A WATER SUPPLY FOR THE EWA AND WAIANAE DISTRICTS

BOARD OF WATER SUPPLY
HONOLULU, HAWAII

A WATER SUPPLY FOR THE EWA AND WAIANAE DISTRICTS

A Preliminary Report on the Water Resources of the Ewa and Waianae Districts and Possible Means of Development

Honolulu.

BOARD OF WATER SUPPLY
HONOLULU, HAWAII

FEBRUARY, 1958

Limited ed.

contents

Letter of Transmittal — 1

Principal Findings — 2
Recommendations — 3
A Suggested Plan of Financing — 4

General Background — 7

Developable Areas and Water Requirements — 11

Existing Water Systems in the Ewa-Waianae Districts — 17

Possible Projects — 19

Study "A" — Interim Water Supply for Standard Oil Company of California — 22
Study "B" — Greater Utilization of Water Resources of Waianae District — 23
Study "C" — Water Development Projects at Pearl Harbor Springs — 28
Study "D" — Possible Major Maui-type or Drilled Well Stations — 34
Study "E" — Additional Projects Relative to Waianae Water Supply — 39

Salt Water Conversion — 42

Economic Analysis — 45

Estimated Population Growth — 45
Economic Comparison of Basic Development Plans — 47
Comparison of Estimated Revenue with Total Cost — 50

Methods of Financing Improvements — 57

Principal Source Material — 64

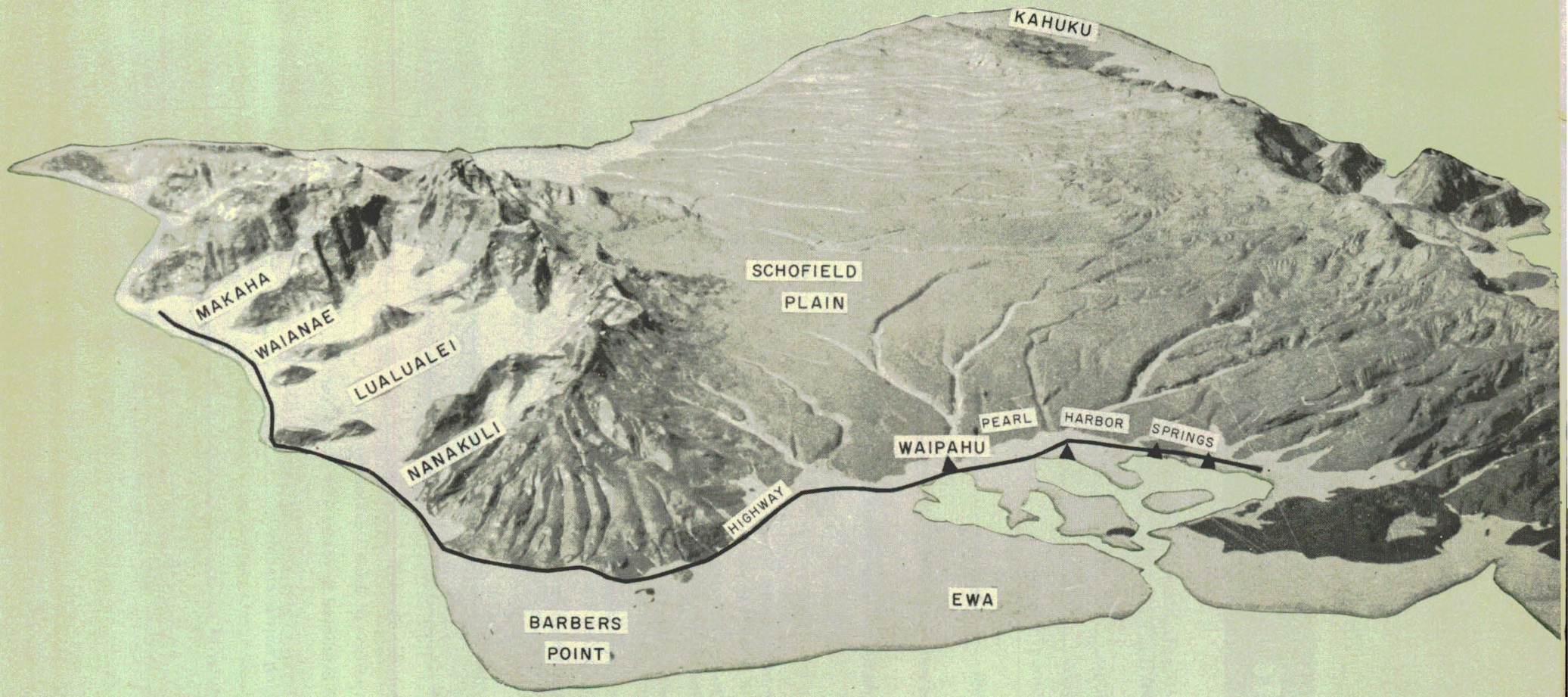

PLATE I

A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

RELIEF MAP

SHOWING

AREAS DISCUSSED IN THIS REPORT

BOARD OF WATER SUPPLY

HONOLULU, HAWAII

February 10, 1958

Honorable Mayor and Members
Board of Supervisors
City and County of Honolulu
Honolulu, Hawaii

Gentlemen:

In accordance with your request, I am transmitting herewith a report which covers our findings and recommendations on a water supply for the Ewa-Waianae districts.

The growth of Oahu has been, and will continue to be, largely dependent upon the development of its water resources. This growth has created water problems which are becoming progressively more and more difficult and costly of solution. Not only are we faced with the problem of developing new sources, but the transporting of water over greater distances has become a real challenge.

Nature has provided an abundance of rainfall on Oahu. It is unfortunate, however, that the water is not always available where it is needed.

The semiarid Ewa-Waianae area has been deficient in water for years. This has become more critical recently because of a rapidly growing population and tremendous promise of expansion and diversification in agricultural and industrial activities.

We have studied the problem as exhaustively as possible since your request. Investigations have been made on water availability, sources of supply, potability, areas to be served, quantities required, cost and other factors. The study resolves itself into a consideration of transporting water from areas of surplus to areas of deficiency involving, roughly, one-third of the island of Oahu.

In planning for water resources development, first consideration must be given to the requirements of the area from which the water is to be diverted. If there is a surplus, it might well be put to its highest and best use elsewhere. It is believed that there is a surplus of water in the Pearl Harbor area. This can be better determined after the current studies of the U. S. Geological Survey are completed. It can be said with relative certainty, however, that large quantities of water can be made available by aggressive conservation measures.

We feel that this report provides a basis for finalizing an over-all, long-range master plan for water development and water distribution to the Ewa-Waianae area.

Several plans are shown, together with cost and other pertinent data. The various plans should be regarded as broad and flexible patterns which may be altered as additional data and experience are gained. There is no doubt that some of the plans shown are very costly and may not be feasible for many years.

It should also be pointed out that no attempt was made in this study to evaluate the potentialities of surface water recovery. Although available records indicate little promise of such a source, particularly in view of the fact that much of the dependable perennial stream flow is already being utilized by plantations, its possibilities should nevertheless be explored more fully at some future date.

PRINCIPAL FINDINGS

The principal findings resulting from our study are as follows:

1. With certain exclusions, as listed on page 11, a net total of approximately 16,500 acres may be considered as developable in the Ewa-Waianae districts. In this report the 16,500 acres will be referred to as "the area under study."

