HONOLULU, HAWAII 96813

IN REPLY REFER TO:  
ATP 8.2446

December 21, 1973

Dr. Richard E. Marland  
Interim Director  
Office of Environmental  
Quality Control  
550 Halekauwila St., Room 301  
Honolulu, Hawaii 96813

Dear Dr. Marland:

Subject: Draft Environmental Statement  
Kaneohe-Kailua Sewer System

We have reviewed the above subject Statement and have concluded that the future of our Heeia-Kea Boat Harbor facilities will be greatly enhanced when sewer discharge connection capabilities become available. Please be informed that we will again be reviewing the final outfall design prior to construction since a Shorewater Construction Permit issued by our Harbors Division is required. Also, all work must comply with our "Rules and Regulations Relating to the Accommodation and Installation of Utilities on State Highways and Federal-Aid Secondary County Highways".

On pages I-35 to I-36, the author compared tables I-V-5 and I-V-6 and concluded that rezoning of agricultural lands must be considered if the population of the district is to be increased. In our judgment, the adequacy of zoning cannot be determined by merely evaluating the tables. The amount of land general planned for residential purposes and presently vacant or in agricultural use is a better indicator of capacity.

Sincerely,

*Douglas S. Sakam*  
f E. ALVEY WRIGHT  
Director

UNITED STATES DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

---

440 Alexander Young Bldg., Honolulu, HI 96813

December 17, 1973

Dr. Richard E. Marland  
Office of Environmental Quality Control  
Room 301, 550 Halekauwila St.  
Honolulu, HI 96813

Dear Dr. Marland:

We are submitting our comments concerning the Kaneohe-Kailua Sewer System Draft Environmental Impact Statement as you requested in your transmittal letter of November 8, 1973.


Page I-54: The second sentence states: "There appears ... ground cover, etc." We do not concur in this statement. There does exist information, developed by the Agricultural Research Service, University of Hawaii, and Soil Conservation Service, concerning sediment load with respect to soils, land use, topography, vegetation, etc.

Page II-80, 129, 171: On these pages you have referred to "flood control project," "Kahaluu Watershed Project," and "Kahaluu Flood Control Project" respectively. We recommend consistent use of these terms. The proper name is Kahaluu Watershed Project. We also recommend that, to better orient the public, the EIS include the names of the sponsors of the project. The Kahaluu Watershed Project is sponsored by the Windward Oahu Soil and Water Conservation District and the City and County of Honolulu. This project is authorized under the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended.

Page II-130: The information in parenthesis would be more descriptive if it read: "... (now intended for water-based recreation and flood control)..." Recreational facilities are planned for inclusion within this project.

Page II-159: The EIS would be stronger if it stated whether or not composting of municipal refuse was definitely planned or was definitely being considered. As the statement now reads, the reader is left with the impression that consideration of refuse disposal has not been considered.

Very truly yours,

  
Francis C. H. Liu  
Soil Conservationist

For your information:

Page II-82 - typographical error - overall grading plan not plant.

Page II-129 - typographical error - the word preventing in line 9 should probably be permitting.

DEPARTMENT OF THE AIR FORCE  
HEADQUARTERS 15th AIR BASE WING (PACAF)  
APO SAN FRANCISCO 96353



REPLY TO  
ATTN OF DEEE

20 DEC 1973

SUBJECT: Draft Environmental Impact Statement

TO: Office of Environmental Quality Control  
Office of the Governor  
550 Halekauwila Street  
Tani Office Building, Third Floor  
Honolulu, Hawaii 96813

1. Reference is made to your letter of 8 Nov 73, subject as above.
2. This office has no comment to render relative to the draft environmental impact statement for the Kaneohe-Kailua Sewer System project.

A handwritten signature in cursive script, appearing to read "Susan M. Yamada".

SUSAN M. YAMADA  
Asst Dep Comdr for Civil Engrg

DEPT. OF  
FEB 12 10 03

National Marine Fisheries Service  
West Region  
1300 South Ferry Street  
Terminal Island, California 90731

January 22, 1974 TO

Colonel Leonard Edelstein  
District Engineer  
Honolulu District  
Corps of Engineers  
Building 96, Fort Armstrong  
Honolulu, Hawaii 96813

1-28  
FEB 13 AM 11 28

RECEIVED  
DIVISION OF SEWERS

Dear Colonel Edelstein:

Subject: Public Notice No. PODCO-0 1106-S, dated 3  
December 1973 - Proposed Mokapu Ocean Outfall  
Sewer at Kaneohe, Oahu, Hawaii

We have reviewed the above permit application, utilizing the draft EIS for the project prepared by the Department of Public Works, City and County of Honolulu. We have several comments concerning the proposed outfall location and recommend that consideration is given to those points before the permit is issued.

1. Moku Manu Islands and their southeast fringing reefs lie approximately one mile north of the proposed outfall site. These offshore islands have some of the most viable coral reefs on the windward side of Oahu. This is primarily because they are situated far enough offshore to protect them from the large amounts of freshwater runoff and accompanying sediment loads which adversely affect most of the near-shore windward reefs of Oahu. Studies outlined in the draft EIS indicate that during the months of April to August, particularly during flood tide conditions, the surface and subsurface current flow is to the north and northwest. Dye and drogoue cast results during this period indicate effluent transport from the proposed outfall site would be directly across the Moku Manu reefs. We recommend this problem be studied in greater detail, especially with regard to the degree of effluent dilution at the time the effluent reaches the above mentioned reef area.

2. Extensive live coral formations are evident from the outfall water entry zone to a depth of about 40 feet.

Page 2  
January 22, 1974  
Colonel Edelman


From the 40-foot isobath to a depth of 100 feet the bottom consists of hard limestone substrate with occasional live coral colonies consisting of Pocillopora meandrina, Porites compressa, and P. lobata. This is mentioned in the EIS and has been substantiated by inspection dives.

We recommend that selection of final underwater outfall alignment be done in order that a minimum of viable coral will be destroyed. Trenching techniques should be carried out with as little blasting as possible.

3. A biological monitoring program should be established after the ocean outfall becomes operational. This program should be detailed in the final project EIS. Baseline surveys, especially for the Moku Manu area, should be made prior to construction. If the marine environment is found to be deteriorating significantly beyond baseline data in surrounding areas such as Kailua Bay or Moku Manu, then adjustments (i.e. extension of the outfall into deeper water) should be made. These adjustments should be anticipated and outlined in the final EIS.

We believe the good points of this project far outweigh the possible adverse effects. This is evident when considering the conditions of Kaneohe and Kailua Bays and how this project should improve these conditions. Therefore, we would not object to the issuance of this permit if the preceding requests are considered. We would appreciate early notification of your action in this regard.

Sincerely,

  
Gerald V. Howard  
Regional Director



HONOLULU DISTRICT COLLEGE OF ENGINEERS  
BUILDING 96, FORT ARMSTRONG  
HONOLULU, HAWAII 96813

PODED-P

28 December 1973

Dr. Richard E. Marland  
Office of Environmental Quality Control  
State of Hawaii  
550 Halekauwila Street  
Honolulu, Hawaii 96813

Dear Dr. Marland:

We have reviewed the draft EIS for the Kaneohe-Kailua Sewer System and thank you for the opportunity to make the following comments:

- a. The application by the City and County of Honolulu to the Corps of Engineers for issuance of a permit under authority of the River and Harbor Act of 1899 for construction of the Mokapu Outfall should be mentioned in the EIS.
- b. The EIS should discuss the requirements of the Federal Water Pollution Control Act amendments of 1972 (PL 92-500) with regard to the possible need for a National Pollutant Discharge Elimination System (NPDES) permit for a discharge of outfall water which may not meet applicable water quality standards.
- c. The site of the proposed Kahaluu Wastewater Treatment Plant is within a flood hazard area. The EIS should include a discussion of this problem with regard to the immediate flood hazard to the proposed treatment plant and in terms of the cumulative primary and secondary impacts on the Kahaluu community of the treatment plant and the proposed flood control project if the two are to be coordinated in implementation.
- d. The EIS should state the sequence of programming of construction so as to clarify the impacts of implementation of each part of the proposal.
- e. The entire sewage disposal system as outlined in the EIS would provide capacity for considerable population growth in the region. The EIS states that for projection purposes population growth was allocated equally throughout the three service areas. Yet in the North Kaneohe

28 December 1973

Bay area (area 1--Kahaluu) only a small portion of the land is zoned urban, and the EIS states (I:36) that "...rezoning of agricultural lands must be considered if the population of the district is to be increased." From these statements it is not clear that the population growth for which the system is designed is provided for in the General Plan, nor is it clear where the growth is to occur.

Placement of the facilities will reduce options for growth if the General Plan has not specified the areas to be developed. The EIS should discuss consonance with the General Plan of the subject proposal and in addition should consider the economic, social, and environmental impacts of population growth and developments upon existing communities and land uses.

f. Although the EIS discusses the pollution which has taken place in the south sector of Kaneohe Bay, the EIS does not discuss the effects on the bay from the removal of the effluent other than to state that "... (removal will) permit the bay to recover, to a limited degree, to its former conditions (II-224)." Since the EIS discusses such contributors to bay degradation as urban storm water runoff and siltation as well as sewage effluent, it would be helpful to summarize existing knowledge about the relative loads of nitrogen, phosphorous, and other water quality parameters from these diverse sources. This should be followed by some discussion of the effects on bay restoration which may or may not be achieved through effluent diversion to the Mokapu Outfall.

g. The EIS states that sludge disposal is proposed to be at the Kailua dump. Effects on water quality of Kawainui Swamp should be discussed, with consideration for the quality of the sludge and leachate which may flow to the swamp. This sludge disposal alternative should also be discussed in reference to the proposed Kawainui Park.

h. If the Mokapu Outfall effluent is chlorinated, the potential effects of chlorine on receiving waters and biota should be discussed in the EIS.

i. We would like to see the EIS present an estimated display of the extent of areal coverage that the surface plume would have during normal trade winds, kona winds, tidal changes, and winter storms, for the quantity of effluent discharge.

j. The discussion concerning backfilling of the outfall trench (II:46) should include the estimated quantities of quarry stone required, its source, and the impact on traffic along the haul route. Deposition of the excavated material alongside of the trench (II:49) will result in siltation and erosion impacts which are not addressed in the EIS.

FODED-P

28 December 1973

Dr. Richard E. Marland

k. "The refusal of the Army Corps of Engineers to issue a permit until an EIS was prepared,..." (II:48) should be deleted since it is erroneous and out of context.

l. Underwater construction across Kaneohe Stream (II:75) will also require a Department of the Army permit. An application for this work has not been received.

m. The sludge disposal sites for the existing sewage treatment plants are not identified nor is the sludge disposal site for the proposed Kahaluu sewage treatment plant (II:167) adequately identified and discussed. What are the life expectancies of the existing and proposed disposal sites? What alternate land disposal sites were considered?

n. If the proposed sludge disposal site in Kawainui Swamp is subject to tidal action, a Department of the Army permit may be required for the land fill.

Sincerely yours,



ELROY K. C. CHINN  
Acting Chief, Engineering Division

Copy furnished:  
City & County of Honolulu  
Division of Sewers

HEADQUARTERS  
FOURTEENTH NAVAL DISTRICT

BOX 110  
FPO SAN FRANCISCO 96610

IN REPLY REFER TO:

48A:RMC:el

Ser 4168

20 DEC 1973

Dr. Richard E. Marland  
Interim Director  
Office of Environmental Quality Control  
550 Halekauwila Street  
Honolulu, Hawaii 96813

Dear Dr. Marland:

In reference to your memorandum of 8 November 1973 which forwarded the draft environmental statement for the Kaneohe-Kailua Sewer System, the following Navy comments are forwarded:

Page I-73 Kaneohe Marine Corps Air Station - The third sentence should be revised to read: "The main components of the facility are the air degriter unit, primary clarifier, digester, trickling filter, final clarifier, one acre detention pond and an effluent pump station to transmit the treated effluent to the golf course irrigation system. About 500,000 gallons of the treated effluent is used daily to irrigate the golf course and the balance is presently discharged through a 20-inch outfall extending between Halekou Pond and KMCAS Pier approximately 500 feet into 15 feet of water".

Page II-40 Construction Impact - This section of the report should mention the land portion of the outfall being close to the bird sanctuary areas. As such, all construction work, including blasting, should be kept to the very minimum. The same precautions should apply to areas where the outfall is going to be relatively close to family housing. Nuisance to families as well as possible damage to underground utilities should be considered.

Page II-55 Traffic - Arrangements must be made to provide adequate detour routes so as not to disrupt the traffic at the entrance to KMCAS, any more than necessary. Also temporary parking areas should be provided if existing parking areas are going to be affected by the new construction.

Page II 115 and 116 - The Nuupia Pond and adjoining area is now a bird sanctuary and the construction of the outfall

48A:RMC:el  
Ser 4168

will have some impact, at least during construction and should be examined.

Thank you for the opportunity to comment on this draft EIS.

Sincerely,



L. G. TIMBERLAKE  
CAPTAIN, CEC, USN  
DISTRICT CIVIL ENGINEER  
BY DIRECTION OF THE COMMANDANT



# University of Hawaii at Manoa

Environmental Center  
Maile Bldg. 10 • 2540 Maile Way  
Honolulu, Hawaii 96822  
Telephone (808) 948-7381

Office of the Director

January 9, 1974

## MEMORANDUM

TO: Richard Marland  
FROM: Jerry M. Johnson  
SUBJECT: Kailua-Kaneohe Sewerage Plan EIS

Participating in this review at the request of the Environmental Center were A. H. Banner, Zoology and Hawaii Institute of Marine Biology; Doak C. Cox, Hawaii Environmental Simulation Laboratory; Gordon Dugan, Civil Engineering and Hawaii Environmental Simulation Laboratory; Jed Hirota, Hawaii Institute of Marine Biology; Jerry Johnson, Environmental Center and Public Health; John Maciolek, Cooperative Fisheries Unit; T. K. Newbury, Oceanography and Edward Stroup, Oceanography.

In general, this is a well written, comprehensive and thorough EIS with which we have no major disagreements concerning the data, interpretations and conclusions presented therein. Certainly the Department of Public Works should be commended for the effort expended in its preparation. However, whenever a statement is prepared in such depth and detail, the reviewer is bound to find some areas of disagreement. This statement is no exception. Keeping that thought in mind, we offer the following comments.

1. The KMCAS is recycling some effluent for golf course irrigation (I-21). The plan apparently is economically feasible and desirable, perhaps because the effluent contains important nutrients. Yet the EIS shows no plans for recycling effluent for similar purposes in other localities in Kaneohe-Kailua. In this area there are at least five golf courses and two cemeteries, plus the grounds of hospitals and correction homes. The EIS indicates that recycling of effluent is neither economically feasible nor desirable (II-175), which seemingly contradicts the conclusion of the KMCAS. In the EIS it is stated that there is sufficient water available, and therefore there is no need to recycle; but were the estimates of sufficient fresh water based on the predicted population level? The EIS indicates, also, that use of recycled water will degrade the potable water resources, but neither the use of effluent by the KMCAS nor the presence of many septic tanks in the Kaneohe-Kailua-Kahaluu area seem to have threatened the fresh water supply in the Koolaus. The EIS should consider more seriously the uses of and provisions for recycled effluent.

January 9, 1974

2. The sewer line will pass through the water bodies between Mokapu Peninsula and mainland Kailua. These water bodies were once royal fishponds (I I-114) and are probably of archaeological interest. The EIS ought to consider possible cooperation with archaeological groups, such as the Bishop Museum, during this phase of the operation because of the chance of turning up artifacts or sites.

3. Miscellaneous Comments.

- a. p. I-1, P.1. The objective of a water quality management program ought not necessarily to be to minimize pollution, but to optimize the control of pollution with respect to overall, long-term human interests.
- b. p. I-5, P.2. Not all sanitary engineers would agree that the combination of extremes of treatment and an extreme outfall length would always provide excellent results. In addition to the economic disadvantages of such a combination, there might well be local environmental disadvantages (as would be the case at Sand Island), and there would certainly be overall environmental disadvantages in the commitments of materials and energy required.
- c. p. I-25, P.2.(a) Fossil reefs do not grow.
- (b) An ideal caprock structure for underground injection need not involve a lower stratum of impermeable material. If the head of the bedrock basal groundwater is high, all flow would be from the bedrock to the caprock aquifers, and no contamination of the caprock should occur. Much more important considerations are the location of the ocean discharge area of the aquifer in which the injection will be made and the rate of natural flow through the aquifer. Nearshore discharge through a caprock aquifer with a low natural discharge rate might have very nearly the same ecological effects as near-shore discharge through an ocean outfall. Some of the listed potential areas for underground injection may be ruled out on this account.
- d. p. I-50, P.2. The phosphorus values may represent total phosphorus, or phosphate phosphorus and may be reported as phosphorus or as phosphate, but cannot be "total phosphorus (in phosphate)."
- e. p. I-51, Ps.2 & 3. and table I-NI-4. The estimates of stream nutrient loads from the OWQP study are shaky if there is "no discernable pattern between nutrient loads and stream discharge."