2. The ultimate population of the area under study is estimated at 225,000. Under an accelerated growth pattern the population in this area might reach 100,000 by 1990 and 225,000 by the year 2020, or roughly in about 60 years. The estimated population under a conservative growth trend is about 40 per cent of the accelerated growth figures. The population of the area at present is about 17,000.

3. Additional water required for ultimate development of the area is estimated at 40 mgd.

4. Possible sources of water for the area are at Pearl Harbor Springs, Waikakalaua, lower Kunia, and Schofield Plateau.

5. Economic recovery of a domestic supply directly from Pearl Harbor Springs will probably be only 25 per cent of the recorded (visible) flow for reasons shown in this report. In such case the minimum quantity developable would be in the neighborhood of 13 mgd. In order to develop a minimum of 20 mgd, rapid sand filtration, together with softening and treatment for chloride reduction, would be necessary. The cost of this type of treatment, however, is so high that further consideration would be unwarranted. Furthermore, to pipe good quality water to a central treatment plant would require a collection system extending over 6 miles of shoreline. In preference to treating the flow from the springs, it is believed that potable water may be recovered from wells located at relatively short distances back of the springs. The feasibility of such a

method will be dependent upon field tests recommended in this report.

6. From the standpoints of ultimate need and hydrologic-geologic advantages, an inland shaft or well field at Waikakalaua seems to be most promising.

7. A drilled well development of at least 20 mgd in lower Kunia, while economically attractive, appears problematical pending completion of the current studies by the U. S. Geological Survey.

8. Development of high-level water at Schofield seems least desirable economically.

An economic analysis of the various plans and alternates appears on page 47.

RECOMMENDATIONS

A number of plans for supplying water to the Ewa-Waianae districts are discussed in this report. They range from relatively small-scale utilization of local sources to multimillion dollar projects to serve the ultimate needs of the area. Generally, priority for the adoption of any of these projects is dependent upon the demand for water, availability of water at the sources mentioned, and availability of funds.

Our approach to a solution of this problem is generally as follows:

1. As soon as feasible, adopt an over-all, long-range water plan for the Ewa-Waianae districts and work toward its ultimate accomplishment.

2. To complete further studies and evaluations and to find funds for a multimillion dollar project would undoubtedly require some time. In the meantime, the following should be undertaken to provide for current and expanding activities and population in the near future:

   a. Provide as rapidly as possible, an interim water supply for the Standard Oil refinery. Suggestions are made in Study "A" of this report (page 22).

   b. Complete the project now being undertaken by the Suburban Water System whereby an estimated 2 mgd of water will be transported to the Ewa district from lower Kunia.

   c. Complete the projects now being considered by the Suburban Water System for the improvement of the Waianae System. It is suggested that pipe and storage tank capacity be designed to utilize for potable purposes the estimated 4 mgd of water now available in upper Waianae from the City and County "Kunesh" Tunnel and the former plantation system.

d. Develop and rearrange for optimum use additional available sources of domestic and irrigation water in the Waianae district. Suggestions are made in Study "B" herein (page 23).

3. At the completion or during the construction of the projects mentioned above the advisability of proceeding with the multimillion dollar water system for the area under study should be reviewed and re-evaluated. In connection with the list of projects shown in Table 3, page 51, it appears that a well-field development in lower Kunia would be most economical. However, we are not recommending the initiation of this project without the concurrence of the U. S. Geological Survey because the actual safe yield may fall far short of the assumed production due to existing installations in the general vicinity. It should, nevertheless, be used as a starting point for the purpose of evaluating construction priority. On the other hand, the most promising but costlier site appears to be a development in the Waikakalaua area. If it is determined that the assumed yields shown in Table 3 are too high, a composite installation may well be considered whereby the quantities which can safely be obtained from the various sources are integrated into one system.

4. The final selection of a project, as suggested under Item 3 above, should be based on an initial capacity of 20 mgd. Our studies show that this amount would be sufficient to serve the area for at least 30 years under accelerated growth.

5. It is recommended that none of the major developments listed in Table 3 be started without the concurrence of the U. S. Geological Survey or until after the completion of its current study relative to water resources in the Pearl Harbor area. Because of the numerous long-term factors which must be considered, it is desirable that the investigation by the U. S. Geological Survey be a continuing one, even after completion of its current study.

A SUGGESTED PLAN OF FINANCING

The state of California has assumed financial responsibility for the development of a part of its two-billion dollar project whereby water will be transported from water-surplus northern areas to water-short southern areas, all for the purpose of broadening the economic base, attracting new industries, and providing additional homes and jobs for a growing population. The State has looked upon this as a proper participation, leaving the financing of local feeder main developments to municipalities and benefited lands. We should point out, however, that in some cases provision for repayment is included.

Similarly, the 1957 Territorial Legislature, by Acts 150 and 289, set up a general obligation bond fund in the amount of 7 1/2 million dollars for the development and transportation of water from areas of surplus to the Ewa-Waianae districts. As shown in the section on "Economic Analysis" in this report, this amount is inadequate for the over-all development and may be supplemented by funds from the sources suggested below. Because of the great distances involved and relatively small population served, compared with the cost of the primary project, the opening up of lands at Ewa and Waianae may not be economically feasible without, as with California, State or Territorial participation.

We therefore suggest that, because of the factors involved and the magnitude of the project, the most attractive financing plan would be a combination of all of the following:

a. Funds as provided by Acts 150 and 289, S. L. H. 1957.
b. Revenue bonds issued by the municipal water department.
c. Contributions from developers who are benefited.

We are aware that, unless the funds as authorized under Acts 150 and 289 are committed by priority, Congressional action to raise the debt limits of the Territory and the City and County must be necessary to make them available.

We wish to express our appreciation to the U. S. Geological Survey and the Suburban Water System for their cooperation. We also appreciate the opportunity of contributing toward the solution of a problem which so greatly affects the future growth of Oahu.

Respectfully submitted,

(s) E. J. Morgan
Manager and Chief Engineer

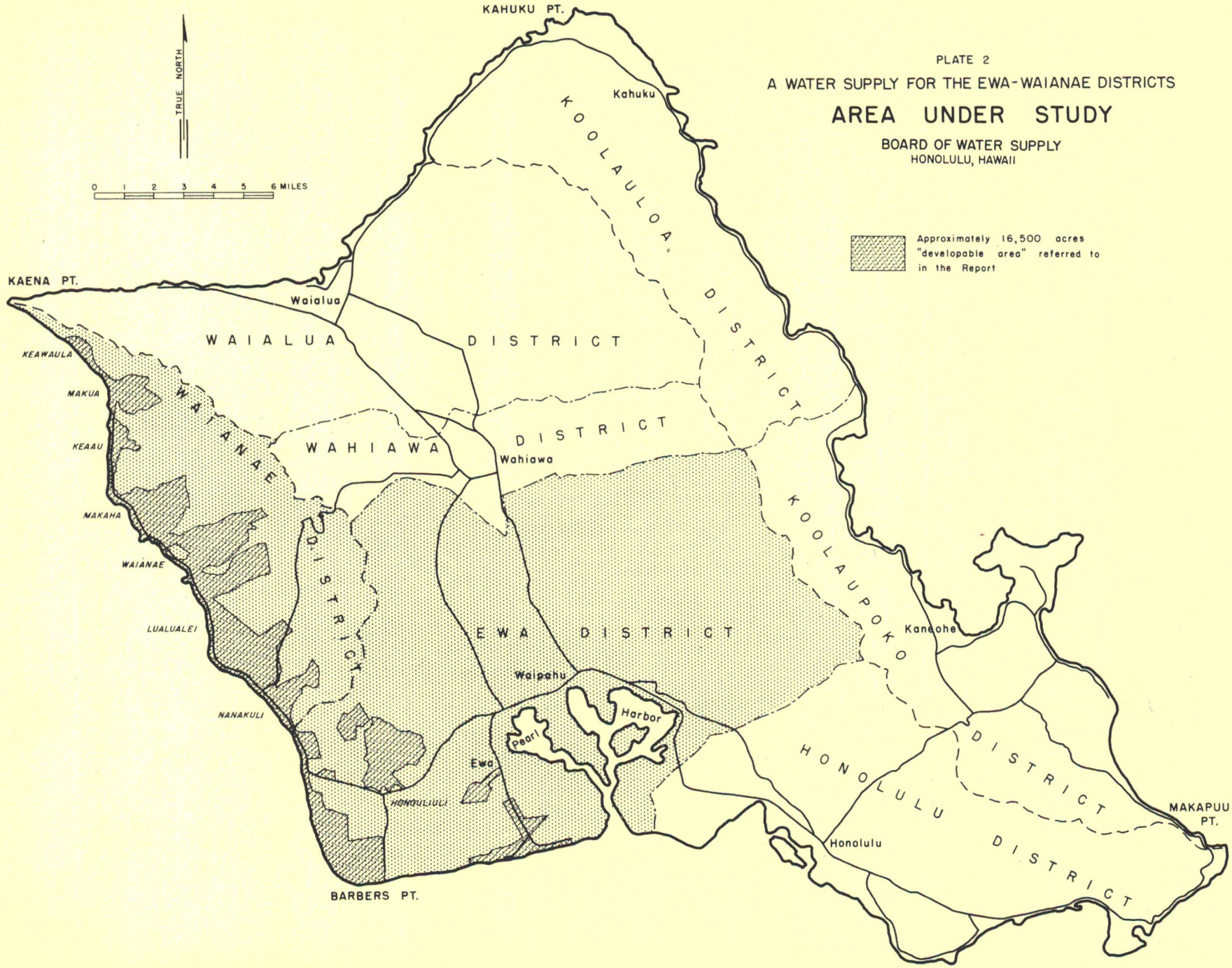
PLATE 2
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
AREA UNDER STUDY
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
Approximately 16,500 acres "developable area" referred to in the Report
TRUE NORTH
0 1 2 3 4 5 6 MILES
KAHUKU PT.
Kahuku
KOOLAULOA DISTRICT
KAENA PT.
Waialua
WAIALUA DISTRICT
KEAWAULA
MAKUA
KEAAU
MAKAHA
WAIANAE
LUALUALEI
NANAKULI
WAIANAE DISTRICT
WAHIAWA DISTRICT
Wahiawa
EWA DISTRICT
Waipahu
Pearl Harbor
Ewa
HONOULIULI
BARBERS PT.
KOOLAUPOKO DISTRICT
Kaneohe
HONOLULU DISTRICT
Honolulu
MAKAPUU PT.

GENERAL BACKGROUND

Until just before World War II the water resources of the Ewa-Waianae districts were primarily the concern and under the jurisdiction of four sugar plantations: Honolulu Plantation Company, Oahu Sugar Company, Ewa Plantation Company, and Waianae Company. Public water distribution by Suburban Water System served only relatively small areas.

During the past two decades, the area has gradually undergone a transition from what was essentially a huge plantation into an area of greatly diversified activity. The principal developments and the major changes in the water supply picture during this period are as follows:

1. The development of the water of the Waiau group of "Pearl Harbor Springs" by the Hawaiian Electric Company for cooling purposes at its new Pearl Harbor plant. The bulk of the plant effluent, or a maximum of about 23 mgd, is delivered into Oahu Sugar Company's irrigation system.

2. The merging of Honolulu Plantation Company with Oahu Sugar Company.

3. The completion of a major Maui-type water development at Red Hill by the Navy, and the installation by the Board of Water Supply of a similar station in North Halawa Valley. The Navy also completed an important but smaller station to serve Barber's Point Naval Air Station.

4. The termination of its plantation enterprise by the Waianae Plantation, and the resultant sale of its property to a land investment corporation.

5. The subdivision of the Waianae Plantation property into several hundred farm and residential lots. This created a potable water demand that could not be met.

6. The completion of the "Kunesh" Tunnel by the Suburban Water System to tap dike-entrapped water at the end of Waianae Valley.

7. The completion by the Navy of a major Maui-type station in Waiawa Valley, and the transfer of the Pearl Harbor-Hickam Field draft from its Red Hill and Halawa stations to the new station. The principal reason for this shift was the Navy's recognition of the future needs of Honolulu.

8. The sale by the Ii Estate of the land at Waipio, a principal portion of Oahu Sugar Company's plantation, to Hawaiian Pineapple Company. As a re-

sult of this sale large areas were converted from sugar to pineapple culture, with resultant reduction in water requirement.

9. The planning by the Board of Water Supply of a major Maui-type station in Waimalu Valley. Property for the station has already been acquired, and it is believed that its operation will not be detrimental to existing installations. It is not known as to when the station will be constructed. However, this station is not to be considered as a source of water for the Ewa-Waianae districts at this time.

10. The initiation of a study by the U. S. Geological Survey in 1956 on the ground-water resources of the Pearl Harbor area. The study will cover a period of at least two complete sugar cane crop cycles.

11. The recent accelerated rate of occupancy of the newly subdivided Waianae areas, and the current development of many subdivisions within the general outer boundaries of Oahu Sugar Company.

12. The announcement of the Campbell Estate in 1956 of its plan to offer large areas for residential, farming, and industrial use, provided necessary water supplies could be made available by others. The water resources of the Estate are almost entirely committed to its principal lessee, Ewa Plantation Company.

13. The passage of Acts 150 and 289 in the 1957 session of the Legislature authorizing general obligation bonds for the financing of a project to deliver water from the Pearl Harbor area to the area under study. Act 150 authorizes a Territorial issue of $4,500,000, and Act 289, a City and County issue of $3,000,000.