January 9, 1974

- f. p. I-52, P.3. The estimates of sediment deliveries to Kaneohe Bay derived from stream sampling do not agree, by a factor of at least 3 or 4 and possibly nearly 10, with estimates of sediment accumulations in the Bay (Roy, 1970).
- g. p. I-54, P.1. It is true that there appears to be no analyses of the relation of sediment load of streams to land use. However, the HESL study of the relationship between soil loss and land use is a start (Bartram, 1973).
- h. p. I-85, P.2. No reference is made to the studies of the conditions off Mokapu, in the area proposed for the outfall, by a group of UH students under the Marine Options Program. Were the results of these studies available and used?
- i. p. I-92, P.2. and Fig. I-14. This figure appears to be based in part on Laevastu, Avery & Cox 1950 via the OWQP report, though the earlier report is not cited.
- j. p. I-148, P.1. Is ref. 13. the product of the Marine Options Program referred to in the comment on p. I-85, P.2.?
- k. p. I-203, P.3., et seq. No consideration seems to have been given to the tsunami hazard.
- l. p. II-88, P.3. et seq. It is questioned whether the discharges of nutrients and suspended solids to Kaneohe Bay will be "substantially terminated" by the diversion of the sewage effluents from the Bay. They will be greatly reduced but the statement overlooks the contributions of the streams. As pointed out in p. II-89, P.2., the leachate from cesspools will be reduced in time, but the usage of fertilizers in the region will continue to produce nutrients and the streams will continue to contribute suspended solids of erosional origin.
- m. p. II-182, P.2. See comment (b) on p. I-25, P.2.
- n. p. II-203, P.3. et. seq. In addition to the turbidity resulting from the excavation, the possible increase in nutrients by the dredging of high-nutrient sediments should not be overlooked as a disadvantage of Alternative 1.
- o. p. II-205, P.2. A high pumping lift but not a high static head would result over the Mokapu Saddle road from Alternative 3.



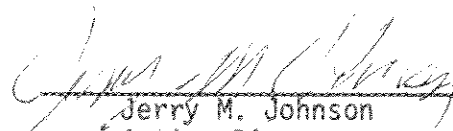
January 9, 1974

## p. Misspellings etc.

I-166, Table I-IX-4	<u>Naviculla</u> → <u>Navicula</u>
I-167, " "	<u>Neocalanus gracilie</u> → <u>N. gracilis</u>
I-168, " "	<u>liauphilus</u> → <u>Liauphilus</u>
I-168, " "	<u>Corycarus</u> → <u>Corycaeus</u>
I-169, Table I-IX-5	<u>Nitzchia</u> → <u>Nitzschia</u>
" " "	<u>Skeletonema costaum</u> → <u>S. costatum</u>
" " "	<u>Pleuposigma delicatulum</u> → <u>Pleurosigma delicatulum</u>
I-210, 4th line from bottom: plague-forming → plaque-forming	
I-211, 6th line from bottom: Aeromanas → Aeromonas	
I-218, 6th line from bottom: (MPM) → (M.P.N.)	

## 4. References

- Bartram, P., 1973. Erosion in the Kaneohe Watershed: Background and Techniques for Estimating Soil Loss. Hawaii Environmental Simulation Laboratory Working Paper 72-003.
- Roy, K. J., 1970. Change in Bathymetric Configuration, Kaneohe Bay, Oahu, 1882-1969. Hawaii Institute of Geophysics, Univ. of Hawaii, HIG-70-15.

  
 Jerry M. Johnson  
 Acting Director

cc: Contributors




Director and Chief Engineer  
Department of Public Works  
Page 2  
January 14, 1974

We are pleased the plan proposes to incorporate the effluent from the Kailua sewage treatment facilities since we believe that outfall is too close to shore and to recreational areas. If this is not altered, it would probably only be a matter of time before the recreational waters of Kailua Bay become fouled with the sewage of its own citizens.

The HPHA considers that the proposed system a wise move and urges its implementation at the earliest possible time.

Sincerely,



Jerrold M. Michael  
President

JMM:myo

Attachment

SELECTED ACUTE ILLNESS CONDITIONS  
POSSIBLY ASSOCIATED WITH POLLUTED WATER

Typhoid and paratyphoid fever  
Dysentery, all forms, not elsewhere classified (NEC)  
Other infectious diseases, intestinal tract, NEC  
Streptococcal sore throat  
Hepatitis (infectious)  
"Virus" (infection) ill defined or not otherwise stated (NOS)  
Other diseases due to viruses, NEC  
Dermotophytosis (athlete's foot)  
Conjunctivitis and ophthalmia  
Stye  
Other inflammatory diseases of eye  
Inflammatory diseases of ear  
Other acute upper respiratory infections  
Influenza with digestive manifestations  
Gastro-enteritis, acute, NEC  
Boil and carbuncle, NEC  
Jaundice, NOS



RECEIVED  
DEPT. OF PUBLIC WORKS

JAN 16 10 09 AM '74

HAWAII SECTION—AMERICAN SOCIETY OF CIVIL ENGINEERS

P. O. BOX 917  
HONOLULU, HAWAII 96808

*D.W. [unclear]  
Dep [unclear]  
Enr [unclear]  
Sewer (copies)*

January 14, 1974

Mr. Edward Hirata  
Director and Chief Engineer  
Department of Public Works  
City and County of Honolulu  
Honolulu, Hawaii 96813

Dear Mr. Hirata:

KANEOHE-KAILUA SEWER SYSTEM

The Hawaii Section of the American Society of Civil Engineers, consisting of 520 members in the State, wishes to go on record as commending the Department of Public Works for their well-written, comprehensive and thorough Environmental Impact Statement for the Kaneohe-Kailua Sewer System.

In almost any document that requires detailed preparation, there is likely to be areas of disagreement. In this case, however, these areas are relatively minor and in concept the Society concurs with the data, interpretations and conclusions presented therein.

The Hawaii Section recommends prompt construction of the system to help improve the quality of Windward coastal waters.

Sincerely,

*Howard Schirmer, Jr.*  
Howard Schirmer, Jr.  
President  
Hawaii Section--A.S.C.E.

HAS:gn  
(Three copies submitted)

Kahaluu Coalition  
47-253 Waihee Road  
Kaneohe, Hawaii 96744  
December 20, 1973

Dr. Richard E. Marland  
Office of Environmental Quality Control  
550 Halekauwila Street, Room 301  
Honolulu, Hawaii 96813

Dear Dr. Marland:

The Kahaluu Coalition of Community Organizations endorses the concept of the ocean outfall sewage disposal system to serve the Kailua, Kaneohe, Kahaluu region. The deterioration of Kaneohe Bay is of great concern to us. The ocean outfall system will eliminate pollution of the Bay by sewage. Overall, we endorse the ocean outfall because the present level of sewage is already threatening the Bay with irreparable damage.

While endorsing the system as a whole, we would like to voice our objections to the selection of the site for the Kahaluu sewage treatment plant. The original designation of twenty acres in the middle of the Kahaluu flood plain in 1964 for a sewage treatment plant and the preparation of the EIS were done without consultation with Kahaluu residents. In fact, the Public Facilities Committee of Hui Koolau (before the formation of the Coalition) was led to believe that the City had no intention of using the designated site for a treatment plant. It was led to believe, until a year and a half ago, that sewage from Kahaluu would be treated at Kualoa or at an expanded Kaneohe treatment plant. The Kahaluu community has always been opposed to the DLUM designated site and anticipated that in the City's general plan revision process now in motion, the views of the community would be heard.

It was with a sense of shock that the eighteen member organizations of the Coalition learned that the City has recently decided to move ahead with the acquisition of the site. We were not notified that the City's thinking had changed in regard to this site. This is particularly galling because the City has been participating in the development of a flood control-park complex which is in direct conflict with the DLUM designated site. The flood control-park complex envisioned a lagoon-settling basin surrounded by a park. Radiating from the park would be green strips along the flood control channels and natural streams. These would extend to the forest reserve line, preserving public

access to the mountains. The sewage treatment plant would sit in the middle of the park, disrupt the green strips, and two of the flood control channels would cut through the site. The Kahaluu Coalition is unanimously opposed to that site, and believes that the flood control-park complex should have precedence over the treatment plant.

There has emerged a sharp contrast between the City's handling of the flood control plans and its handling of the sewage treatment plant site. The community has been vitally involved in the planning of the flood control system. It has hardly been consulted in the decisions concerning the original selection of the site, the drafting of the environmental impact statement, or the decision to move ahead on land acquisition.

The City is presently in the process of revising its general plan. There is a great need for this revision process in Kahaluu where the DLUM is obsolete. The flood control project cannot get under way until some major changes are made in the Detailed Land Use Map for the area. It would appear to us that the selection of a site for the sewage treatment plant should be a part of the general plan revision process. As things stand now, the community will be planned around the sewage treatment plant, rather than the community being planned first and the sewage treatment plant then placed in the least obnoxious location. The DLUM designated site is in the geographical and symbolic center of Kahaluu proper. It could easily become the identifying landmark for Kahaluu, replacing the Hygienic Store in this regard. Needless to say, this is not an uplifting idea for Kahaluu residents.

Specific comments on the five alternative sites considered in the EIS follow.

Alternative 1 is the DLUM designated site. We are opposed to this site. It is located within 1000 feet of the Kahaluu Elementary School. Winds would take odors in that direction 15% of the time. It is located in the geographical and symbolic center of Kahaluu, as mentioned earlier. Therefore, it could become the identifying landmark for Kahaluu. It interferes with and disrupts the park-flood control complex. It is badly placed, even in the 1964 DLUM, which shows the site surrounded by commercial, residential, and park areas. Nothing has yet been done to change that situation.

Alternative 2 is the existing Ahuimanu treatment plant. This plant has a capacity of 1.4 mgd and present flows average .3 mgd. It therefore has over a million gallons of capacity remaining. Although the site is too small to handle the projected population of the area by 2020, it is adequate to handle the projected population until at least 1990, and maybe as far as 2000. (See Table I-VI-3.) If this plant is retained instead of phased out, three advantages are realized. First, a new plant will not be needed for nearly 20 years. Second, a smaller plant and therefore a smaller site will be needed to serve the expected 2020 population, rather than two phases on the DLUM site, the Ahuimanu plant could be retained as the first phase. Greater flexibility would then be gained for the location of the second phase, since it will be smaller than that which is needed under the present plan. Third, the capital outlay has already been made for this plant. This would compensate for the expense of pumping sewage to this site.

We have no comments beyond those already contained in the EIS regarding alternative 3, the Kualoa site.

Alternative 4 has the same problems as the DLUM site. In addition, prevailing winds are towards the school and the industrial area may be needed to provide employment in the Kahaluu community.

Alternative 5, the Waiahole site, may help open that area to development. Such an eventuality would further degrade the natural environment of the Windward side, especially Kaneohe Bay. No development has taken place there yet, one of the few areas of Oahu which can make that claim.

We question whether the Ahuimanu plant has been adequately studied as the treatment facility for Kahaluu over the next 15 to 20 years. A second facility could be constructed somewhere else then this plant's capacity is reached. Such a course would allow the City time to update its general plan for the area and to select the site for the second facility within the context of this updating. This course would also allow greater flexibility in site selection because a smaller area than 14 acres would be needed for the second facility. The recommended phasing out of the Ahuimanu plant makes it more urgent and also more difficult to find an acceptable site in the Kahaluu area. We urge that the retention of the Ahuimanu plant be investigated along with another site for a second sewage treatment plant in Kahaluu if it is needed.

In summary, we feel that the Sewers Division has been so engrossed in minimizing the potential odor problems that they have overlooked the overall negative impact upon the total Kahaluu environment of locating a huge sewage treatment complex in the middle of what would otherwise be a beautiful park complex. Such a visibly obvious and centrally located site would tend to dominate the Kahaluu area in a negative way. The Kahaluu community is appalled at the prospect of a sewage treatment plant in such a location. It would be difficult to imagine a proposed development in any community that would have such an undesirable impact upon the total community environment as the proposed sewage treatment complex in the proposed location.

Sincerely yours,

*Bob Nakata*

Bob Nakata, Executive Secretary  
Kahaluu Coalition





**THE OUTDOOR CIRCLE** 200 No. Vineyard, Honolulu, Hawaii 96817

December 17, 1973

Dr. Richard E. Marland, Interim Director  
Office of Environmental Quality Control  
Office of the Governor  
550 Halekauwila Street, Room 301  
Honolulu, Hawaii 96813

Dear Dr. Marland:

The Outdoor Circle welcomes the opportunity to review and comment on the Draft Environmental Impact Statement for the Kaneohe-Kailua Sewer System. As a community group whose basic purpose is "to work for a more beautiful State, freeing it from disfigurement, developing its natural beauty and advantages and cooperating in all efforts toward community welfare, health and sanitation," we deplore the pollution of our marine environment and the threat to the health of our coral-based ecosystem. Recognizing the importance of the problem we have tried to cooperate in attempts towards its solution through attendance at community and governmental meetings and hearings, through representation on action groups such as the "Kaneohe Bay in Crisis" and the Governor's Kaneohe Bay Task Force, and through study of the reports of the City and County consultants and discussions with governmental representatives. It has been a very worthwhile process.

Since the EIS procedure is relatively new, may we interject a few procedural suggestions. If public participation in the planning process is to be encouraged, it should be facilitated. First, there should be early notification of the availability of the EIS to groups and individuals who have shown prior interest or who are vitally concerned through established avenues of communication. We must note that we feel this was not adequately done in this case. Time is of the essence since there is a deadline for submission of comments. Second, one must realize that many potentially interested readers do not have sufficient time or technical background to find their way through the report. May we suggest that a summary of the problem, alternatives, pertinent studies, conclusions and recommendations with a guide to further exploration would make their task easier. Because of the complexity of this problem which necessitated the combined efforts of many scientific and technical specialists, the material should be presented in language that the layman

B-28

THE OUTDOOR CIRCLE  
100E, HAWAII 96744

KONA OUTDOOR CIRCLE  
KAILUA-KONA, HAWAII 96740

LAHAINA OUTDOOR CIRCLE  
LAHAINA, MAUI, HAWAII 96751

LANI-KAILUA OUTDOOR CIRCLE  
BOX 261—KAILUA, HAWAII

MAUI OUTDOOR CIRCLE  
BOX 402—KAMULUI, MAUI, HAWAII 96752

WAI-MOMI OUTDOOR CIRCLE  
BOX 455—AIHA, HAWAII 96701

Dr. Marland

Page 2  
December 17, 1973

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can understand. There should be a focus on the questions to be answered, the relevance of cited material and studies to the environmental impact of the waste disposal method under consideration, the limitations and gaps in present knowledge and technology and finally, the recommendations as to possible courses of action.

We are impressed by the complexity of the problems raised by coastal waste disposal and with the uncertain state of much of our present knowledge of the ecological system, of the possible health hazards due to viral contamination, of the process of bacterial decay in the ocean, of the effects of nutrients on biostimulation, the paucity of baseline data on physical parameters, benthic communities, current structure with its annual and seasonal variation et cetera. Further financial support to advance our knowledge and technology is needed.

If Kaneohe Bay should serve as a lesson, it is that an extensive and meaningful monitoring system should be instituted immediately upon completion of the outfall so that we may be alerted by an early warning system as to possible adverse changes. These indicators clearly must be selected on the basis of relevance to Hawaiian waters rather than to mainland standards. Kaneohe Bay should improve with the diversion of sewage and hopefully Kailua Bay will benefit from the relocation of the outfall. We hope that what is lacking in flexibility at the present time, in terms of technical feasibility for extension of the outfall or precise bases for further treatment of the effluent, will be available when it is needed because we have planned for it at this time.

Further commentary on specific points raised by the Environmental Impact Statement will be sent to you under separate cover for your consideration.

Sincerely,

*Susan Fristoe*

Mrs. Ashby J. Fristoe,  
President

*Wm. F. Barck*

Mrs. William F. Barck,  
President, Kailua Outdoor Circ

SF:sb:aa

*Marcia G. Rice*

Mrs. Charles G. Rice  
President, Kaneohe Outdr

# WINDWARD REGIONAL COUNCIL

FORMERLY: WINDWARD CITIZEN PLANNING COMMISSION  
46-018 Kam Highway Room 206 Kaneohe, Hawaii 96744 Phone 235-1511

14 December 1973

Dr. Richard E. Marland, Interim Director  
Office of Environmental Quality Control  
550 Halekauwila Street, Room 301  
Honolulu, Hawaii 96813

Dear Dr. Marland:

Thank you for the opportunity to review the EIS on the total deepwater outfall system for wastewater from the Kaneohe Bay watershed.

We are most impressed with the thoroughness of the information provided on this vitally needed system. Two points remain troublesome, however.

1. The Kahaluu wastewater treatment plant site receives an inadequate examination in terms of its relationship to existing and potential land uses in that vicinity. The community of Kahaluu, being strongly opposed to the particular site ranked highest in this EIS, has explored nearby alternatives which deserve consideration. Kahaluu leaders have already been in communication with City engineers on alternative possibilities. The prospect of the school and adjacent regional parks being "subject to unsatisfactory air quality and odor nuisances" even 15% of the time (p. II - 139) is sufficient justification to necessitate a fuller exploration of this aspect of the EIS.
2. Throughout the EIS the emphasis is upon getting rid of "wastewater." That view no doubt derives logically from the "two fundamental objectives" cited on p. I-1 which see sewage only as "deleterious substances" rather than also as a resource. The possibilities for eventually using WWTPs as sources of energy and minerals draws relatively no attention. We believe flexibility should be a major consideration in the design of this total system.

Overlooking a few somewhat out-of-date minor data and maps, we are quite satisfied with this EIS and look forward to an early completion of the project.