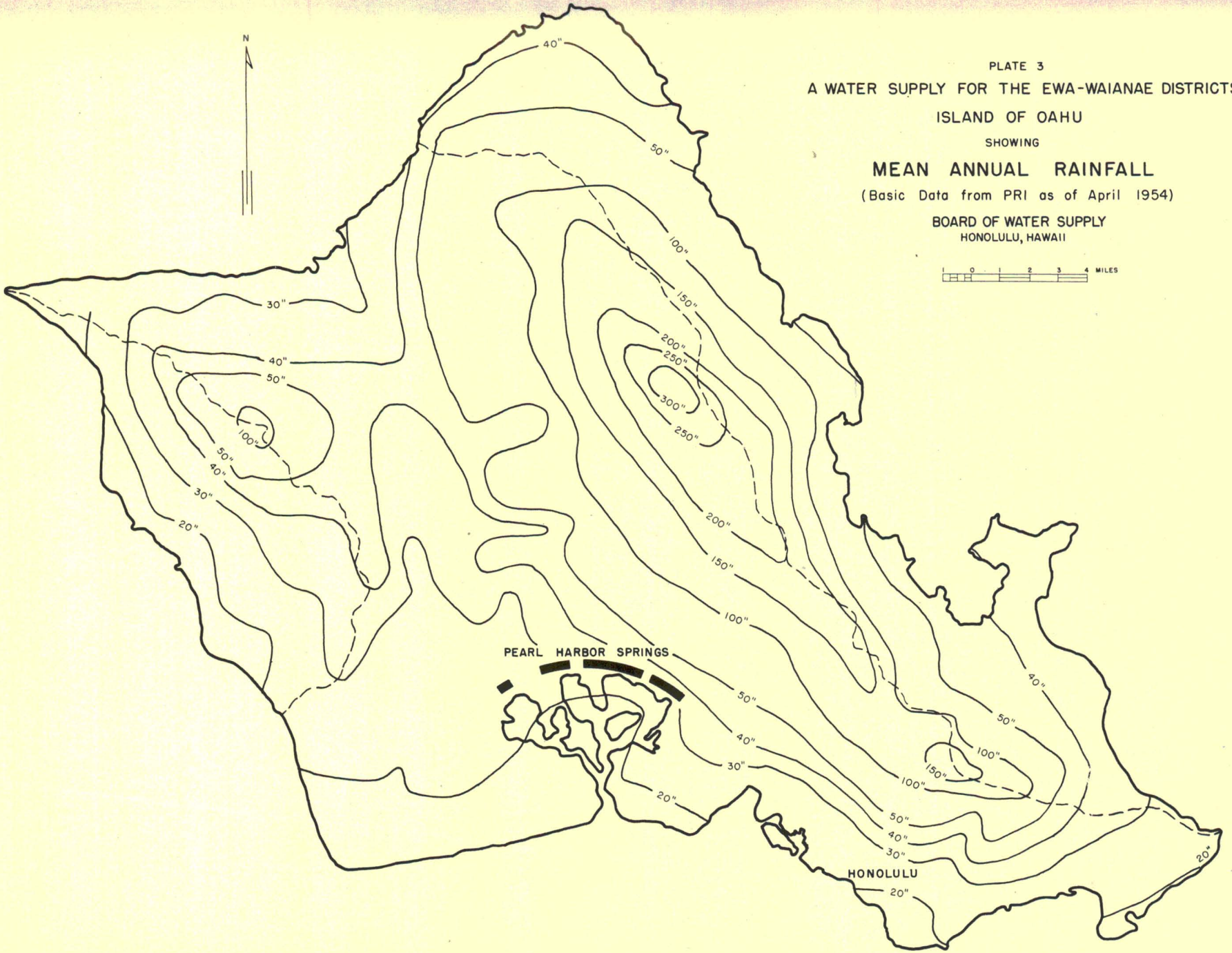
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PLATE 3
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
ISLAND OF OAHU
SHOWING
MEAN ANNUAL RAINFALL
(Basic Data from PRI as of April 1954)
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
1 0 1 2 3 4 MILES
PEARL HARBOR SPRINGS
HONOLULU
40"
50"
100"
150"
200"
250"
300"
30"
20"
20+

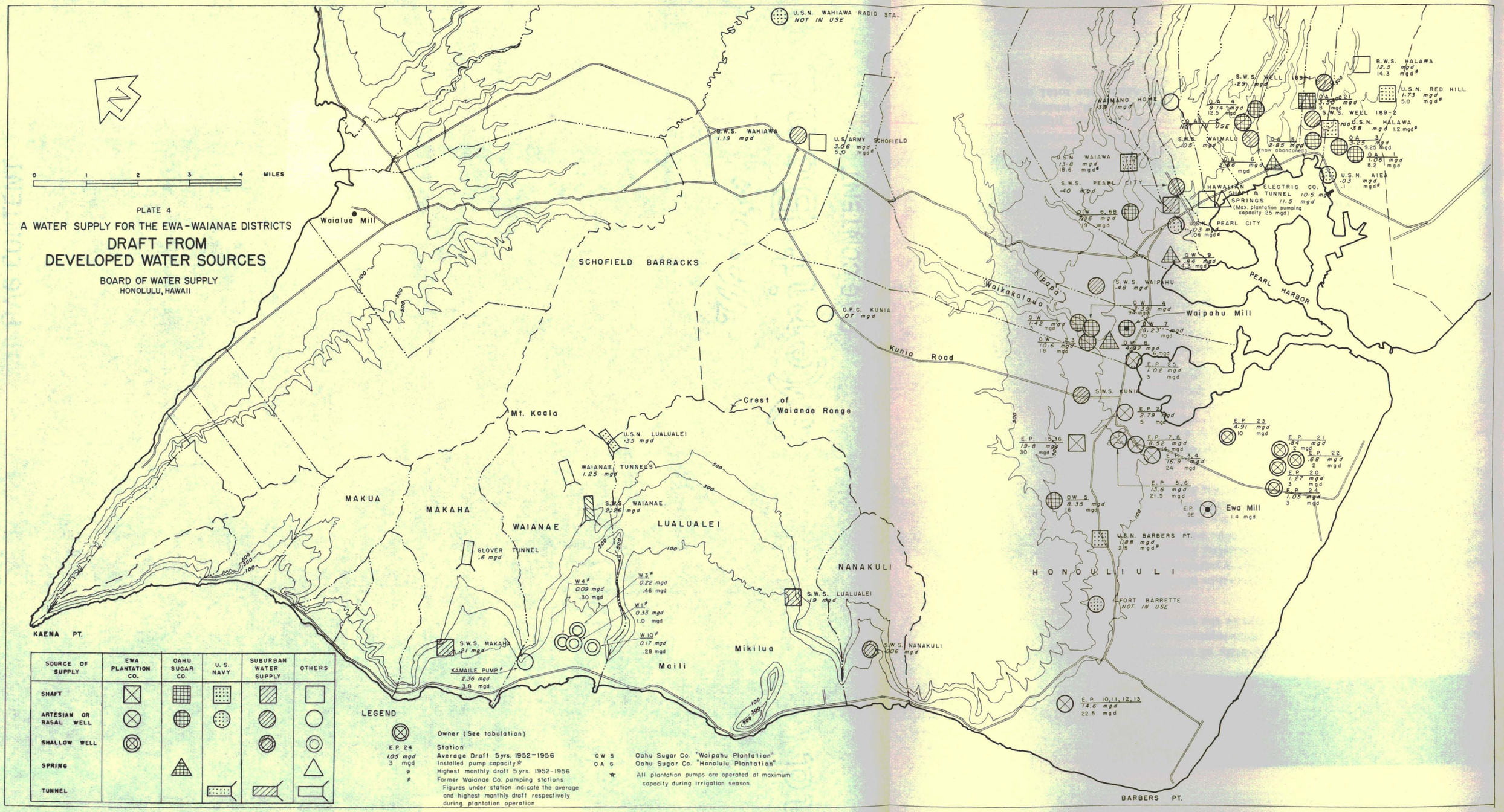


PLATE 4
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
DRAFT FROM
DEVELOPED WATER SOURCES
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
0 1 2 3 4 MILES
U.S.N. WAHIAWA RADIO STA.
NOT IN USE
S.W.S. WAHIAWA
1.19 mgd
U.S. ARMY SCHOFIELD
3.06 mgd
5.0 mgd#
Waialua Mill
SCHOFIELD BARRACKS
C.P.C. KUNIA
.07 mgd
Kunia Road
Crest of
Waianae Range
Mt. Kaala
U.S.N. LUALUALEI
.35 mgd
WAIANAE TUNNELS
1.25 mgd
S.W.S. WAIANAE
2.26 mgd
MAKUA
MAKAHA
WAIANAE
LUALUALEI
GLOVER TUNNEL
.6 mgd
W4#
0.09 mgd
.30 mgd
W3#
0.22 mgd
.46 mgd
W1#
0.33 mgd
1.0 mgd
W10#
0.17 mgd
.28 mgd
S.W.S. MAKAHA
.21 mgd
KAMAILE PUMP#
2.36 mgd
3.8 mgd
Maili
Mikilua
NANAKULI
S.W.S. LUALUALEI
.19 mgd
S.W.S. NANAKULI
.06 mgd
KAENA PT.
LEGEND
Owner (See tabulation)
E.P. 24
1.05 mgd
3 mgd
Station
Average Draft 5yrs. 1952-1956
Installed pump capacity☆
Highest monthly draft 5 yrs. 1952-1956
Former Waianae Co. pumping stations
Figures under station indicate the average and highest monthly draft respectively during plantation operation
OW 5 Oahu Sugar Co. "Waipahu Plantation"
OA 6 Oahu Sugar Co. "Honolulu Plantation"
☆ All plantation pumps are operated at maximum capacity during irrigation season.
SOURCE OF SUPPLY
EWA PLANTATION CO.
OAHU SUGAR CO.
U.S. NAVY
SUBURBAN WATER SUPPLY
OTHERS
SHAFT
ARTESIAN OR BASAL WELL
SHALLOW WELL
SPRING
TUNNEL
WAIMANO HOME
.53 mgd
S.W.S. WELL 189-1
.29 mgd
B.W.S. HALAWA
12.5 mgd
14.3 mgd#
U.S.N. RED HILL
1.73 mgd
5.0 mgd#
S.W.S. WELL 189-2
U.S.N. HALAWA
.38 mgd
1.2 mgd#
S.W.S. WAIMALU
.05 mgd
NOT IN USE
(now abandoned)
U.S.N. AIEA
.03 mgd
.1 mgd#
U.S.N. WAIAWA
13.8 mgd
18.6 mgd#
S.W.S. PEARL CITY
.40 mgd
HAWAIIAN ELECTRIC CO.
SHAFT & TUNNEL
SPRINGS
11.5 mgd
(Max. plantation pumping capacity 25 mgd)
U.S.N. PEARL CITY
.03 mgd
.06 mgd#
PEARL HARBOR
Kipapa
Waikakalaua
S.W.S. WAIPAHU
.48 mgd
Waipahu Mill
S.W.S. KUNIA
E.P. 15,16
19.8 mgd
30 mgd
E.P. 7,8
9.52 mgd
14 mgd
E.P. 3,4
16.9 mgd
24 mgd
E.P. 5,6
13.6 mgd
21.5 mgd
E.P. 23
4.91 mgd
10 mgd
E.P. 21
.84 mgd
2 mgd
E.P. 22
.68 mgd
2 mgd
E.P. 20
1.27 mgd
3 mgd
E.P. 24
1.05 mgd
3 mgd
Ewa Mill
1.4 mgd
U.S.N. BARBERS PT.
1.88 mgd
2.5 mgd#
HONOULIULI
FORT BARRETTE
NOT IN USE
E.P. 10,11,12,13
14.6 mgd
22.5 mgd
BARBERS PT.

DEVELOPABLE AREAS AND WATER REQUIREMENTS

In order to determine the quantity of water required, an estimate was made of the total area suitable for development within a reasonable time. For this study a period of 30 years, which is the usual life of a revenue bond issue, was assumed.

Our study has considered the possible ultimate development of the entire district of Waianae and the southwesterly portion of Ewa district. Areas roughly east of Waikele Stream, including Waipahu, Pearl City and Aiea were not considered because it is believed that potable water now being used for cane irrigation would be sufficient for any new use which might arise. Also excluded are all other areas under sugar cane and pineapple cultivation, areas under military jurisdiction, forest reserve lands, and areas with slopes in excess of 20 per cent.

The Ewa-Barber's Point section consists primarily of developments proposed by the Campbell Estate, as shown in a report by Harland Bartholomew and Associates, dated December 1955. Farming areas in Waianae now served by nonpotable water have been included because of the probability that fresh water service will be required ultimately. Plate 2 shows the boundaries of the Ewa and Waianae districts and the developable areas considered.

As shown on Plate 6 the area has been, for planning purposes, arbitrarily divided into three service zones: The first extends from sea level up to the 100-foot contour; the second from the 100-foot to the 300-foot contour; and the third from the 300-foot to the 500-foot contour. With the exception of the "Ewa Mountain Lot" area, all land above the 500-foot contour was excluded for the purpose of this report.

The developable areas in the various sections and for the respective service zones are shown in Table 1.

Some of the agricultural areas may be converted to residential areas in the near future. Nevertheless, the quantity of water allowed for agricultural activities is ample for residential needs.

In estimating the total quantity of water required, an allowance of 2,500 gallons per acre per day was made, with the exception of certain areas at Barber's Point specifically zoned for industries, golf courses, piggeries, and ranching. In order to compute the additional water required, which, incidentally, must be transported from the Pearl Harbor area, the total amount of

water now being obtained from adjacent sources was deducted from the computed estimated total requirement.

In summary, estimated future water requirements are shown in Table 2.

COMMENTS ON WATER REQUIREMENTS

EWA BEACH

Present consumption at Ewa Beach, supplied by the Suburban Water System from the Navy Pearl Harbor system, is only 0.24 mgd. The estimated future total requirement of 2.29 mgd is expected to be met by the Suburban Water System's project now under construction at lower Kunia, the maximum anticipated yield from which is estimated at 4 mgd.

EWA VILLAGE

The amount of water now furnished the village by Ewa Plantation Company is not measured, but is estimated at 0.75 mgd. However, the plantation system is expected to adequately provide for any future needs.

BARBER'S POINT

Consideration has been given to the proposed Campbell Estate development at Barber's Point which consists of areas specifically zoned for residential, industrial, parks, golf course and small farm uses. The ultimate requirement is estimated at 6.64 mgd of which none is immediately available in the area. The water requirements are estimated as follows:

Activity	Acreage	Requirement Per Acre (gpd)	Total Requirement (mgd)
Residential areas	465	2,500	1.16
Parks and golf course	441	2,000	0.88
Industrial	1,012	3,000	3.04
Piggeries and small farms	430	3,000	1.29
Ranching headquarters	133	2,000	0.27
Total	2,481		6.64

BARBER'S POINT NAVAL AIR STATION

At the present time the Naval Air Station's requirement of 3 to 5 mgd is met through its own system. However, there is a possibility that the

Navy might decide to purchase water from the Suburban Water System if satisfactory financial arrangements could be made. Under such an arrangement, the Barber's Point shaft would be put on a stand-by status for emergency purposes.

EWA MOUNTAIN LOTS AND MOUNTAIN LODGES

These developments will ultimately require a total of 5.9 mgd, much of it in an area of elevation in excess of 500 feet.

STANDARD OIL COMPANY REFINERY

For the purpose of this study, a potable water requirement of 2 mgd, as estimated by Standard Oil officials, is being considered. Water for cooling purposes is presumed to be met by sea water or by shallow well brackish water to be developed either by the Campbell Estate or Standard Oil Company.

NANAKULI

Present consumption at Nanakuli, which is being supplied principally by the City and County tunnel at Waianae, is 0.24 mgd. A very small amount is furnished by Well No. 16 at Nanakuli. The additional future requirement of 1.52 mgd must be supplied from outside sources.