Sincerely,



Leonard C. Moffitt  
Executive Director

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Leonard C. Moffitt, Executive Director  
Hannah Constorphine, Secretary

APPENDIX C - RESPONSE TO COMMENTS

(Includes Substantive Comments Only)

## CONTENTS OF APPENDIX C

<u>City and County</u>	<u>Page</u>
Board of Water Supply	C-1
Department of Land Utilization	C-1
Department of General Planning	C-2
Department of Transportation Services	C-2
 <u>State of Hawaii</u>	
Department of Agriculture	C-3
Department of Planning and Economic Development	C-4
Department of Transportation	C-4
 <u>Federal Agencies</u>	
Department of Agriculture	C-6
Department of Commerce	C-6
Army Corp of Engineers	C-8
Fourteenth Naval District Headquarters	C-13
 <u>Others</u>	
Environmental Center, University of Hawaii	C-15
Hawaii Public Health Association	C-20
Kahaluu Coalition	C-21
The Outdoor Circle	C-23
Windward Regional Council	C-23

## BOARD OF WATER SUPPLY

"...., we recommend close coordination between agencies during the planning and construction phases of the project to insure protection of our existing mains."

Inasmuch as the Division of Sewers has been merged with the Board of Water Supply, coordination within the agency should not be a problem. In addition, the Sewer Division will keep the other affected agencies informed on any changes in plans and construction schedules.

## DEPARTMENT OF LAND UTILIZATION

"It appears that the implementation of this system will involve work within the shoreline setback area as well as subdivision activity. Compliance with the Subdivision Rules and Regulations and the Shoreline Rules and Regulations will be required."

The proposed site of the Kahaluu wastewater treatment plant has already been subdivided (August 1973). Other land activities including acquisition for easements and pump station sites will be submitted as individual projects in accordance with the applicable Subdivision Rules and Regulations.

We have just completed the public hearings requirement of Section 14.6 of the Shoreline Setback Rules and Regulations. The first hearing was conducted at the Kailua High School, Kailua, Oahu on April 30, 1971 when the project was first conceived and prior to the adoption of the applicable shoreline laws and rules. An additional hearing was held at the Benjamin Parker School in Kaneohe, Oahu, April 5, 1972 to allow Kaneohe residents to express their views regarding the project. The final hearing was convened on January 16, 1974, again at Benjamin Parker School after the project was substantially designed and planned and prior to the beginning of the construction phase

## DEPARTMENT OF GENERAL PLANNING

"A generalized delineation of the proposed service areas on Figure I-12, showing how the population projected in Table I-VI-3 is expected to be distributed, would be helpful in providing an understanding of the relationship of the sewerage system to the officially adopted plans for the area."

Figure I-12 has been revised to show the projected 1990 and 2020 populations of the tributary subdistricts.

## DEPARTMENT OF TRANSPORTATION SERVICES

"Being that Kaneohe Bay is one of the major routes, we request that one lane be kept opened or other provisions be made to permit buses through passage. Should the roadway be closed for the convenience of construction in short increments (as stated), the only bypass is via the Mokapu Saddle Road. Utilizing the by-pass will inconvenience the Kaneohe Bay Drive passengers and/or defeat continued service until the entire narrow segments of Kaneohe Bay Drive is completed."

This oversight by DOTS is unfortunate because the Division of Sewers did consult with DOTS and received approval to affect closure of Kaneohe Bay Drive during the actual construction hours of the narrow segment of the highway. We would recommend that DOTS re-route their buses on Mokapu Boulevard or on the completed portion of TH-3 and perhaps run a shuttle vehicle along Kaneohe Bay Drive if this service is desired. If shuttle service can not be provided or is not desirable, the maximum walking distance to the re-routed line would be approximately 3/4 miles.

The buses could use Kaneohe Bay Drive during the evening hours, holidays, and the early morning and late afternoon hours when passenger loads are generally the heaviest. During the construction working period between 8:00 a.m. to 3:00 p.m. when light passenger loads could be expected, the buses can use the Mokapu Boulevard route.

DEPARTMENT OF AGRICULTURE, STATE OF HAWAII

"The consequence of diverting fresh water from the inshore boundaries are only partially addressed. Biological effects of nutrients and silt loads are recognized, but the importance of maintaining a brackist water breeding and nursery zone is not even mentioned."

Discharge of fresh water into Kaneohe Bay is approximately 34 mgd from storm runoff and 60 mgd from other sources (pg. I-41). Prior to 1954, there was no direct point source discharges of wastewater effluent into the Bay. Present wastewater flow into the Bay is approximately 4.2 mgd from the three existing plants. By diverting all effluent presently entering the Bay, we would in effect be returning to the brackist water concentration which existed in 1954. The status of Kaneohe Bay as a nursery ground still remains unanswered according to Miller, et al (Reference 35). The diversion of wastewater effluent from Kaneohe Bay has been endorsed by the Hawaii Institute of Marine Biology.

"Effects of coral are thoroughly documented leaving the implication that viable coral within the fringe is a desirable attribute. Documentation and survey data on fish populations are sketchy."

The fringing coral reefs are an important natural resource to the people of Oahu. These reefs provide a certain amount of physical protection for beaches and shores and provide the necessary habitats for a great many aquatic organisms. Coral reefs are probably the most biologically productive of all natural communities whether they be marine or terrestrial. The corals provide suitable habitats for thousands of other kinds of plants and animals which would die or migrate from the area should the corals be selectively killed. Thus, it appears imperative that corals receive the maximum protection possible to ensure the continued existence of other desired marine organisms.

A fish survey was conducted in Kailua Bay during August 1971 (Reference 13). A limited number of copies of the report is available for distribution. No survey was initiated for Kaneohe Bay since this information is available in the literature, the latest being "Atlas of Kaneohe Bay: A Reef Ecosystem Under Stress" by Smith, et al, 1973 (Reference 35).



"The option of recharge of treated waste water into the salt water margin is dismissed without considering its environmental effect."

We believe that the alternative of recharging treated effluent into the ground was sufficiently discussed. The engineering for ground injection systems is not precise and the ultimate path, location and residence time of the effluent are at best speculation and least understood.

"There are no immediate effects of the proposed system on agricultural activities. However, the long-range effect will be to favor urban development with more "waterproofing" of the infiltration zones now provided by agricultural activities. The long-range effects of the plan may well be elimination of the productive zones suitable for bananas."

Development of any area is the results of many factors other than the provisions of wastewater treatment and disposal systems. Growth in any area should be controlled by proper zoning and land use regulations.

#### DEVELOPMENT OF PLANNING AND ECONOMIC DEVELOPMENT, STATE OF HAWAII

"We might mention that in regard to noise from construction due to the use of piles that there are techniques which might be applicable which are able to solve the load-bearing problems with piles."

Drilling and vibratory techniques are available for driving point-bearing piles under certain specific subsurface soil conditions. Such techniques will be investigated and could be employed if feasible.

#### DEPARTMENT OF TRANSPORTATION, STATE OF HAWAII

"Please be informed that we will again be reviewing the final outfall design prior to construction since a Shorewater Construction Permit issued by our Harbors Division is required."

Also, all work must comply with our 'Rules and Regulations Relating to the Accommodation and Installation of Utilities on State Highways and Federal-Aid Secondary County Highways.'

Request for final approval for a Shorewater Construction Permit was sent by letter SD 73-275 dated October 11, 1973 to the Harbors Division, Department of Transportation. The aforementioned Rules and Regulations relating to installation of utilities on federal aided county highways have been inserted in the statement and were fully considered during the design phase of the various projects and in the selection of alignment alternatives.

"On pages I-35 to I-36, the author compared tables I-V-5 and I-V-6 and concluded that rezoning of agricultural lands must be considered if the population of the district is to be increased. In our judgment, the adequacy of zoning cannot be determined be merely evaluating the tables. The amount of land general planned for residential purposes and presently vacant or in agricultural use is a better indicator of capacity."

One of the most difficult problems with the demographic studies of WQPO was the distribution of the projected total island-wide population by districts. Distribution of the total population was made to the various sewer districts after consulting with the land use boundaries of the Land Use Commission, field surveys, population trends of each area, and finally a judgment factor reached after consultation with a committee of professionals from private and government agencies.

We concur in part with the DOT comments, however, even though their suggested method has pitfalls. For example, the urban use boundaries of the Kaneohe-Kailua district could remain as they are and population densities could be increased by rezoning present urban lands to accommodate the projected future population. There are other variations and combination of factors which can be utilized to arrive at common conclusions. The draft statement has been corrected with respect to the DOT comments.

UNITED STATES DEPARTMENT OF AGRICULTURE,  
SOIL CONSERVATION SERVICE

"page I-54 comment - The second sentence states: 'There appears...ground cover, etc.'" We do not concur in this statement. There does exist information, developed by the Agricultural Research Service, University of Hawaii, and Soil Conservation Service, concerning sediment load with respect to soils, land use, topography, vegetation, etc."

Our statement was to point out that there was no relationship between sediment loads to land use, topography, ground cover, etc. that were discernible for the Pearl Harbor and Kaneohe Bay streams from the data that was available. Nevertheless, we were not aware that local information recently developed by the University of Hawaii and the Soil Conservation Service will be available so that a realistic sediment control program for Kaneohe Bay can be formulated. The text has been rewritten to rectify the ambiguity in the draft statement.

Other suggestions for improving the statement have been incorporated in the text.

UNITED STATES DEPARTMENT OF COMMERCE

"Moku Manu Islands and their southeast fringing reefs lie approximately one mile north of the proposed outfall site. These offshore islands have some of the most viable coral reefs on the Windward side of Oahu...Studies outlined in the draft EIS indicate that during the months of April to August, particularly during flood tide conditions, the surface and subsurface currents flow is to the north and northwest. Dye and drogue cast results during this period indicate effluent transport from the proposed outfall site would be directly across the Moku Manu reefs. We recommend this problem be studied in greater detail, especially with regard to the degree of effluent dilution at the time the effluent reaches the above mentioned reef area."

During the summer of 1972, a student group from the University of Hawaii conducted a baseline study in Kailua Bay with assistance and guidance provided by the Water Resources Research Center, UH. The project was funded by the National Science Foundation (NSF) and included characterization of the present marine biota around Mokapu Peninsula which will be used later to identify changes in the marine life due to construction and

operation of the Mokapu outfall sewer. The effects of the effluent on coral was considered in the design of the outfall. Based on observations made at the existing Kailua outfall sewer and an unpublished report of the Hawaii Kai outfall sewer, coral communities do not appear to be adversely affected by open ocean discharges. The initial dilution provided by the proposed Mokapu outfall will be 20 times greater than the existing Kailua outfall sewer. Using a current velocity of 0.5 knots, normal to the proposed outfall, a dilution of over 420 to 1 will be provided before the effluent field reaches Moku Manu Island. This is considered more than adequate to protect coral in the area.

"We recommend that selection of final underwater outfall alignment be done in order that a minimum of viable coral will be destroyed. Trenching techniques should be carried with as little blasting as possible."

This was considered in the selection of the alignment of the outfall. Excavation through the coral formation is mentioned in the statement (pgs. II-47, II-48).

"A biological monitoring program should be established after the ocean outfall become operational. This program should be detailed in the final EIS. Baseline surveys, especially for the Moku Manu area, should be made prior to construction. If the marine environment is found to be deteriorating significantly beyond baseline data in surrounding areas such as Kailua Bay or Moku Manu, then adjustments (i.e. extension of the outfall into deeper water) should be made. These adjustments should be anticipated and outlined in the final EIS."

A monitoring program will be established after the ocean outfall becomes operational. A monitoring program is mentioned in the statement (pg. II-105). Stations established during the Kailua monitoring program and the NSF studies will be monitored for physical, chemical, bacteriological, and biological characteristics. These stations are located strategically in Kailua Bay and around Mokapu Peninsula and will be used to determine potential adverse changes in the ocean environment. If the marine environment is found to be deteriorating, more treatment will be provided at the treatment plants. Extension of the present proposed outfall into deeper waters may not be possible because of the steep bottom topography at the terminus, however, the outfall and diffuser section can be relocated toward

Moku Manu channel. The monitoring program in the statement will be expanded to cover specific studies.

ARMY CORPS OF ENGINEERS, HONOLULU DISTRICT

"The application by the City and County of Honolulu to the Corps of Engineers for issuance of a permit under authority of the River and Harbor Act of 1889 for construction of the Mokapu Outfall should be mentioned in the EIS."

An application for a Corps of Engineers permit for construction in navigable waters for the Mokapu outfall was filed on October 11, 1973. A new subsection on construction permits has been added to the statement.

"The EIS should discuss the requirements of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) with regard to the possible need for a National Pollutant Discharge Elimination System (NPDES) permit for a discharge of outfall water which may not meet applicable water quality standards."

NPDES permits are required pursuant to Sec. 402 and 403 of the Act and according to the guidelines promulgated by EPA under Title 40, Part 125, published in the Federal Register, Volume 38, Number 141, Part II, dated July 24, 1973. For the Mokapu outfall, the City must file a complete NPDES application at least 180 days in advance of the date on which it is desired to commence the discharge of pollutants. Applications for NPDES permits for the existing Kailua and Kaneohe discharges were filed on December 21, 1973 with the notation that these discharges would be eliminated and all flows diverted to the Mokapu outfall for disposal.

The anticipated effluent characteristics from the Mokapu outfall and the Federal guidelines for effluent quality for secondary treatment are listed on page II-22 of the statement. Discussions are located on page II-21.

"The site of the proposed Kahaluu Wastewater Treatment Plant is within a flood hazard area. The EIS should include a discussion of this problem with regard to the immediate flood hazard to the proposed treatment plant and in terms of the cumulative

primary and secondary impacts on the Kahaluu community of the treatment plant and the proposed flood control project if the two are to be coordinated in implementation."

The Kahaluu Watershed Project will permit utilization of the proposed plant site. The plant will be graded to conform with an overall grading plan that will be prepared later. The grading plan will be designed to eliminate flood hazards of the site after taking into account the designed features of the Kahaluu Watershed Project. There has been active coordination between the Soil Conservation Service, who is doing the design of the project, the Department of Recreation, and the Drainage Section of the Division of Engineering, DPW. Construction and long term impacts of the plant are discussed on pages II-79 to II-85, and pages II-128 to II-168.

"The EIS should state the sequence of programming of construction so as to clarify the impacts of implementation of each part of the proposal."

Construction sequence and scheduling were uncertain at the time the statement was prepared and are still uncertain at this time (April 1974), due to the uncertainty of funding from all sources. This was mentioned in the statement. It is the intention of the City to proceed with the construction of the Kaneohe EPS, Kaneohe EFM, Kailua EPS, Kailua EFM, and Mokapu Outfall concurrently with five separate construction contracts during 1974. The Kahaluu WWTP and Effluent Sewer will be constructed later as funds become available.

"The entire sewage disposal system as outlined in the EIS would provide capacity for considerable population growth in the region. The EIS states that for projected purposes population growth was allocated equally throughout the three service areas. Yet in the North Kaneohe area (area 1-Kahaluu) only a small portion of the land is zoned urban, and the EIS states (I-36) that 'rezoning of agricultural lands must be considered if the population of the district is to be increased.' From these statements it is not clear that the population growth for which the system is designed is provided for in the General Plan, nor is it clear where the growth is to occur.

Placement of the facilities will reduce options for growth if the General Plan has not specified the areas to be developed. The EIS should discuss consonance with the General Plan of the

subject proposal and in addition should consider the economic, social, and environmental impacts of population growth and development upon existing communities and land uses."

The EIS states (pgs. I-30,31) that projected future population was based on population increases made between the 1960-1970 decadal period and projected for the various districts based on land available for growth and other known factors. It was assumed that the projected population will be distributed equally within each subdistrict. WQPO population projection is to the year 2020. The projected population increase for the General Plan (1964) was based on a population of 500,409 in 1960 to 681,000 in 1970 and 820,000 by 1980. The projected civilian resident population from WQPO for the entire island is 1,688,000 in 2020, about twice the Planning Department forecast for 1980. Since the land use pattern for the 1964 General Plan was based on a population of 820,000, we can expect for the entire island of Oahu either (1) an increase in the present population density of urban lands or (2) rezoning or agricultural or other non-urban areas to urban use.

Wastewater treatment and pump station facilities are designed on the basis of 15-20 years and are constructed in increments. If the projected population does not materialize, it will just mean that the incremental facilities will be operating for a longer period of time. Therefore, the proposed wastewater system should not be considered the deciding factor for accelerating development in an area. Growth in an area are controlled by proper zoning and land use regulation. It would be purely speculative to discuss economic, social and population impact in an area unless there were actually proposals for General Plan amendments in this statement. This subject is not within the scope of the sewer project.

"Although the EIS discusses the pollution which has taken place in the south sector of Kaneohe Bay, the EIS does not discuss the effects on the bay from the removal of the effluent other than to state that '...removal will permit the bay to recover, to a limited degree, to its former conditions (II-224).' Since the EIS discusses such contributors to bay degradation as urban storm water runoff and siltation as well as sewage effluent, it would be helpful to summarize existing knowledge about the relative loads of nitrogen, phosphorus, and other water quality parameters from these diverse sources. This should be followed by some discussion of the effects on bay restoration which may or may not be achieved through effluent diversion to the Mokapu Outfall."

The nutrient and sediment loading into Kaneohe Bay from all known sources are summarized on pages I-50 through I-57. A discussion on the restoration of the Bay once sewage effluent are removed is presented on pages II-88 through II-91. Further refinement of the discussion is purely speculation.