MIKILUA

The water system at Mikilua, owned by Mikilua Associates, distributes water from the City and County water development shaft at Lualualei. Although the shaft is capable of producing 0.25 mgd, the salt content is too high for satisfactory domestic use. This condition can be corrected, however, by decreased pumpage. The supply is used for irrigation and domestic purposes and is supplemented by brackish water from many private wells. To meet future needs, an additional 2.34 mgd would be required.

MAILI

The present system at Maili distributes water from the City and County tunnel at Waianae. About 4.16 mgd of additional water is needed for the future development of Maili.

LUALUALEI

Here also, water from the City and County Waianae tunnel is distributed for domestic use, supplemented by several small private wells. Future requirements are estimated at 3.14 mgd.

LUALUALEI NAVAL RESERVATION

The 0.35 mgd now consumed at Lualualei Naval Reservation represents the capacity output of the Navy's high-level tunnel. Hence, the estimated future requirement of 0.25 mgd must be furnished from other sources.

WAIANAE

Approximately 2.5 mgd is collected from various tunnels, springs, wells and "overflow" from the City and County tunnel and distributed by Waianae Development Company for domestic and irrigation use throughout Waianae Valley. Because of its crude recovery and transportation system, this supply is subject to objectionable variations in color and turbidity. Therefore, it should be treated before inclusion in the Suburban Water System. (The City and County tunnel at Waianae produces approximately 2.25 mgd, of which 0.77 mgd is utilized at Lualualei, Maili, and Nanakuli. The remaining 1.48 mgd, due to the lack of pipelines and other facilities needed to convert it to domestic use, is being used for irrigation only.) Future requirements at Waianae are estimated at 2.65 mgd.

MAKAHA

Only 0.18 of the 0.60 mgd capacity of Pump No. 17 is being utilized for domestic purposes. In addition to the excess of 0.42 mgd, the 0.6 mgd now produced by the Glover Tunnel should be considered for future domestic needs. Former plantation wells could be reactivated for irrigation purposes.

KEAAU, MAKUA AND KEAWAULA

The present water consumption is negligible and no dependable local sources are available; hence, all future requirements totaling about 4.55 mgd must be fulfilled by outside sources.

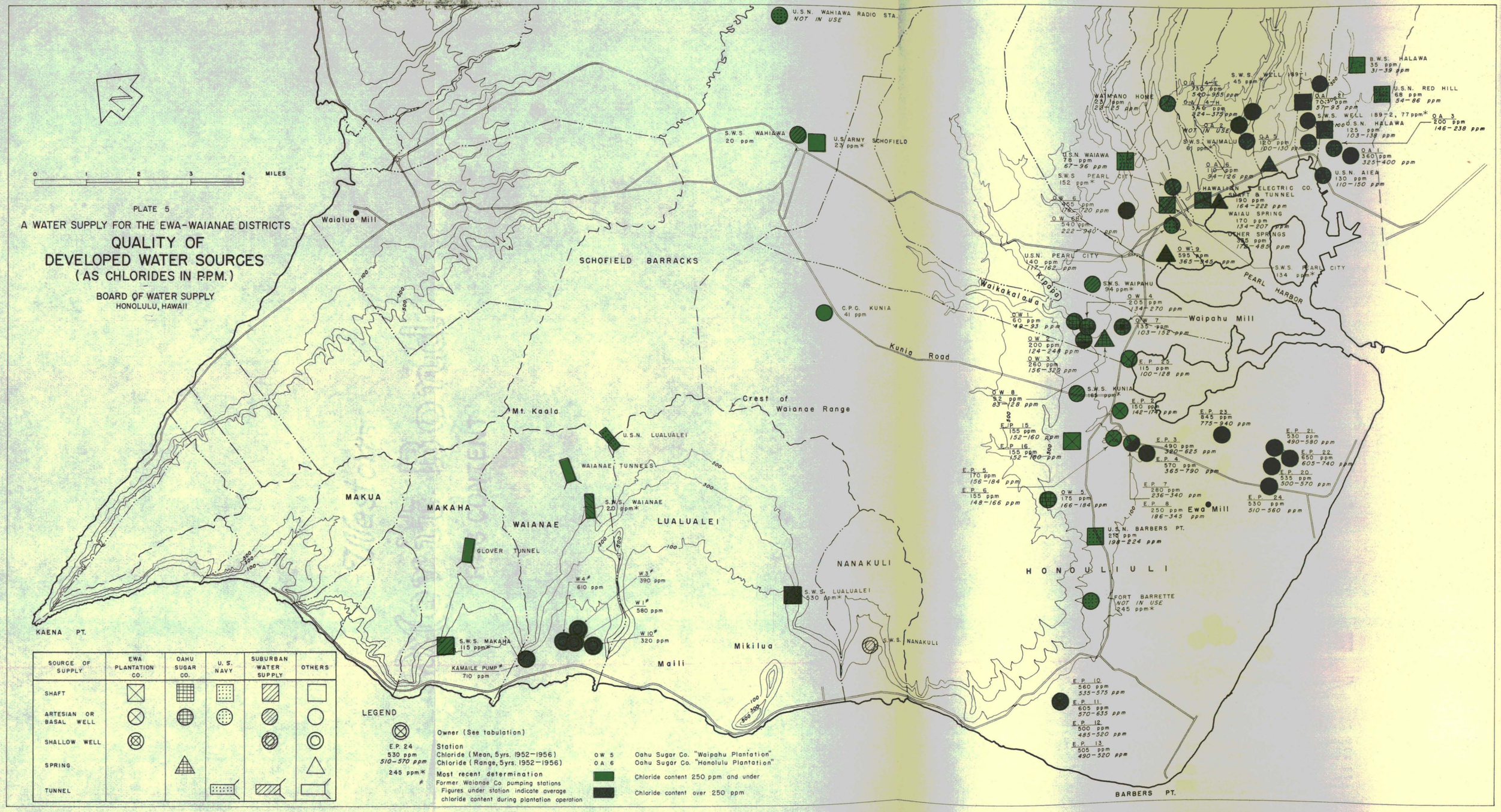


PLATE 5
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
QUALITY OF
DEVELOPED WATER SOURCES
(AS CHLORIDES IN P.P.M.)
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
0 1 2 3 4 MILES
U.S.N. WAHIAWA RADIO STA.
NOT IN USE
S.W.S. WAHIAWA
20 ppm
U.S. ARMY SCHOFIELD
23 ppm*
Waialua Mill
SCHOFIELD BARRACKS
C.P.C. KUNIA
41 ppm
Kunia Road
Mt. Kaala
Crest of Waianae Range
U.S.N. LUALUALEI
WAIANAE TUNNELS
S.W.S. WAIANAE
20 ppm*
MAKUA
MAKAHA
WAIANAE
LUALUALEI
GLOVER TUNNEL
W 4#
610 ppm
W 3#
390 ppm
W 1#
580 ppm
W 10#
320 ppm
S.W.S. MAKAHA
115 ppm*
KAMAILE PUMP #
710 ppm
Maili
Mikilua
S.W.S. LUALUALEI
530 ppm*
NANAKULI
S.W.S. NANAKULI
KAENA PT.
WAIMANO HOME
23 ppm
28-25 ppm
O A 4-E
730 ppm
540-955 ppm
O A 4-H
360 ppm
324-379 ppm
S.W.S. WELL 189-1
45 ppm*
O A 2
NOT IN USE
S.W.S. WAIMALU
61 ppm*
O A 5
120 ppm
100-130 ppm
O A 6
110 ppm
94-126 ppm
U.S.N. WAIAWA
78 ppm
67-96 ppm
S.W.S PEARL CITY
152 ppm*
O W 6
455 ppm
175-720 ppm
O W 5
540 ppm
222-940 ppm
U.S.N. PEARL CITY
140 ppm
112-162 ppm
Waikakalaua
Kipapa
S.W.S. WAIPAHU
94 ppm*
O W 1
60 ppm
48-93 ppm
O W 2
200 ppm
124-248 ppm
O W 3
260 ppm
156-328 ppm
O W 4
205 ppm
134-270 ppm
O W 7
135 ppm
103-152 ppm
Waipahu Mill
E.P. 25
115 ppm
100-128 ppm
O W 8
82 ppm
83-128 ppm
S.W.S. KUNIA
165 ppm*
E.P. 6
150 ppm
142-175 ppm
E.P. 15
155 ppm
152-160 ppm
E.P. 16
155 ppm
152-160 ppm
E.P. 5
170 ppm
156-184 ppm
E.P. 6
155 ppm
148-166 ppm
O W 5
175 ppm
166-184 ppm
E.P. 3
490 ppm
380-625 ppm
E.P. 4
570 ppm
365-790 ppm
E.P. 7
280 ppm
236-340 ppm
E.P. 8
250 ppm
186-345 ppm
Ewa Mill
E.P. 23
845 ppm
775-940 ppm
E.P. 21
530 ppm
490-580 ppm
E.P. 22
650 ppm
605-740 ppm
E.P. 20
535 ppm
500-570 ppm
E.P. 24
530 ppm
510-560 ppm
U.S.N. BARBERS PT.
215 ppm
198-224 ppm
HONOULIULI
FORT BARRETTE
NOT IN USE
245 ppm*
E.P. 10
560 ppm
535-575 ppm
E.P. 11
605 ppm
570-635 ppm
E.P. 12
500 ppm
485-520 ppm
E.P. 13
505 ppm
490-520 ppm
BARBERS PT.
B.W.S. HALAWA
35 ppm
31-39 ppm
U.S.N. RED HILL
68 ppm
54-86 ppm
O A 3
200 ppm
146-238 ppm
S.W.S. WELL 189-2, 77 ppm*
O A 1
70.5 ppm
57-95 ppm
U.S.N. HALAWA
125 ppm
103-139 ppm
O A 1
360 ppm
325-400 ppm
U.S.N. AIEA
130 ppm
110-150 ppm
HAWAIIAN ELECTRIC CO.
SHAFT & TUNNEL
190 ppm
164-222 ppm
WAIAU SPRING
170 ppm
134-207 ppm
OTHER SPRINGS
365 ppm
175-485 ppm
O W 9
595 ppm
365-945 ppm
S.W.S. PEARL CITY
134 ppm*
PEARL HARBOR
SOURCE OF SUPPLY
EWA PLANTATION CO.
OAHU SUGAR CO.
U. S. NAVY
SUBURBAN WATER SUPPLY
OTHERS
SHAFT
ARTESIAN OR BASAL WELL
SHALLOW WELL
SPRING
TUNNEL
LEGEND
E.P. 24
530 ppm
510-570 ppm
245 ppm*
#
Owner (See tabulation)
Station
Chloride (Mean, 5yrs. 1952-1956)
Chloride (Range, 5yrs. 1952-1956)
Most recent determination
Former Waianae Co. pumping stations
Figures under station indicate average chloride content during plantation operation
O W 5 Oahu Sugar Co. "Waipahu Plantation"
O A 6 Oahu Sugar Co. "Honolulu Plantation"
Chloride content 250 ppm and under
Chloride content over 250 ppm