"The EIS states that sludge disposal is proposed to be at the Kailua dump. Effects on water quality of Kawainui Swamp should be discussed, with consideration for the quality of the sludge and leachate which may follow to the swamp. This sludge disposal alternative should also be discussed in reference to the proposed Kawainui Park."

The disposal of sludge from the Kaneohe and Kailua plant in the Kapaa sanitary landfill is an existing permitted practice. For this reason, no mention was made in the statement regarding the possibility of leachate from the sludge contaminating the groundwater in Kawainui Swamp. Under the provision of Section 4c of the proposed Public Health Regulations, Chapter 46 (Seventh Draft - 2/14/74) - Solid Waste Management Control, disposal of sewage sludge in sanitary landfill will continue to be an accepted practice. According to the proposed regulation, sanitary landfills will be designed and operated in such manner as to prevent leachate from entering the waters of the State without receiving the best practicable treatment or control. Leachate from the existing sanitary landfill is not expected to pollute the waters of Kawainui Swamp according to a study performed by the Public Health Division of Environmental Health of the University of Hawaii for the Department of Public Health. Water quality parameters evaluated during the study included pH, specific conductance, total hardness, calcium hardness, alkalinity, chloride, nitrate, sodium, phosphorus iron, BOD, dissolved oxygen, and bacteriology. The period of sampling was between October 1969 to August 1970. The study was able to conclude, "on the basis of the water samples examined that the use of Kawainui Swamp for landfill has absolutely no adverse effect upon the swamp water represented by a sample collected in an uninfluenced area." There was also evidence in the early samples that coliform bacteria were absent from the samples as the result of the filtering action of the tight impermeable clay in the area.

"If the Mokapu Outfall effluent is chlorinated, the potential effects of chlorine on receiving waters and biota should be discussed in the EIS."



As mentioned in the EIS, continuous chlorination is not required nor recommended because of the rapid bacteria decay rate and favorable oceanographic conditions, however, it is needed to comply with the effluent limitation bacteriological standards for secondary treatment (See pg. II-22 of the statement). No harmful effects on the receiving waters and biota have been observed at the existing Kailua outfall discharge area and none is expected at the proposed receiving waters off Mokapu Peninsula because the travel time of the effluent in the outfall will be more than sufficient to reduce the chlorine residual of the effluent to zero. There are no toxic effects when the residual is zero.

"We would like to see the EIS present an estimated display of the extent of area coverage that the surface plume would have during normal trade winds, kona winds, tidal changes, and winter storms, for the quantity of effluent discharge."

The areal extent of the surface plume will always be within the zone of mixing shown on page II-104 of the EIS.

"The discussion concerning backfilling of the outfall trench (II:46) should include the estimated quantities of quarry stone required, its source and the impact on traffic along the haul route. Deposition of the excavated material alongside of the trench (II:49) will result in siltation and erosion impacts which are not addressed in the EIS."

The EIS has been revised to include this discussion.

"The refusal of the Army Corps of Engineers to issue a permit until an EIS was prepared,..." (II:48) should be deleted since it is erroneous and out of context.

Deleted.

"Underwater construction across Kaneohe Stream(II:74) will also require a Department of the Army permit. An application for this work has not been received."

Underwater construction across Kaneohe Stream will be in a portion of the Kahaluu Effluent Sewer which is in the initial design stage. A permit application for this work as required by the Army Corps of Engineers will be submitted when the design is substantially completed and project is funded for its construction.

"The sludge disposal sites for the existing sewage treatment plants are not identified nor is the sludge disposal site for the proposed Kahaluu sewage treatment plant (II:167) adequately identified and discussed. What are the life expectancies of the existing and proposed disposal sites. What alternate land disposal sites were considered?"

Sludge drying beds are shown in Figure II-8 and II-9 for the Kailua and Kaneohe plants respectively. Dried sludge is hauled to the existing City and County sanitary landfill at Kapaa Quarry. No sludge drying beds are planned at Kahaluu (Figure II-11). Discussion in the EIS has been limited to the proposed effluent disposal system and the Kahaluu WWTP and was not intended to cover every environmental aspect of the existing plants.

"If the proposed sludge disposal site in Kawainui Swamp is subject to tidal action, a Department of the Army permit may be required for the landfill."

The Division of Sewers does not intend to establish a separate sludge disposal site in Kawainui Swamp or anywhere else and will utilize the existing or proposed City and County refuse disposal sites.

#### HEADQUARTERS, FOURTEENTH NAVAL DISTRICT

"Page I-73 Kaneohe Marine Corps Air Station - The third sentence should be revised to read: 'The main components of the facility are the air degriter unit, primary clarifier, digester, trickling filter, final clarifier, one acre detention pond and an effluent pump station to transmit the treated effluent to the golf course irrigation system. About 500,000 gallons of the treated effluent is used daily to irrigate the golf course and the balance is presently discharged through a

20-inch outfall extending between Halekou Pond and KMCAS Pier approximately 500 feet into 15 feet of water!"

The text has been amended to include this more recent information.

"Page II-40 Construction Impact - This section of the report should mention the land portion of the outfall being close to the bird sanctuary areas. As such, all construction work, including blasting, should be kept to the very minimum. The same precautions should apply to areas where the outfall is going to be relatively close to family housing. Nuisance to families as well as possible damage to underground utilities should be considered."

Blasting of explosives for the land portion of the outfall is not anticipated (pg. II-53). Location of existing and proposed underground utilities was considered during the design phase. The usual construction practice of the City at utility crossings is to expose the existing utility line by hand digging to prevent accidentally breakage. Disturbance of wild life is mentioned under the Kaneohe Effluent Force Main (pg. II-66) but should have been mentioned under the land portion of the Mokapu Outfall Sewer. The text has been rewritten to correct this omission.

"Page II-55 Traffic - Arrangements must be made to provide adequate detour routes so as not to disrupt the traffic at the entrance to KMCAS, any more than necessary. Also temporary parking areas should be provided if existing parking areas are going to be affected by the new construction."

The contractor will be required to coordinate his work schedule with the Base Provost Marshall so as not to disrupt the traffic at the entrance to KMCAS. Detour traffic lanes and temporary parking areas will be provided if required.

"Page II-115 and 116 - The Nuupia Pond and adjoining area is now a bird sanctuary and the construction of the outfall will have some impact, at least during construction and should be examined."

The referenced portion of the statement addressed itself to the long term environmental impact. The construction impact has been considered Section II-IV (pgs. II-43 to II-56).

ENVIRONMENTAL CENTER, UNIVERSITY OF HAWAII

"The KMCAS is recycling some effluent for golf course irrigation (I-21). The plan apparently is economically feasible and desirable, perhaps because the effluent contains important nutrients. Yet the EIS shows no plans for recycling effluent for similar purposes in other localities in Kaneohe-Kailua. In this area there are at least five golf courses and two cemeteries, plus the grounds of hospitals and correction homes. The EIS indicates that recycling of effluent is neither economically feasible nor desirable (II-175), which seemingly contradicts the conclusion of the KMCAS. In the EIS it is stated that there is sufficient fresh water available, and therefore there is no need to recycle; but were the estimates of sufficient fresh water based on the predicted population level? The EIS indicates, also, that use of recycled water will degrade the potable water resources, but neither the use of effluent by the KMCAS nor the presence of many septic tanks in the Kaneohe-Kailua-Kahaluu area seem to have threatened the fresh water supply in the Koolaus. The EIS should consider more seriously the uses of and provisions for recycled effluent."

The EIS stated "that reclamation of wastewaters from the Kaneohe-Kailua district is not now feasible nor desirable because of the high chloride content of the Kailua and Kaneohe flows (chlorides in excess of 1,500 and 1,800 mg/l respectively)." It is uneconomical to demineralize the effluents and construct expensive irrigation systems just for golf course irrigation purpose. At one time, it was proposed to reuse the effluent from the Ahuimanu plant for irrigation of the cemetery. This proposal was abandoned because it was felt that nutrients in the effluent would eventually reach Kaneohe Bay because of the combination of heavy rainfall and soil conditions in the area. Nutrient run-off of the KMCAS golf course will be into the ocean.

The Board of Water Supply did not have any objections for deep well injection and also irrigation if there was no potential danger of ground water contamination. This determination is made on a case by case basis. Kailua including KMCAS could be suitable for sod irrigation and the BWS would have no objection in this area. The reasons why effluent from cesspools have not contaminated the potable water supply in some

areas are not clearly understood, however, BWS studies, along with a University of Hawaii study, indicate that recycling of wastewater for irrigation may have undesirable effects on the quality of ground water in certain areas.

The estimates of sufficient fresh water for the predicted population was based on the BWS "2020 Plan."

"The sewer line will pass through the water bodies between Mokapu Peninsula and mainland Kailua. These water bodies were once royal fishponds (II-114) and are probably of archaeological interest. The EIS ought to consider possible cooperation with archaeological groups, such as the Bishop Museum, during this phase of the operation because of the chance of turning up artifacts or sites."

Further investigation indicated that a portion of the Kailua Effluent Force Main will traverse a State Registered Historic Site and could possibly be within a Hawaiian burial site in the KMCAS property. We have notified the State Department of Land and Natural Resources regarding our finding and have submitted a set of our construction drawings for their review and evaluation.

"The objective of a water quality management program not necessarily to be to minimize pollution, but to optimize the control of pollution with respect to overall, long-term human interests."

We feel that the initial portion of the statement (pgs. 1-1 to 1-2) deals with the subject adequately.

"Not all sanitary engineers would agree that the combination of extremes of treatment and an extreme outfall length would always provide excellent results. In addition to the economic disadvantages of such combination, there might well be local environmental disadvantages (as would be the case at Sand Island), and there would certainly be overall environmental disadvantages in the commitments of materials and energy required."

We do not include our water quality consultants and ourselves as part of this group.

"Fossil reefs do not grow. ... An ideal caprock structure for underground injection need not involve a lower stratum of impermeable material. If the head of the bedrock basal groundwater is high, all flow would be from the bedrock to the caprock aquifers, and no contamination of the caprock should occur. Much more important considerations are the location of the ocean discharge area of the aquifer in which the injection will be made and the rate of natural flow through the aquifer. Nearshore discharge through a caprock aquifer with a low natural discharge rate might have very nearly the same ecological effects as nearshore discharge through an ocean outfall. Some of the listed potential areas for underground injection may be ruled out on this account."

The term 'growth' was used as a figure of speech. In the example cited in the draft statement, an ideal structure for underground injection described the injection well disposal system at Waimanalo. This is a proven system that is working. The conditions cited in the comments might also work but is there a proven case? We are not recommending any ground injection disposal system in any of the listed potential areas until a complete geological and hydrological study is made.

"The phosphorus values may represent total phosphorus, or phosphate phosphorus and may be reported as phosphorus or as phosphate, but cannot be total phosphorus (in phosphate)."

The term for ( $\text{PO}_4\text{-P}$ ) should have been 'phosphate phosphorus.'

"The estimates of stream nutrient loads from the OWQP study are shaky if there is no discernable pattern between nutrient loads and stream discharge."

The reference is made only for the Kaneohe streams. Data by WRRC, UH collected in 1968 and 1969 from 11 Kaneohe streams were the basis for estimating the average mass emission rates and concentrations of nitrogen and phosphate. The basic problem was that stream flows were not measured at the time and location of sampling. Consequently, to estimate the mass emission rates, flows were approximated from hydrographs for upstream gages which did not necessarily correspond with USGS maintained stations. Because of this deficiency, the results were not as successful as the results for the Pearl Harbor streams. Therefore, the average concentrations were determined

by pooling all data for Kaneohe Bay and determining the geometric mean. Obviously more study on the Kaneohe streams is needed as it is stated in the draft statement.

"The estimates of sediment deliveries to Kaneohe Bay derived from stream sampling do not agree, by a factor of at least 3 or 4 and possibly nearly 10, with estimates of sediment accumulations in the Bay (Roy, 1970)."

WQPO estimates of sediment loads carried by streams into Kaneohe Bay were based on USGS data for 'inventoried areas' tributary to the flow gaging sites. The inventoried areas are in the upper elevations at the foot of the Koolau Range, are heavily vegetated, and may not be representative for the entire region. However, urbanization is occurring in these areas and several exposed areas or cuts along the slopes have been noticeable. We are not familiar with Roy's work.

"It is true that there appears to be no analyses of the relation of sediment load of streams to land use. However, the HESL study of the relationship between soil loss and land use is a start (Bartram, 1973)."

See comments by the Soil Conservation Service, USDA.

"No reference is made to the studies of the conditions off Mokapu, in the area proposed for the outfall, by a group of UH students under the Marine Options Program. Were the results of these studies available and used?"

The "Mokapu Outfall Baseline Study" was started in 1972 by fifteen UH students for the purpose of characterizing the present marine biota of selected areas in Kailua Bay and Mokapu Peninsula. A brief mention of the project was made on page I-170. A field investigation was completed in 1973 but a final report has not been finalized as yet. A characterization of the marine biota around the proposed outfall sewer was undertaken for the City and County by Arthur S. Reed and Alison E. Kay of the University of Hawaii. Dr. Reed and Dr. Kay were faculty advisors to the student group. Baseline data collected by the student group will supplement our data and will be utilized later to identify potential changes in the marine life due to construction and operation of the outfall.

"Fig. I-14. This figure appears to be based in part of Laevastu, Avery & Cox 1950 via the OWQP report, though the earlier report is not cited."

A large anticyclonic gyre for the area around the Hawaiian Archipelago was proposed in 1942 by Sverdrup. Additional details were provided by the works by Reid (1961), Patzert, et al (1970), Barclay (1968), and Bathen (1970) in support of the existence of an East Pacific Gyre. Nearshore current patterns occurring seasonally around the island of Oahu during flood and ebb tides were based on the works of past investigators including those of Laevastu, Avery & Cox (1964). This report is given proper credit in the Final Report of Work Area 6 & 8, WQPO, 1971.

"Is ref. 13 the product of the Marine Options Program referred to in the comments on p. I-85, P. 2?"

Reference 13, 'A Baseline Survey of Benthic Biota in Kailua Bay, Oahu', by Reed and Kay was funded by the City and County of Honolulu as part of the Kailua Monitoring Program. The discussion on coral on page I-148 was from WQPO observations.

"No consideration seems to have been given to the tsunami hazard."

We disagree completely. Full consideration was given to the tsunami hazard in the design of the ocean outfall. The reader is directed to the report, 'Design Hurricane, Winds, Waves, Stone Size and Wave Forces for Mokapu Ocean Outfall' by Charles L. Bretschneider, January 1972.

"It is questioned whether the discharges of nutrient and suspended solids to Kaneohe Bay will be 'substantially terminated' by the diversion of the sewage effluents from the Bay. They will be greatly reduced but the statement overlooks the contributions of the streams. As pointed out in p. II-89, P. 2, the leachate from cesspools will be reduced in time, but the usage of fertilizers in the region will continue to produce nutrients and the streams will continue to contribute suspended solids of erosional origin."



The contribution of nutrients and suspended solids from streams into Kaneohe Bay is given in Tables I-VI-1 and I-VI-4 (pages I-38 and I-55). Total daily contribution of nitrogen and phosphorus from the streams was estimated at 110 and 15 pounds respectively compared with 570 and 240 pounds from the treatment plants. The pollution loads from the plants represent 85 to 95 percent of the total daily nitrogen and phosphorus contributions to the bay (excluding unknown quantities from cesspool leachate). Hence, the diversion of wastewater effluent from the bay will result in a substantial reduction of nutrients. The suspended solids mentioned refers to materials from organic sources.

"In addition to the turbidity resulting from the excavation, the possible increase in nutrients by the dredging of high-nutrient sediments should not be overlooked as a disadvantage of Alternate 1."

This possibility was considered and should have been mentioned in the statement. The EIS will be amended to include this omission.

"A high pumping lift but not a high static head would result over the Mokapu Saddle Road from Alternative 3."

The correct engineering term is static head. A pumping lift refers to the distance between the center of the suction end of a pump and the free surface of the liquid being pumped.

Minor misspelling, typographical errors, etc. suggested have been made in the statement.

#### HAWAII PUBLIC HEALTH ASSOCIATION

Although there are no direct epidemiological evidence showing certain increased illnesses resulting from water contact sports on Oahu and in particular in Kaneohe Bay, we concur with the general statement of the association.

## KAHALUU COALITION

### Comments on entire letter

It is disappointing that the Kahaluu residents took no action to delete the present DLUM treatment plant site from the General Plan between the period from 1964 to 1970 if they were diametrically opposed to the location of the site. The final report of the WQPO (February 1972) clearly stated that the treatment plant will be located in Kahaluu (pgs. XIII-27 to 31, and Figure XIII-4). The concept of treating Kahaluu's wastewater at a proposed plant at Kualoa or an expanded Kaneohe plant were alternatives which were considered but rejected by the City's consultants. The retention and expansion of the existing Ahuimanu plant was also considered and rejected by WQPO. These considerations were discussed in the draft statement. The results of WQPO were given wide publicity and copies of the reports were available at libraries for any community groups or individuals.

Concerning conflicts between the flood-park complex with the DLUM treatment plant site, the Division of Sewers had never publicly stated that this site would be abandoned in favor of another site. With respect to the Kahaluu Watershed Project, the affected public agencies were told to respect the boundary of the DLUM site. When informed of potential conflicts with the watershed project in 1973, we voluntarily reduced the proposed plant site from 20 acres to 14 acres after many meetings with the US Department of Agriculture, Soil Conservation Services, the Department of Recreation, and the Drainage Section and Land Division of the Department of Public Works. Reduction of the area was accomplished by redesigning the sludge handling facilities of the plant. Finally, several alternate sites were considered in the immediate area but were rejected in favor of the DLUM site with boundaries adjusted on the east (makai) and south sides.

The reduced plant site could be compatible and could accommodate the lagoon basin and stream alignments, at the same time still allow for development of a park complex and green belt strips around the lagoon and along Waihee Stream. In addition, the proposed landscaped perimeter buffer area of the plant (a width of 200 feet) could be made available for park-recreation related activities, if so desired by the Department of Recreation. In respect to potential odor nuisance, the plant will be designed as an odor-free facility.

The City and County, being aware of the Kahaluu Coalition opposition to the DLUM site in 1973 indicated its willingness to cooperate with them and consider alternate sites for the

plant proposed by the Coalition. It was in November 1973, when the draft EIS was completed, that the Coalition suggested a site. The Coalition site was located between the DLUM site as adjusted and Ahaolelo Road. The need to prepare an EIS as early as possible to assess environmental concerns is one of its primary motivation. Progress was hindered after work began on the draft statement in February 1973 because of benthic studies delays for inclement weather and ocean conditions. Discussion of the Coalition suggested site could not be included in the draft statement because it was proposed too late and of the need to secure subsurface conditions at the suggested site. Preliminary soils investigation of the Coalition site was completed on January 24, 1974.

We wish to comment further on the Coalition proposal to retain the existing Ahuimanu plant. With respect to the available capacity of the Ahuimanu plant, this capacity is earmarked for developments in the immediate area and projects under the control of plant builder-developer. None of the areas experiencing health and sanitation problems caused by overflowing cesspools can be served. The City cannot use the plant capacity for its sewer improvement district projects which will reduce the capacity jeopardizing the planned sewer connections of the developer-builder. Under the Coalition proposal, the present unsewered areas of Kahaluu, Waiahole, and Kuuialoa would continue to be served by cesspools possibly until 1990, an undesirable situation.

The two-plant scheme proposed by the Coalition will be more expensive to operate and maintenance. Manpower requirement for the operating plants will be increased by a minimum of fifty percent and possibly more. A two-plant scheme would still require another site, probably in the same location of the DLUM site.

The objections raised by the Coalition against the DLUM site are applicable to the Ahuimanu site also. Using two different criteria for comparing the two sites is being attempted by the Coalition. The existing Ahuimanu plant is located adjacent to the major transportation arterial traversing Kahaluu. It is much more readily observable than the DLUM site since it lacks sufficient buffer area. Potential odor problems are applicable to both sites. The Ahuimanu site is closer to existing residential sites than the DLUM site. In addition, it was not designed as a complete odor free facility. The plant at the DLUM site will be. Concerning aesthetic, the Ahuimanu community is just as adamant against retention of a temporary facility as the Coalition is against construction of a centralized plant for the Kahaluu

district. Were the concerns of the people in Ahuimanu taken into account by the Coalition in recommending the retention of that plant. Were they consulted?

In summary, we are disappointed that the site suggested by the Kahaluu Coalition to the City was not even mentioned in their letter of December 20, 1973. The City went to much effort and expense to determine the suitability of their suggested site from the structural (foundation) consideration because we consider the suggestion a legitimate one.

The EIS has been revised to include new material regarding the Coalition suggested site and their other comments.

#### THE OUTDOOR CIRCLE

"If Kaneohe Bay should serve as a lesson, it is that an extensive and meaningful monitoring system should be instituted immediately upon completion of the outfall so that we may be alerted by an early warning system as to possible changes."

The City and County intends to pursue an intensive ocean monitoring program off Mokapu Peninsula and Kailua Bay after the completion of the effluent disposal system. Existing baseline data for water quality parameters, benthic flora and fauna, fish species and abundance, analysis of micro-molluscs, etc. have already been collected.

#### WINDWARD REGIONAL COUNCIL

"The Kahaluu wastewater treatment plant site receives an inadequate examination in terms of its relationship to existing and potential land uses in that vicinity. The community of Kahaluu, being strongly opposed to the particular site ranked highest in this EIS, has explored nearby alternatives which deserved consideration. Kahaluu leaders have already been in communication with City engineers on alternative possibilities. The prospect of the school and adjacent regional parks being 'subject to unsatisfactory air quality and odor nuisance' even 15% of the time (p. II-139) is sufficient justification to necessitate a fuller exploration of this aspect of the EIS."

The City engineers have met on several occasions with members of the Kahaluu Coalition to determine if nearby alternative sites for the wastewater treatment plant were available and suitable. Only one alternative site was suggested by the Kahaluu Coalition. This site is located on the Kaneohe side of the DLUM designated plant site and Ahaolelo Road. The draft statement was written before the suggestion for this alternative was conveyed to the City, hence, no discussion could have been prepared. The draft statement has been revised to include this alternate site.

The draft statement does recognize the possibility of unsatisfactory air quality and odor nuisance (pgs. II-145 to II-148) and all facilities will be designed to eliminate, destroy and minimize odors.

"...The possibilities for eventually using WWTP's as sources of energy and minerals draws relatively no attention."

Minerals exist in sewage in trace quantities and the cost of extraction and refining them is prohibitive. Examination of trace metal concentrations in the Kailua and Kaneohe raw wastewater in Table II-III-1 bears this out. For example, the present amount of iron in various compounds is about 130 pounds per day from the combined Kaneohe and Kailua flows. There is no way that the capitalized, and operation and maintenance costs be amortized for any mineral.

Methane gas is a byproduct of organic decomposition by the anaerobic process and comprised about 70 percent of sludge gas. The average heat value of sludge gas is between 640 to 700 Btu. Some of the methane generated at the treatment plants is utilized to heat sludge digestion tanks. The balance of the gas is wasted by burning. At our Kailua plant, provisions were made to use sludge gas to operate an engine generator to generate electricity for in-plant use. To date, the system has not worked because of insufficient gas production.

The use of sludge gas as a fuel is generally not attractive because of its low Btu heat value and also because of the corrosive property of the hydrogen sulfide content in the gas.

Mechanical dewatered sludge has a maximum solids concentration of about 25 percent. Because of its moisture content, sludge is not an attractive source of fuel. Air-dried sludge solids concentration is higher (55 percent), but the quantity is limited and it could be better used as a soil conditioner.

Heat values in Btu per pound (dry weight) vary from 10,300 for raw sewage solids to 6,500 for activated sewage sludge. The latter figure would be applicable to the trickling filter sludge produced at Kaneohe and Kailua. The heat value is derived from the volatile content of the sludge and during incineration between 1,300 and 2,500 Btu is required for each pound of water evaporated from the sludge. The balance of the heat value is just sufficient to incinerate the sludge solids.

Recycling possibilities at small plants such as Kaneohe, Kailua and the proposed plant at Kahaluu are nil. Even large plants such as the proposed ones at Sand Island and Honouliuli have limited possibilities for recycling.

COST ANALYSIS OF THE  
ALTERNATIVE WASTEWATER MANAGEMENT  
SYSTEMS FOR KANEOHE -  
KAILUA SEWERAGE DISTRICT

OCTOBER 1973

CITY AND COUNTY OF HONOLULU  
HONOLULU, HAWAII

WASTEWATER MANAGEMENT SYSTEM FOR  
KANEOHE-KAILUA SEWERAGE DISTRICT

GENERAL

This sewerage district covers the Kahaluu, Kaneohe, and Kailua areas and extends from Kualoa Point to Wailea Point near Lanikai. Development in the Kahaluu area is relatively sparse. The majority of the residences is concentrated in and around the Kaneohe and Kailua areas. The Kaneohe Marine Corps Air Station situated on Mokapu Peninsula is also considered part of this sewerage district.

Presently, wastewater from these areas is basically domestic type waste and is anticipated to remain so in the future.

ALTERNATIVE SYSTEMS

Eight major alternative wastewater systems were considered to serve the tributary area of the Kaneohe-Kailua Sewerage District. Of these, five were eliminated for other than cost reasons leaving three viable alternatives.

1. A single secondary treatment facility located in Kailua phasing out the Kaneohe and Ahuimanu plants with ocean disposal off Mokapu Peninsula. It was assumed that the Kaneohe Marine Corps Air Station (KMCAS) plant will continue to be operated with effluent disposal through this outfall (See Figure 1).



2. A secondary treatment and ocean disposal facility at Kualoa Point to serve the Kahaluu area phasing out the Ahuimanu plant; and the retention of the Kaneohe, Kailua, and KMCAS facilities with their effluent conveyed to the Mokapu outfall for disposal (See Figure 2).
  
3. A secondary treatment facility in Kahaluu phasing out the Ahuimanu plant; and the retention of the Kaneohe, Kailua, and KMCAS facilities with all effluents conveyed to the Mokapu outfall for disposal (See Figure 3).

COST ANALYSIS AND COMPARISON

The results of the present worth analysis for the alternative systems are as follows:

<u>System</u>	<u>Present Worth</u>
Alternative 1	\$ 46,838,000
Alternative 2	39,198,000
Alternative 3	36,538,000

Comparison of the three alternatives on the basis of present worth cost indicated that Alternative 3, the recommended system, is the more economical system. This consists of secondary treatment facilities at Kahaluu, Kaneohe, Kailua, and KMCAS with effluent disposal through an ocean outfall sewer off Mokapu Peninsula.

APPENDIX A

CONSTRUCTION SCHEDULES

ALTERNATIVE 1 - ONE CENTRAL PLANT WITH ONE OUTFALL

FACILITY	1974 - 1979	1980 - 1984	1985 - 1989	1990 - 1994
TREATMENT:				
Kailua	18 MGD Secondary	4 MGD Secondary		
KMCAS (Cost Not Applicable)				
PUMP STATION:				
SPS #4	New Station (5.5 MGD)	Add Pump (2.8 MGD)		
SPS #1a	New Station (6 MGD)	Add Pump (7 MGD)		
SPS #1	New Station (7.5 MGD)	Add Pump (7.3 MGD)		
SPS #3	New Station (14 MGD)	Add Pump (8 MGD)		
SPS #2	New Station (25 MGD)	Add Pump (5 MGD)		
Kaneoche SPS	New Station (50 MGD)	Add Pump (4 MGD)		
Kailua EPS		Add Pump (6 MGD)		
CONDUIT:				
S - 8	10,000 L.F.	10,800 L.F.		
S - 9	5,000 L.F.	4,500 L.F.		
S - 1	3,000 L.F.			
S - 2	3,400 L.F.			
S - 4	4,100 L.F.			
S - 5	1,300 L.F.			
S - 10	10,600 L.F.			
S - 6	3,400 L.F.			
S - 11				
P - 1	1,100 L.F.			
P - 4	500 L.F.			
P - 1a	4,100 L.F.			
P - 3	16,500 L.F.			
P - 2	19,000 L.F.			
Kaneohe FM				
Mokapu Outfall				

ALTERNATIVE 2 - FOUR SEPARATE FACILITIES  
WITH TWO OCEAN OUTFALLS

FACILITY	1974 - 1979	1980 - 1984	1985 - 1989	1990 - 1994
REATMENT:				
Kahaluu	1.85 MGD Secondary			
Kaneohe	6.0 MGD Activated Sludge Conversion		2.0 MGD Secondary	
Kailua	10.0 MGD Activated Sludge Conversion		2.0 MGD Secondary	
KMCAS (Cost Not Applicable)				
UMP STATION:				
SPS #1	New Station (5 MGD)	New Station(0.55MGD)	Add Pump (0.55 MGD)	
SPS #1a	New Station (6 MGD)		Add Pump (3 MGD)	
SPS #4	New Station (6 MGD)		Add Pump (7 MGD)	
SPS #4a	New Station (6 MGD)		Add Pump (7 MGD)	
Kaneohe EPS	New Station (19.5 MGD)		Add Pump (4 MGD)	
Kailua EPS	New Station (35 MGD)		Add Pump (6 MGD)	
Kahaluu EPS	New Station (6 MGD)			
ONDUIT:				
S - 5	5,000 L.F.	3,400 L.F.		
S - 4	5,300 L.F.	4,000 L.F.		
S - 3	7,300 L.F.	1,100 L.F.		
S - 2	10,800 L.F.			
S - 1a	3,800 L.F.			
S - 1				
S - 9				
S - 8				
P - 1	5,300 L.F.	3,000 L.F.		
P - 1a	10,800 L.F.			
P - 4	4,000 L.F.			
P - 4a	16,500 L.F.			
Kaneohe EL	19,000 L.F.			
Mokapu Outfall	9,100 L.F.			
Kualoa Outfall				

ALTERNATIVE 3 - F.C.M. SEPARATE FACILITIES  
WITH ONE OCEAN OUTFALL

FACILITY	1975 - 1979	1980 - 1984	1985 - 1989	1990 - 1994
TREATMENT:				
Kahaluu	1.85 MGD Secondary			
Kaneohe	6.0 MGD Activated Sludge Conversion		2.0 MGD Secondary	
Kailua	10.0 MGD Activated Sludge Conversion		2.0 MGD Secondary	
KMCAS (Cost Not Applicable)				
PUMP STATION:				
SPS #1	New Station(0.55 MGD)		Add Pump (0.55 MGD)	
SPS #4			Add Pump (2.8 MGD)	
Kaneohe EPS	New Station(25 MGD)		Add Pump (4 MGD)	
Kahaluu EPS	New Station(6 MGD)			
Kailua EPS	New Station(35 MGD)		Add Pump (6 MGD)	
CONDUIT:				
S - 5	3,400 L.F.			
S - 2	5,000 L.F.			
S - 4	4,000 L.F.			
S - 1	10,000 L.F.			
S - 3	1,100 L.F.			
S - 8				
S - 9				
P - 1	3,000 L.F.			
P - 4				
Kahaluu EL	31,600 L.F.			
Kaneohe EL	16,500 L.F.			
Mokapu Outfall	19,000 L.F.			
		New Station(2.8 MGD)		
				10,800 L.F.
				4,500 L.F.
				5,400 L.F.

ALTERNATIVE 1: 1 PLANT - 1 OUTFALL

DESCRIPTION	1976 - 1980	1981 - 1985	1986 - 1990	1991 - 1995
<b>KAHALUU FACILITIES</b>				
CONST	1,160		315	-
A, E & C (30%)	348		94	-
CAPITAL	1,508		409	-
ADJUSTED CAPITAL COST	1,562		423	-
REPLACEMENT COST	-		386	-
SUB-TOTAL CAPITAL COST	1,562		809	148
<b>KAHALUU CONDUITS</b>				
CONST	2,810	1,890		
A, E & C (30%)	840	567		
CAPITAL	3,650	2,457		
ADJUSTED CAPITAL COST	3,900	2,630		
REPLACEMENT COST	-	-		
SUB-TOTAL CAPITAL COST	3,900	2,630		
<b>KANEOHE FACILITIES</b>				
CONST	2,470		310	
A, E & C (30%)	740		93	
CAPITAL	3,210		403	
ADJUSTED CAPITAL COST	3,440		414	
REPLACEMENT COST	-		814	
SUB-TOTAL CAPITAL COST	3,440		1,228	
<b>KANEOHE CONDUITS</b>				
CONST	8,370			
A, E & C (30%)	2,500			
CAPITAL	10,870			
ADJUSTED CAPITAL COST	12,350			
REPLACEMENT COST	-			
SUB-TOTAL CAPITAL COST	12,350			
<b>KAILUA FACILITIES</b>				
CONST	19,600		1,900	
A, E & C (30%)	5,900		570	
CAPITAL	25,500		2,470	
ADJUSTED CAPITAL COST	30,000		2,640	
REPLACEMENT COST	-		4,180	
SUB-TOTAL CAPITAL COST	30,000		6,820	

ALTERNATIVE 1

DESCRIPTION	1976 - 1980	1981 - 1985	1986 - 1990	1991 - 1995
KAILUA CONDUITS				
CONST	6,260			
A, E & C (30%)	1,880			
CAPITAL	8,140			
ADJUSTED CAPITAL COST	9,000			
REPLACEMENT COST	-			
SUB-TOTAL CAPITAL COST	9,000			
TOTAL CAPITAL COST	60,252	2,630	8,857	148
P.W. FACTOR	0.7130	0.5083	0.3624	0.2584
PRESENT WORTH	43,000	1,330	3,100	38
TOTAL O & M	494	579	659	732
P.W. FACTOR	4.10	2.92	2.08	1.49
PRESENT WORTH	2,010	1,690	1,370	1,090
SUB-TOTAL PRESENT WORTH	45,010	3,020	4,470	1,110
TOTAL PRESENT WORTH	53,628			
SALVAGE VALUE	1980 - 2,100			
P.W. FACTOR	1980 - 0.6227			
PRESENT WORTH	1,320			
TOTAL SALVAGE PRESENT WORTH	6,790			
GRAND TOTAL PRESENT WORTH	46,838			
				1995 - 24,200
				1995 - 0.220
				5,470

ALTERNATIVE 2: 4 PLANT - 2 OUTFALL

DESCRIPTION	1976 - 1980	1981 - 1985	1986 - 1990	1991 - 1995
<b>KAHALUU FACILITIES</b>				
CONST	6,040	240	360	
A, E & C (30%)	1,810	72	108	
CAPITAL	7,850	312	468	
ADJUSTED CAPITAL COST	8,690	323	485	
REPLACEMENT COST	-	-	1,733	80
SUB-TOTAL CAPITAL COST	8,690	323	2,218	80
<b>KAHALUU CONDUITS</b>				
CONST	7,950	920		
A, E & C (30%)	2,380	276		
CAPITAL	10,330	1,196		
ADJUSTED CAPITAL COST	11,800	1,240		
REPLACEMENT COST	-	-		
SUB-TOTAL CAPITAL COST	11,800	1,240		
<b>KANEHOE FACILITIES</b>				
CONST	3,560		1,380	
A, E & C (30%)	1,070		390	
CAPITAL	4,630		1,770	
ADJUSTED CAPITAL COST	4,960		1,830	
REPLACEMENT COST	-		964	
SUB-TOTAL CAPITAL COST	4,960		2,794	
<b>KANEHOE CONDUITS</b>				
CONST	4,100			
A, E & C (30%)	1,230			
CAPITAL	5,330			
ADJUSTED CAPITAL COST	5,900			
REPLACEMENT COST	-			
SUB-TOTAL CAPITAL COST	5,900			
<b>KAILUA FACILITIES</b>				
CONST	4,460		1,400	
A, E & C (30%)	1,340		420	
CAPITAL	5,800		1,820	
ADJUSTED CAPITAL COST	6,400		1,885	
REPLACEMENT COST	-		1,214	
SUB-TOTAL CAPITAL COST	6,400		3,099	



ALTERNATIVE 2

DESCRIPTION	1976 - 1980	1981 - 1985	1986 - 1990	1991 - 1995
KAILUA CONDUITS CONST A, E & C (30%) CAPITAL ADJUSTED CAPITAL COST REPLACEMENT COST SUB-TOTAL CAPITAL COST	6,260 1,880 8,140 9,000 - 9,000	1,563 0.5083	8,111 0.3624	80 0.2584
TOTAL CAPITAL COST	46,750	795	2,940	2.
P.W. FACTOR	0.7130			
PRESENT WORTH	33,300			
TOTAL O & M	573	665	755	860
P.W. FACTOR	4.10	2.92	2.08	1.49
PRESENT WORTH	2,350	1,940	1,570	1,280
SUB-TOTAL PRESENT WORTH	35,650	2,735	4,510	1,300
TOTAL PRESENT WORTH	44,196			
1995 SALVAGE VALUE (22,083)				
P.W. FACOTR (0.2257)				
PRESENT WORTH	4,998			
GRAND TOTAL PRESENT WORTH	39,198			

ALTERNATIVE 3: 4 CANAL - 1 OUTFALL

DESCRIPTION	1976 - 1980	1981 - 1985	1986 - 1990	1991 - 1995
<b>KAHALU FACILITIES</b>				
CONST	4,520	450	120	
A, E & C (30%)	1,350	135	36	
CAPITAL	5,870	585	156	
ADJUSTED CAPITAL COST	6,500	605	162	
REPLACEMENT COST	-	-	1,232	148
SUB-TOTAL CAPITAL COST	6,500	605	1,394	148
<b>KAHALU CONDUITS</b>				
CONST	5,840	2,480		
A, E & C (30%)	1,760	745		
CAPITAL	7,600	3,225		
ADJUSTED CAPITAL COST	8,400	3,440		
REPLACEMENT COST	-	-		
SUB-TOTAL CAPITAL COST	8,400	3,440		
<b>KANEOHE FACILITIES</b>				
CONST	3,650		1,380	
A, E & C (30%)	1,100		414	
CAPITAL	4,750		1,794	
ADJUSTED CAPITAL COST	5,080		1,860	
REPLACEMENT COST	-		994	
SUB-TOTAL CAPITAL COST	5,080		2,854	
<b>KANEOHE CONDUITS</b>				
CONST	4,660			
A, E & C (30%)	1,400			
CAPITAL	6,060			
ADJUSTED CAPITAL COST	6,700			
REPLACEMENT COST	-			
SUB-TOTAL CAPITAL COST	6,700			
<b>KAILUA FACILITIES</b>				
CONST	4,460		1,400	
A, E & C (30%)	1,340		420	
CAPITAL	5,800		1,820	
ADJUSTED CAPITAL COST	6,400		1,885	
REPLACEMENT COST	-		1,214	
SUB-TOTAL CAPITAL COST	6,400		3,099	

ALTERNATIVE 3

DESCRIPTION	1976 - 1980	1981 - 1985	1986 - 1990	1991 - 1995
KAILUA CONDUITS CONST	6,490			
A, E & C (30%) CAPITAL	1,950			
ADJUSTED CAPITAL COST	8,440			
REPLACEMENT COST	9,330			
SUB-TOTAL CAPITAL COST	9,330			
TOTAL CAPITAL COST	42,410	4,045	7,347	148
P.W. FACTOR	0.7130	0.5083	0.3624	0.2584
PRESENT WORTH	30,100	2,050	2,660	38
TOTAL O & M	521	627	717	827
P.W. FACTOR	4.10	2.92	2.08	1.49
PRESENT WORTH	2,140	1,830	1,490	1,230
SUB-TOTAL PRESENT WORTH	32,240	3,880	4,150	1,268
TOTAL PRESENT WORTH	41,538			
1995 SALVAGE VALUE (22,163)				
P.W. FACTOR (0.2257)				
PRESENT WORTH	5,000			
GRAND TOTAL PRESENT WORTH	36,538			

TABLE C-1

CONSTRUCTION PERIOD VERSUS CAPITAL COSTS

Capital Cost Range of Project	Assumed Construction Time Requirement (Years)
\$0 to \$2,000,000	1
\$2,000,000 to \$5,000,000	2
\$5,000,000 to \$10,000,000	3
\$10,000,000 to \$20,000,000	4
Over \$20,000,000	5

TABLE C-2

FACTORS FOR COMPUTING ADJUSTED CAPITAL COSTS

Length of Construction Period (in Years)	Capital Cost Adjustment Factor
1	1.035
2	1.07
3	1.105
4	1.14
5	1.175

tenance costs are developed as "average" costs during successive five-year periods. The present worth factors resulting from these calculations are presented in Table C-4.

TABLE C-3

PRESENT WORTH FACTORS FOR  
ADJUSTED CAPITAL COSTS

Year of Initial Operation	Present Worth Factor ("p")
1973	1.0000
1978	0.7130
1983	0.5083
1988	0.3624
1993	0.2584

Replacement Costs

Replacement costs are the funds necessary to replace facility components whenever their estimated service life terminates in order to secure continuous and economic operation of the facilities.

A separate replacement period has been used in the calculation of replacement costs for structures, process equipment, auxiliary equipment, and transportation facilities. All structures and major process equipment are assumed to have a useful life of 30 years, all transportation structures (pipelines) are assumed to last for 50 years, and all auxiliary equipment have a service life of 10 years before replacement becomes necessary. The replacement cost factor for

liquid treatment is assumed as 0.25 of the construction cost; for solid treatment, 0.30; and for pump stations the value used is 0.33.

TABLE C-4

PRESENT WORTH FACTORS FOR OPERATION  
AND MAINTENANCE COSTS

Period During Which Operation & Maintenance Costs are Incurred	Present Worth Factor
1976-80	4.10
1981-85	2.92
1986-90	2.08
1991-95	1.49

Salvage Values

The salvage values for all components were derived by using the service lives and replacement cost factors listed under Replacement Costs and straight-line depreciation. Table C-5 shows the factors used in determining the salvage values.

TABLE C-5

SALVAGE VALUE FACTORS

<u>COMPONENT</u>	<u>CONSTRUCTION PERIOD</u>	<u>FACTOR</u>
Liquid treatment and misc.	75 - 79	0.250
	85 - 89	0.500
Solids treatment	75 - 79	0.234
	85 - 89	0.468
Conduits	75 - 79	0.600
	80 - 84	0.700
Pump Stations	75 - 79	0.223
	80 - 84	0.335
	85 - 89	0.446
Auxiliary Equipment	90 - 94	0.500
Land	76 - 95	1973 Market Value

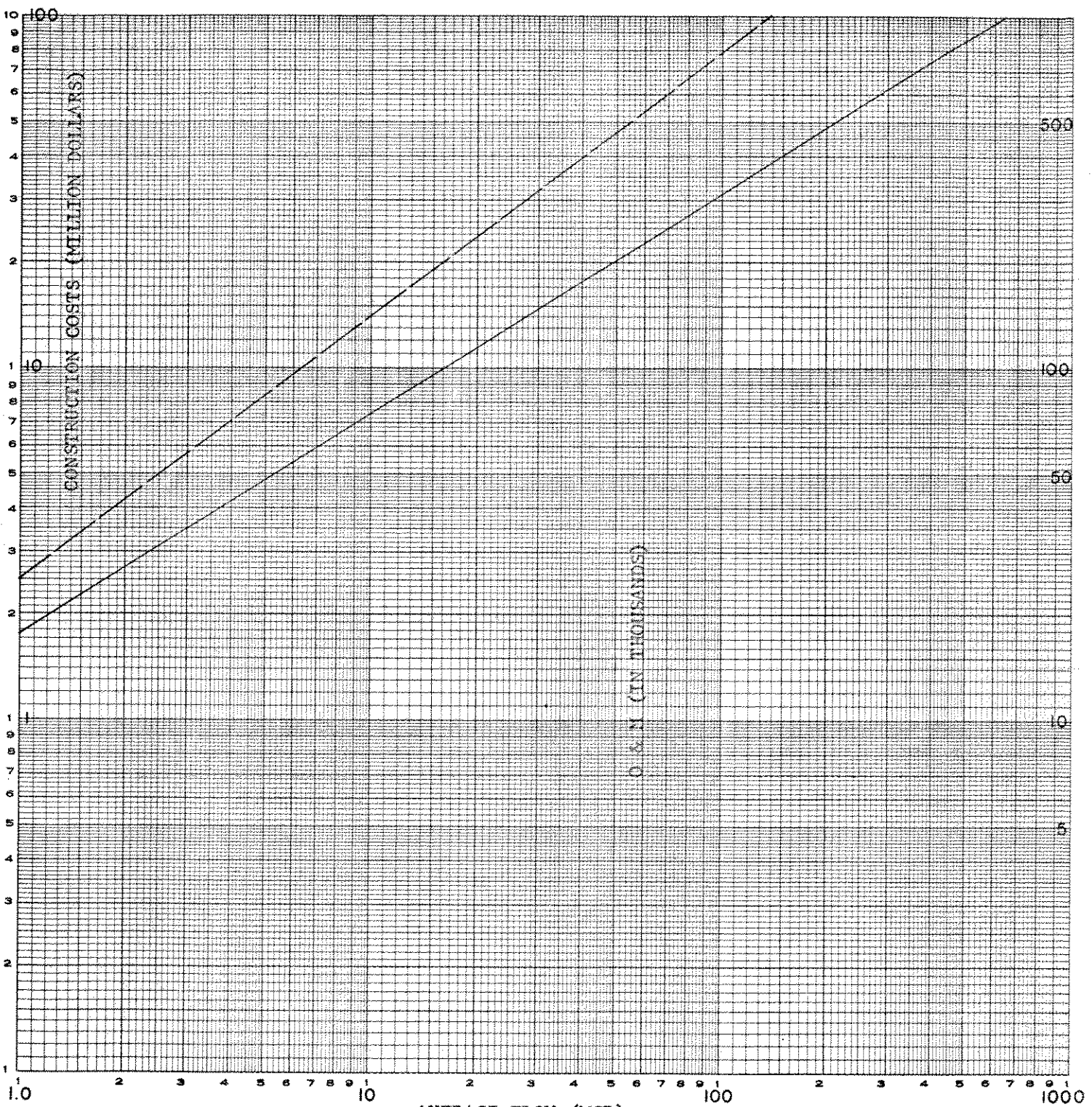
APPENDIX D

SUMMARY OF COST ESTIMATES



LOGGING SERVICE CO.  
MADE IN U. S. A.

LOGARITHMIC  
3 CYCLES X 3 CYCLES



ACTIVATED SLUDGE TREATMENT

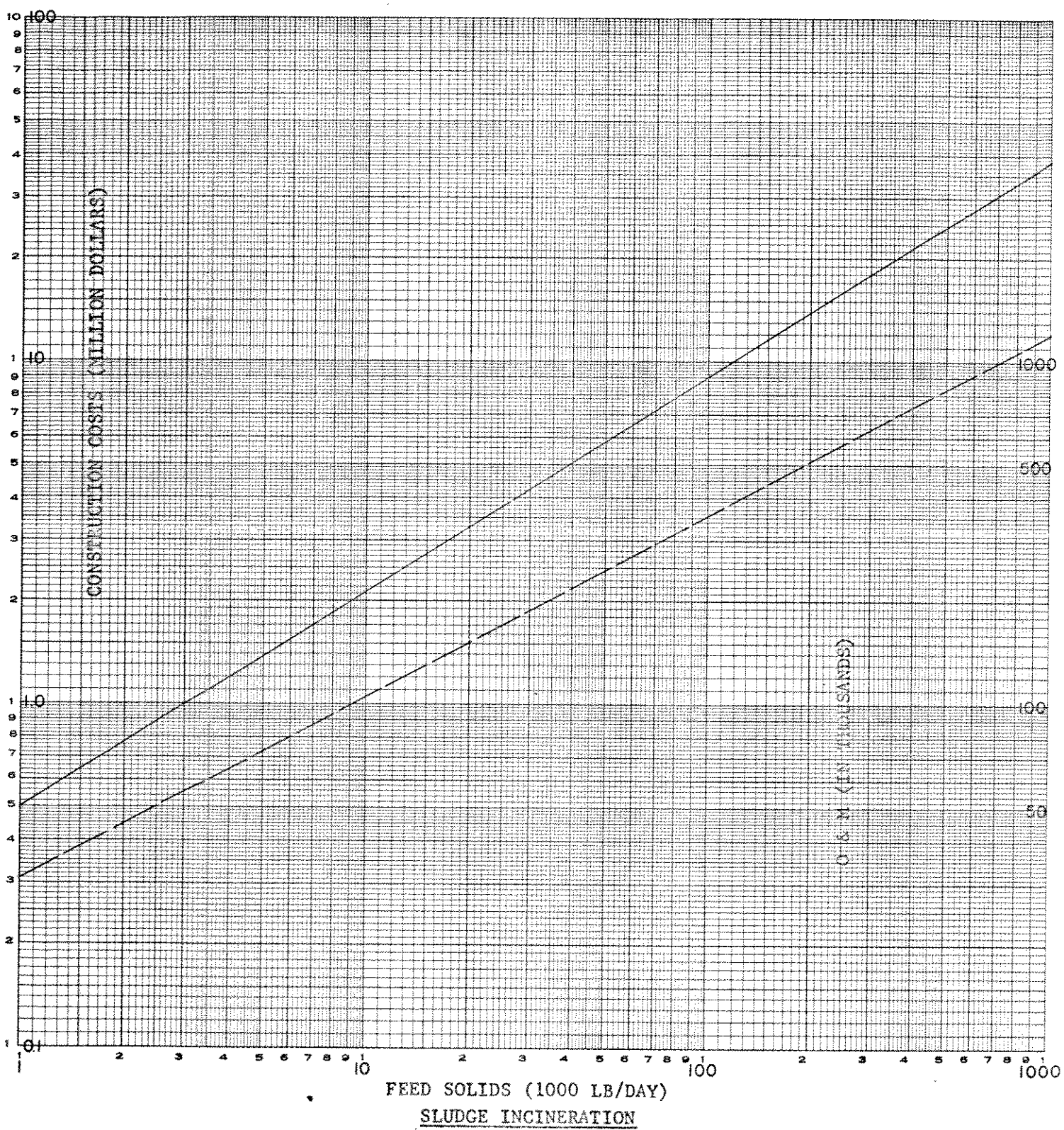
Includes primary treatment, activated sludge, and secondary clarification.  
Does not include Administration, Engineering and Contingency.

--- O & M  
— Const.

FIGURE B-6

EUGENE DIETZEN CO.  
MADE IN U. S. A.

LOGARITHMIC  
3 CYCLES X 3 CYCLES

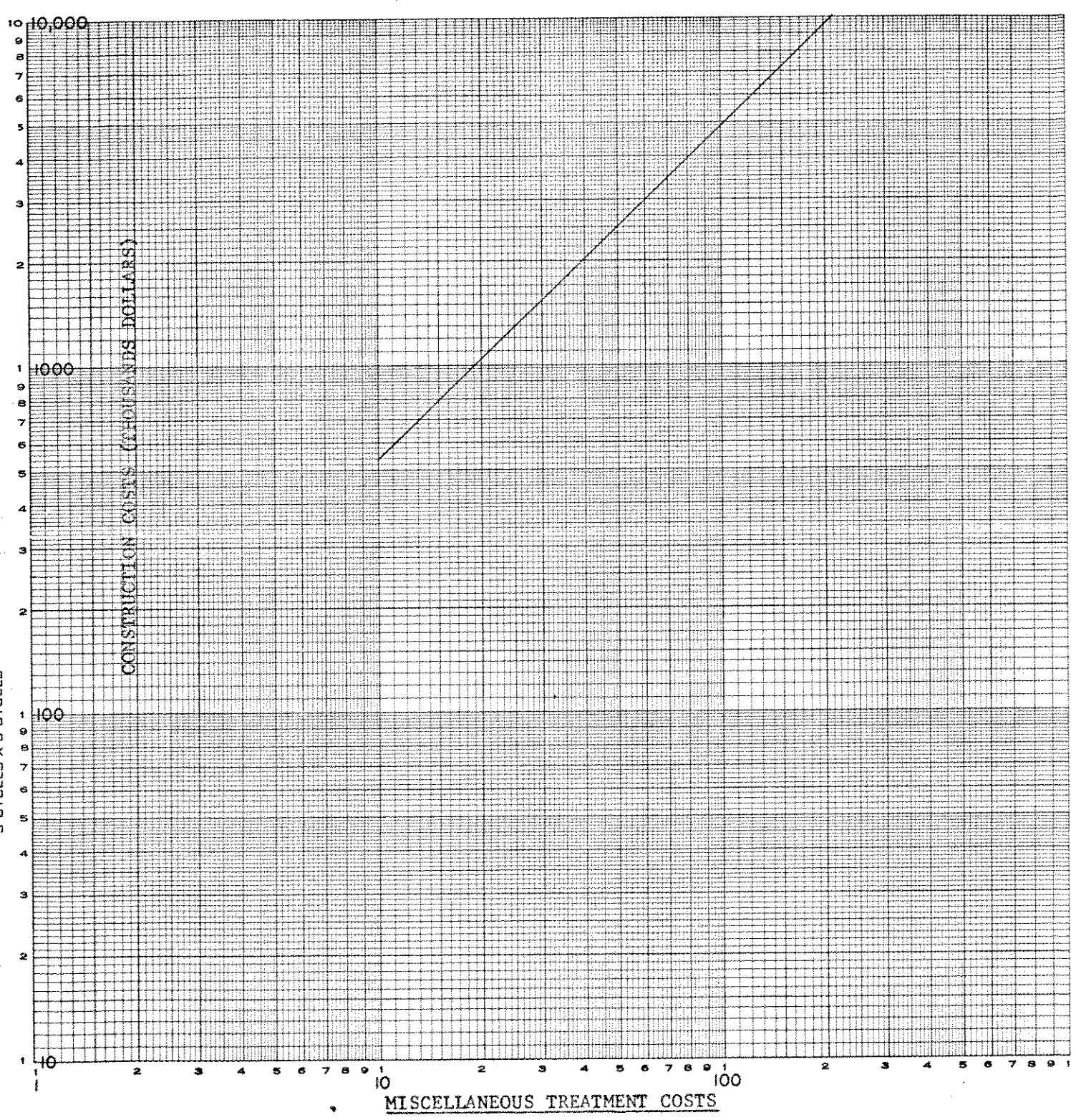


Includes thickening, dewatering, incineration & ash disposal.  
Does not include Administration, Engineering and Contingency.

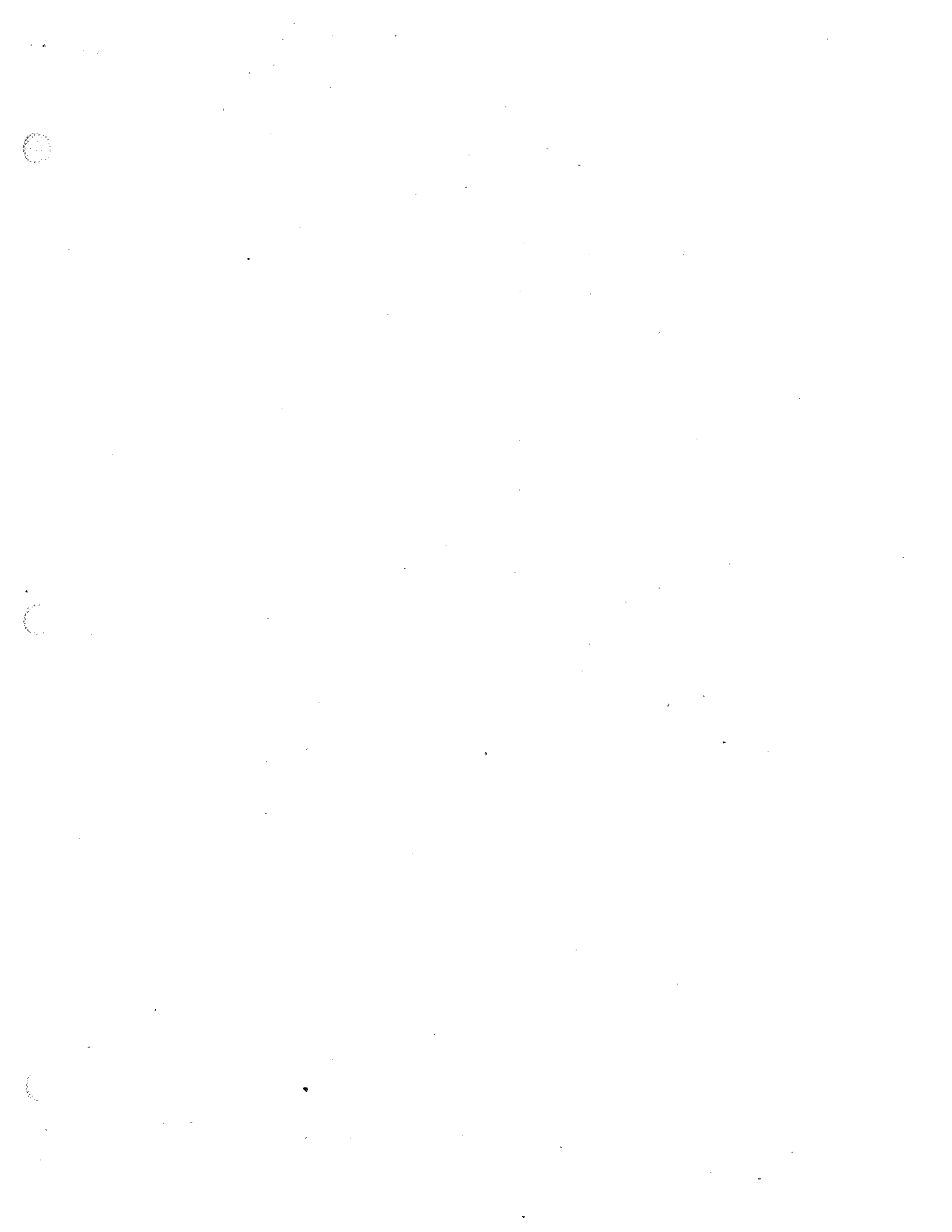
— — — O & M  
- - - - - Const.

MADE IN U. S. A.

LOGARITHMIC  
3 CYCLES X 3 CYCLES



Includes Site Preparation and Admin/Control and Service/Maint Buildings  
 Does not include Land, Administration, Engineering, and Contingency



APPENDIX C

PRESENT WORTH ANALYSIS

## PRESENT WORTH ANALYSIS

Stated simply, present worth is the amount of money required today to construct, operate, maintain, and replace all facilities required in the future. The procedure utilized in this report consists of (1) adjusting capital costs to reflect interest during construction, (2) calculating replacement costs for all structural and mechanical facilities, (3) bringing the adjusted capital costs, replacement costs, and operation and maintenance costs back to present worth, and (4) subtracting the present worth of the salvage value. A detailed development of the factors involved is presented in the following sections.

### Interest Rates

An interest rate of 7 percent per year is used for all present worth computations. A planning period of 20 years is used starting from 1976, the initial date of operation of the system.

### Adjusted Capital Costs

In actual practice, the capital costs for any facility are spread through the construction period. It has been assumed here that the funds for a years construction are available in full at the beginning of each year of the construction period. To eliminate detailed computations of construction schedule versus cash outlay for each facility, typical project capital outlay distributions were estimated for facilities



having different construction periods. Table C-1 gives the relation of construction cost amount to years required for construction which were assumed for this estimate. Table C-2 shows the resultant factors by which construction costs were multiplied to adjust capital costs for interest charges incurred during a given construction period based on the formula; Interest equals  $\frac{1}{2}$  the interest rate (7%) X the construction period in years X the total capital expenditure.

#### Present Worth of Adjusted Capital Costs

To compare the costs of the various alternative systems which have been proposed, all costs must be reduced to present value at some common date. The date used in this report is 1973. The adjusted capital costs described are the present value of capital costs at the date of initial operation of any facility. The adjusted capital costs of each facility is multiplied by factor "p" in order to calculate the present value as of 1973. The factor "p" is derived from the formula  $\frac{1}{(1.07)^n}$ , where "n" represents the number of years between the date of initial operations assumed for a facility and 1973. Table C-3 shows "p" for the years in which initial operation of facilities are assumed.

#### Present Worth of Operation and Maintenance Costs

To reduce future operation and maintenance costs to a common present day value involves a procedure similar to that outlined for Adjusted Capital Costs. However, because of the time span and many variables involved, the operation and main-



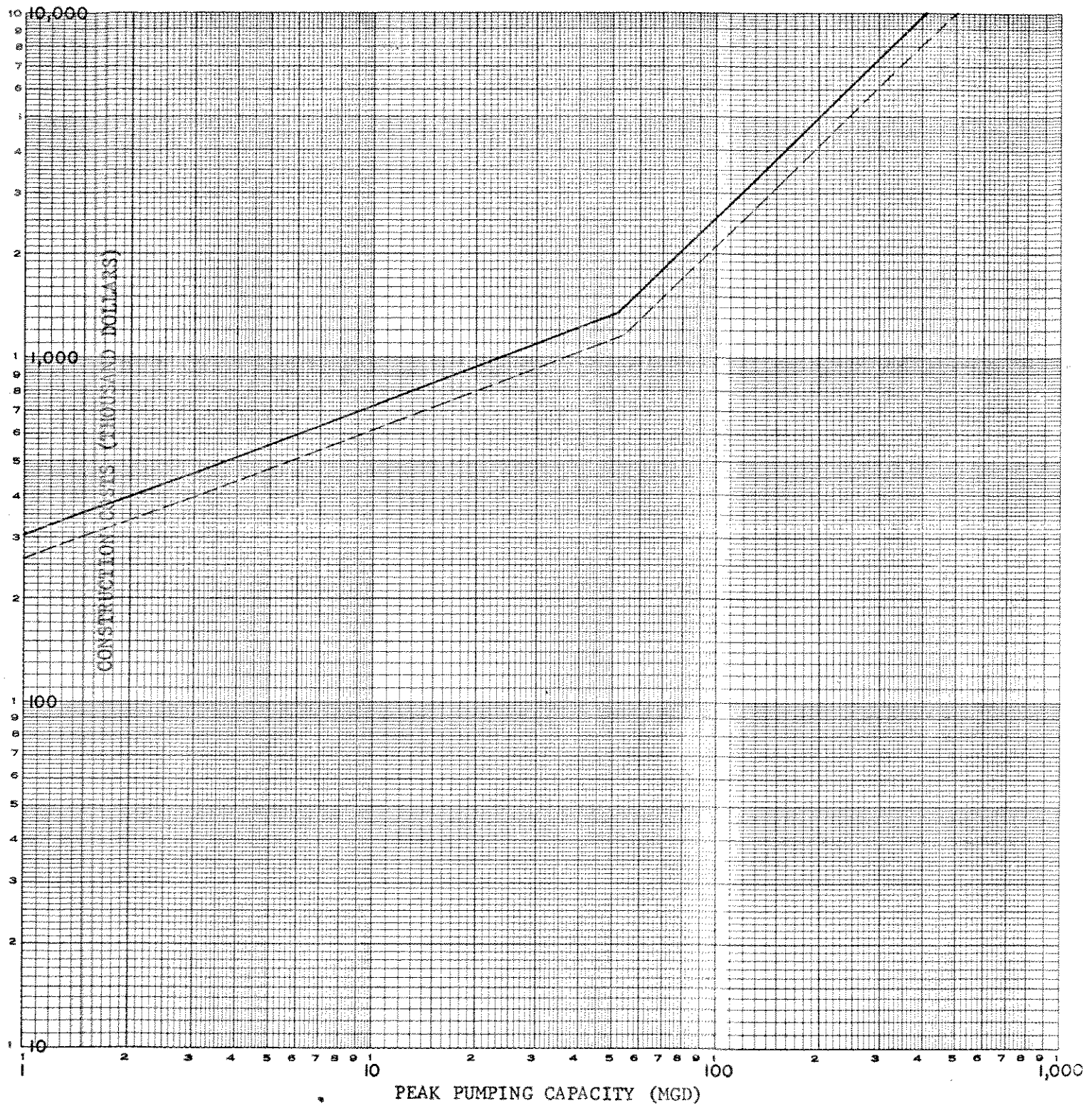






MADE IN U. S. A.

LOGARITHMIC  
3 CYCLES X 3 CYCLES



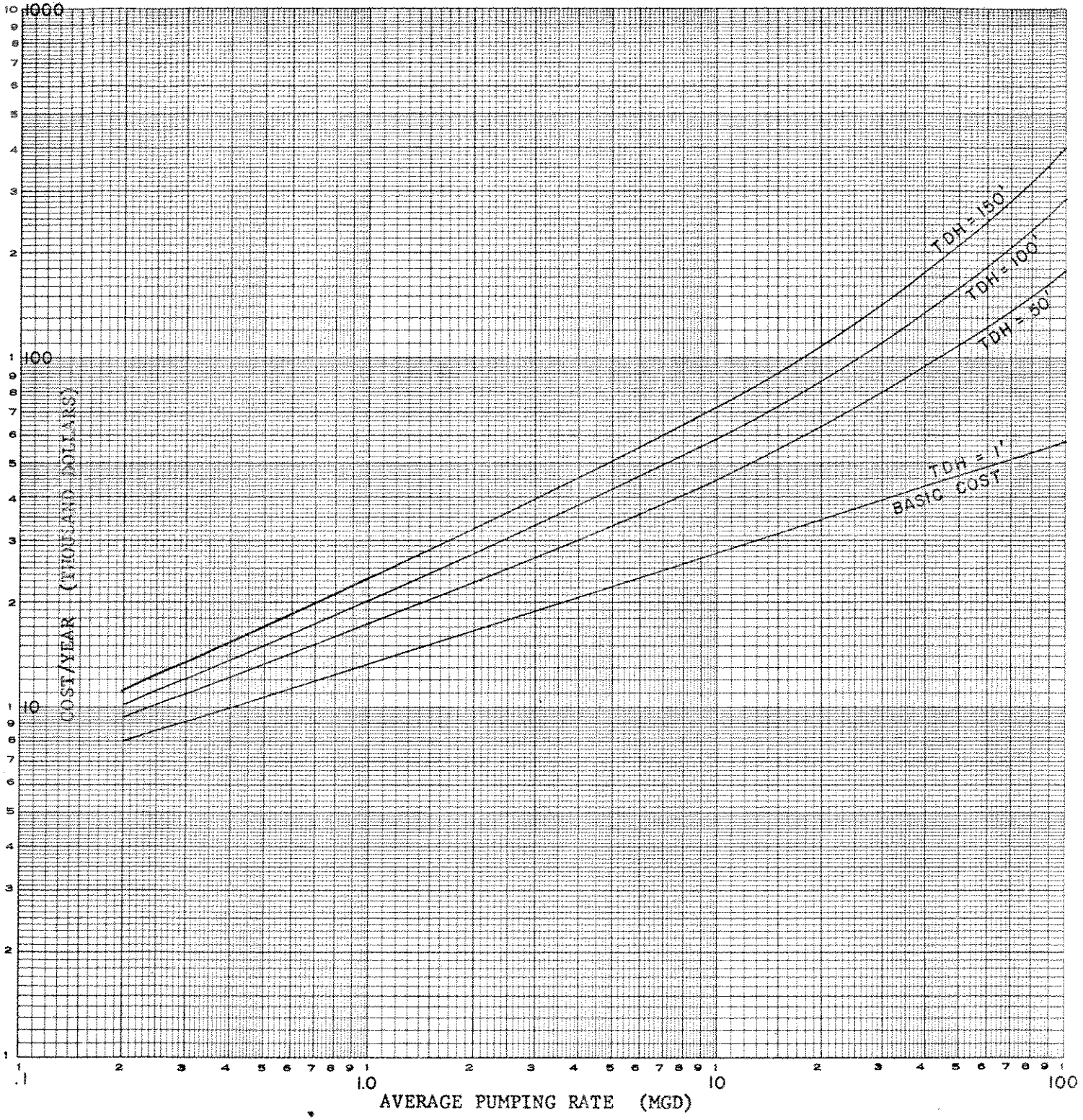
CONSTRUCTION COST CURVE FOR WASTEWATER PUMPING STATIONS

Cost is in place complete.

Does not include Administration, Engineering and Contingency

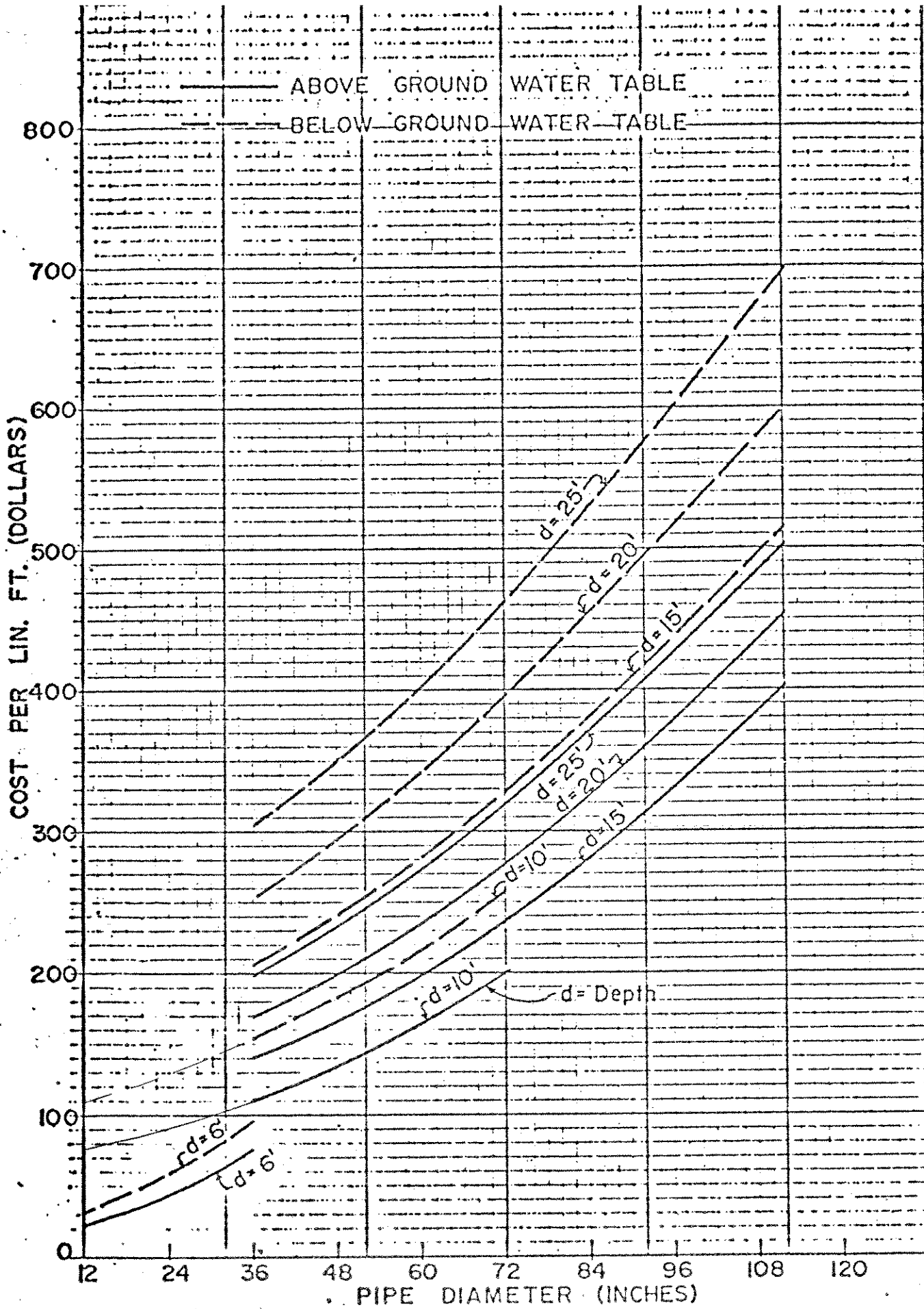
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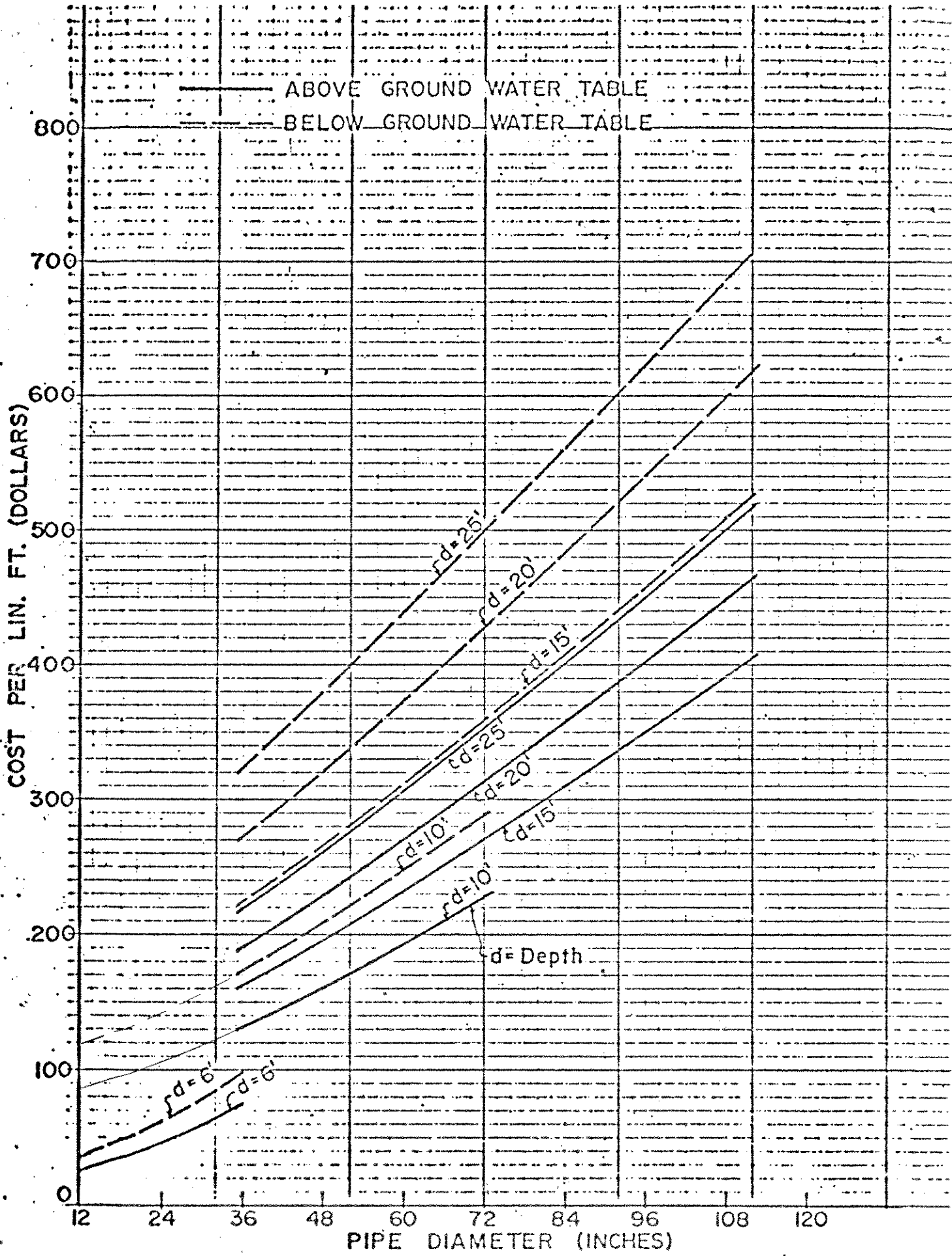


OPERATION AND MAINTENANCE COST FOR WASTEWATER PUMPING STATION

Includes labor, equipment, material, telephone and power.



CONSTRUCTION COST CURVE FOR WASTEWATER PRESSURE MAINS

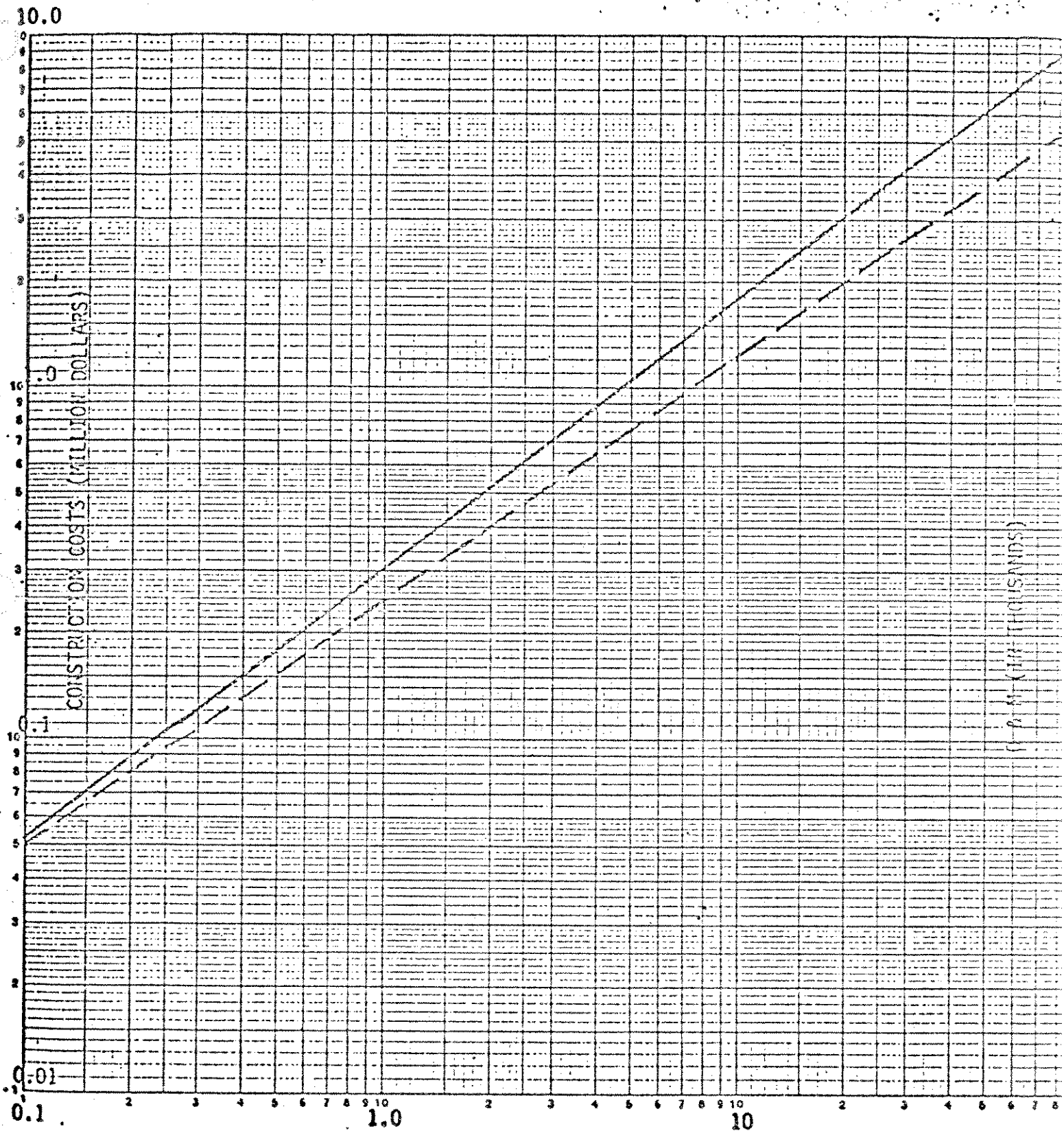


CONSTRUCTION COST CURVE FOR GRAVITY SEWERS

Cost is in place complete.



MADE IN U.S.A.  
Kruppel & Esser Co.



AVERAGE FLOW (MGD)  
PRIMARY TREATMENT

Includes screening, grit removal, comminution, and sedimentation-floatation.  
Does not include Administration, Engineering, and Contingency

--- 0 & 1  
- - - Const

APPENDIX B

BASIS FOR COST ESTIMATES



## BASIS FOR COST ESTIMATES

### General

The cost estimates for the various alternatives are based upon the Estimated Pollutant Loads for the individual systems in Table B-1, the Construction Schedules depicted in Appendix A, and the Construction and Operation and Maintenance Cost Curves included as Figures B-1 to B-8. Tables B-2 to B-4 depict the individual system costs in each alternative. The operation and maintenance costs are based on the average annual costs for the 5 year periods.

### COST CURVES

#### Construction Cost Curve for Pumping Stations

The construction cost curve shown on Figure B-1 was derived from construction cost data of existing pumping stations on Oahu. The EPA (FWPCA) Sewage Construction Cost Index was used to escalate costs from the year of construction to reflect 1973 costs. The base for this index is August 1957-59 = 100. Cost includes material, excavation, backfill, installation, and contractor's overhead and profit.

#### Operation and Maintenance Cost Curves for Pumping Stations

The operation and maintenance cost curve shown on Figure B-2 was derived by plotting the annual O & M costs of existing pump stations on Oahu from 1964 to 1973 versus the average pumping per day during the same period. Cost includes labor, equipment, material, telephone, and power.

## Construction Cost Curves for Gravity Sewers and Pressure Mains

The cost curves for gravity sewers and force mains were developed by studying construction cost data for existing facilities. However, local construction cost data for the lines with diameters exceeding 60 inches are not available. Unit costs for these larger lines were derived by estimating material and installation cost, and excavation and backfill costs. The cost curves shown on Figures B-3 and B-4 reflect estimated installed cost for various sizes of reinforced concrete pipe including contractor's overhead and profit.

## Maintenance Cost Curves for Gravity Sewers and Pressure Mains

Based on information obtained from the maintenance section of the Division of Sewers, the following costs have been allowed for maintenance of sewers proposed in this report.

<u>Pipe Size</u>	<u>Cost/Mile/Year</u>
1. Gravity Sewers	
6" to 12"	1,000
15" to 24"	2,000
27" to 48"	4,000
54" to 72"	7,500
78" to 108"	10,000
2. Pressure Mains	2,000

## Construction Cost Curves for Wastewater Treatment Plants

The construction costs of wastewater treatment facilities at several levels of treatment have been estimated from curves

developed as shown in Figures B-5 through B-7. The basis for developing these curves was the method utilized by R. Smith of the Advanced Waste Treatment Branch of the EPA-WQO. Costs were adjusted to 1973 utilizing the EPA Construction Cost Index. Further adjustments were made for construction costs in the State of Hawaii. A factor of 1.25 was used for Hawaii based on information supplied by contractors and equipment manufacturers.

#### Operation and Maintenance Cost Curves for Wastewater Treatment Facilities

The development of cost curves for the operation and maintenance of wastewater treatment facilities were also based on Smith's report. The adjustment factors involved not only time, but costs of labor, chemicals (where indicated), and power.

#### Miscellaneous Cost Data

The Outfall costs were individually derived based upon present day prices in Hawaii. The costs for miscellaneous treatment items such as site preparation and the administration/control and service/maintenance buildings are obtained from Figure B-8.

TABLE B-1

ESTIMATED POLLUTANT LOADS

DESCRIPTION	KAHALUU			KANEIHOE			KAILUA			KMCAS		
	1970	1990	2020	1970	1990	2020	1970	1990	2020	1970	1990	2020
	Population (thousands)	7	14.5	35	30	63	142	40.5	74.5	153.5		
Average Flow Per Capita (gpd)	75	78	85	85	85	85	90	90	90			
Average Sewage Flow (mgd)	.5	1.1	3.0	2.6	5.4	12.1	3.7	6.7	13.8			
Dry Weather Infiltration (mgd)	.2	.3	.7	.6	1.3	3.0	1.7	3.2	6.6			
Design Average Flow (mgd)	.7	1.4	3.7	3.2	6.7	15.1	5.4	9.9	20.4	1.0	1.4	2.0
Design Max Hourly Flow (mgd)	1.9	3.6	8.1	7.1	13	25.4	10.4	17.4	31.8	3.2	4.1	5.5
Wet Weather Infiltration (mgd)	1.2	2.3	5.2	4.6	6.5	11.2	4.5	7.0	12.7	2.4	2.4	2.4
Design Peak Flow (mgd)	3.1	5.9	13.3	11.7	19.5	36.6	14.9	24.4	44.5	5.6	6.5	7.9
Average Per Capita BOD (lbs/day)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Total BOD (1,000 lbs/day)	1.3	2.8	6.7	5.7	12.0	27.0	8.0	14.2	29.2	1.9	2.7	3.8
Average Per Capita SS (lbs/day)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Total SS (1,000 lbs/day)	1.1	2.3	5.6	4.8	10.1	22.7	6.5	11.9	24.6	1.6	2.2	3.2

NOTE: Estimated population for KMCAS = 6,500 people; however flows indicated reflect plant capacity.



ALTERNATIVE 2: 4 PLANT - 2 OUTFALL  
(COSTS IN THOUSANDS OF DOLLARS)

DESCRIPTION	76 - 80		81 - 85		85 - 90		91 - 95		1995	
	CONST	O & M	CONST	O & M	CONST/REPL	O & M	CONST/REPL	O & M	SALVAGE	
A. KAHALUU (85% SOLIDS REMOVAL)										
Facilities										
Liquid treatment, land and misc.	3,000	24		32	0/750	40		48	975	
Solids treatment	760	31		37	0/230	44		50	178	
Effluent SPS	520	17		18	0/172	19		20	116	
SPS #1			240	8	50	9	0/80	10	120	
SPS #1a	560	19		20	70/185	21		22	125	
SPS #4	600	20		21	120/198	22		23	134	
SPS #4a	600	20		21	120/198	22		23	134	
Sub-total	<u>6,040</u>	<u>131</u>	<u>240</u>	<u>155</u>	<u>360/1,733</u>	<u>177</u>	<u>0/80</u>	<u>196</u>	<u>1,782</u>	
Conduits:										
S - 5	420		250							
S - 4	450		320							
S - 3	740		200							
S - 2										
S - 1a										
S - 1	1,630									
S - 9	390									
S - 8										
P - 1			150							
P - 1a	290									
P - 4	970									
P - 4a	360									
Kualoa Outfall	<u>2,700</u>		<u>920</u>							
	<u>7,950</u>									5,414