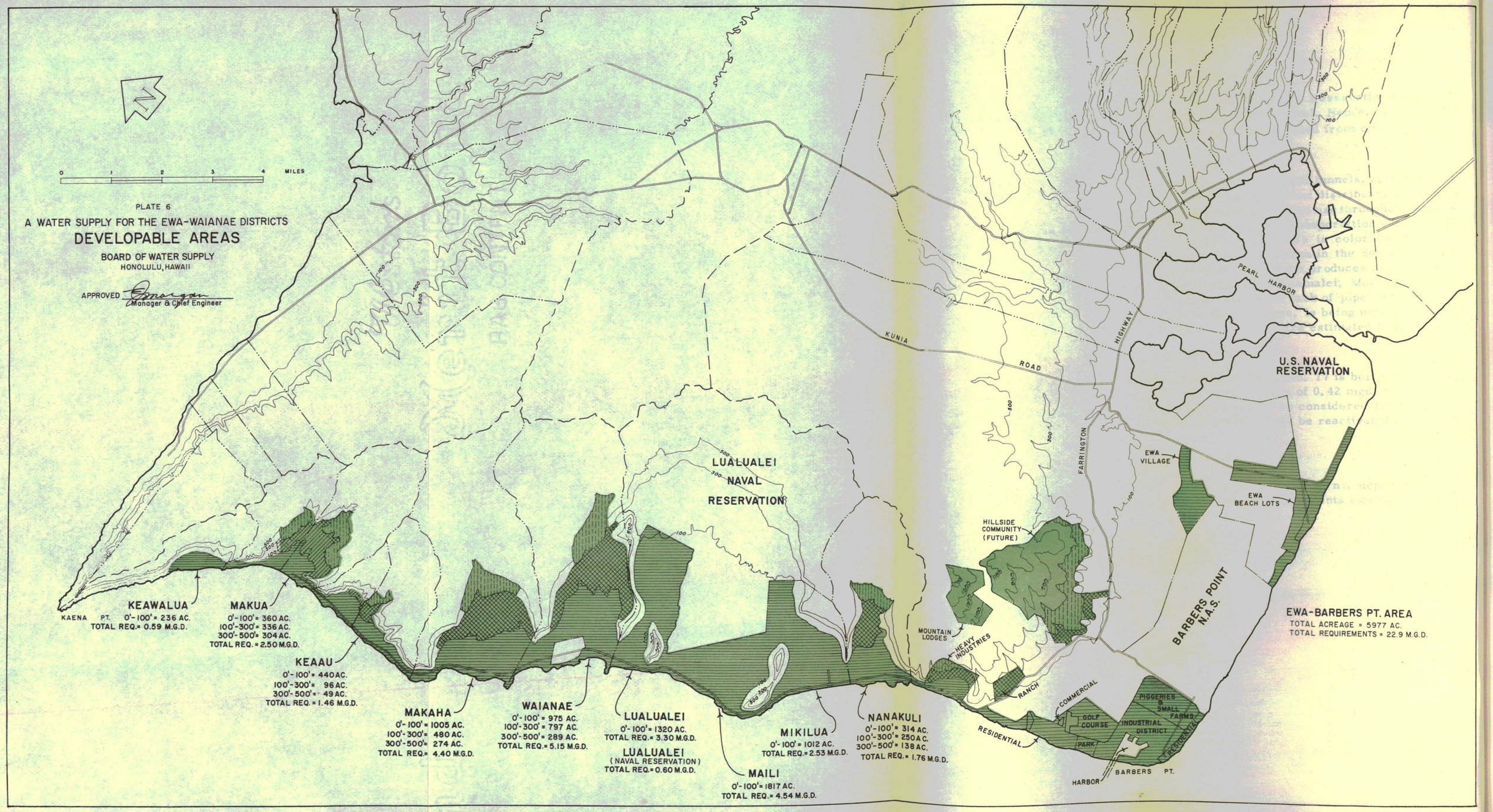

0 1 2 3 4 MILES
PLATE 6
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
DEVELOPABLE AREAS
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
APPROVED
Manager & Chief Engineer
KAENA PT.
KEAWALUA
0'-100' = 236 AC.
TOTAL REQ.= 0.59 M.G.D.
MAKUA
0'-100' = 360 AC.
100'-300' = 336 AC.
300'-500' = 304 AC.
TOTAL REQ. = 2.50 M.G.D.
KEAAU
0'-100' = 440 AC.
100'-300' = 96 AC.
300'-500' = 49 AC.
TOTAL REQ. = 1.46 M.G.D.
MAKAHA
0'-100' = 1005 AC.
100'-300' = 480 AC.
300'-500' = 274 AC.
TOTAL REQ. = 4.40 M.G.D.
WAIANAE
0'-100' = 975 AC.
100'-300' = 797 AC.
300'-500' = 289 AC.
TOTAL REQ. = 5.15 M.G.D.
LUALUALEI
0'-100' = 1320 AC.
TOTAL REQ. = 3.30 M.G.D.
LUALUALEI
(NAVAL RESERVATION)
TOTAL REQ. = 0.60 M.G.D.
LUALUALEI NAVAL RESERVATION
MAILI
0'-100' = 1817 AC.
TOTAL REQ. = 4.54 M.G.D.
MIKILUA
0'-100' = 1012 AC.
TOTAL REQ. = 2.53 M.G.D.
NANAKULI
0'-100' = 314 AC.
100'-300' = 250 AC.
300'-500' = 138 AC.
TOTAL REQ. = 1.76 M.G.D.
KUNIA ROAD
FARRINGTON HIGHWAY
PEARL HARBOR
U.S. NAVAL RESERVATION
EWA VILLAGE
EWA BEACH LOTS
HILLSIDE COMMUNITY (FUTURE)
MOUNTAIN LODGES
HEAVY INDUSTRIES
RANCH
COMMERCIAL
GOLF COURSE
PARK
INDUSTRIAL DISTRICT
PIGGERIES & SMALL FARMS
RESIDENTIAL
BARBERS POINT N.A.S.
HARBOR
BARBERS PT.
EWA-BARBERS PT. AREA
TOTAL ACREAGE = 5977 AC.
TOTAL REQUIREMENTS = 22.9 M.G.D.

Table 1 DEVELOPABLE AREAS

Section	Zone	Acreage Between Elevations 0 to 100'	100' to 300'	300' to 500'	Total Acreage	
EWA-BARBER'S POINT						
Ewa Beach	Residential	914	-	-	914	
Ewa Village Area	Residential, Industrial	406	-	-	406	
Barber's Point	Residential, Industrial, Commercial, Ranch	2,201	227	53	2,481	
Ewa Mountain Lots	Residential	-	144	510	654	
Ewa Mountain Lots above 500'	Residential	-	-	-	1,722	6,177
WAIANAE AREA						
Nanakuli	Residential	314	250	138	702	
Mikilua	Residential, Agricultural	1,012	-	-	1,012	
Maili (including homesteads)	Residential, Agricultural	1,817	-	-	1,817	
Lualualei	Residential, Agricultural, Industrial	1,320	-	-	1,320	
Waianae	Residential, Agricultural	975	797	289	2,061	
Makaha	Residential, Agricultural	1,005	480	274	1,759	8,671
AREA BEYOND MAKAHA						
Keaau	Grazing	440	96	49	585	
Makua	Military (owner T. H.)	360	336	304	1,000	
Keawaula	Military (owner T. H.)	236	-	-	236	1,821
				Total		16,669

Table 2 WATER REQUIREMENTS (Disregarding current use of private wells)

Section	Acreage	Total Requirement (mgd)	Fresh Water Now Served (mgd)	Net Requirement (mgd)	New Water Required (mgd)	
EWA BARBER'S POINT						
Ewa Beach	914	2.29	0.24	2.05[a]	-	
Ewa Village	406	1.02	-	1.02[b]	-	
Barber's Point	-	6.64	-	6.64	6.64	
Barber's Point (Navy)	-	-	-	-	5.00	
Ewa Mountain Lots	2,176	5.95	-	5.95	5.95	
Standard Oil Co. Refinery	-	-	-	-	2.00	19.59
WAIANAE DISTRICT						
Nanakuli	702	1.76	0.24	1.52	1.52	
Mikilua	1,012	2.53	0.19	2.34	2.34	
Maili	1,817	4.54	0.38	4.16	4.16	
Lualualei	1,320	3.30	0.16	3.14	3.14	
Lualualei (Navy)	-	0.60	0.35	0.25	0.25	
Waianae	2,061	5.15	2.50	2.65	2.65	
Makaha	1,759	4.40	1.00	3.40	3.40	
Keaau	585	1.46	-	1.46	1.46	
Makua	1,000	2.50	-	2.50	2.50	
Keawaula	236	0.59	-	0.59	0.59	22.01
					Grand Total	41.60
					Say	40 mgd

a To be furnished from Suburban Water System development in lower Kunia.

b To be furnished from plantation system.

EXISTING WATER SYSTEMS IN THE EWA-WAIANAE DISTRICTS

Listed in this section are brief descriptions of the existing major domestic water systems in the area. Also mentioned are several presently nonpotable systems that could be converted to domestic use. Irrigation facilities are not considered.

Plate 7 shows the various water systems in the area.

WAIANAE DISTRICT

BEYOND MAKAHA

There are no water systems of any significance in this area. The needs of cattle ranches are supplied from brackish "shallow wells."

MAKAHA

The Glover Tunnel and the smaller upper Makaha tunnels, owned by Waianae Development Company, Ltd., furnish water which is used primarily for irrigation purposes.

The City and County system at Makaha consists of Pump 17, a 500,000-gallon reservoir, and a network of 8-inch and 6-inch cast-iron mains which serves the residential and small farm lots in the lower valley and at Makaha Beach.

WAIANAE

An independent, privately owned system at Waianae (Waianae Development Company, Ltd.) supplies the domestic and irrigation needs of the area with water collected from various small tunnels, springs and streams in the upper valley largely owned by the Territory. The distribution system consists of a network of small cast-iron and steel pipes and irrigation ditches. Six pumps of various capacities and the Kamaile wells, all in the lower valley and formerly used by Waianae Plantation, are not presently utilized. Waianae Development Company supplies domestic water to Waianae Village from former plantation Pump 5 and by a small pipeline from upper Waianae sources.

LUALUALEI, MAILI AND NANAKULI

These areas are supplied by the City and County Suburban Water System from the City and County 10,000-foot tunnel at Waianae. Distribution is through 12- and 8-inch mains and is limited to areas immediately adjacent to the mains. At the end of the 12-inch main in Nanakuli are two steel tanks, each of a capacity of 200,000 gallons. Also contributing to

this system is Well 16 in Nanakuli, but the quantity is small and the flow only intermittent. Scattered throughout the area are private drilled wells which provide domestic and irrigation water for their owners.

MIKILUA

The City and County shaft at Lualualei furnishes water that is distributed in the area through the privately owned Mikilua Associates system. This system consists primarily of a 6-inch main not connected to the City and County Lualualei-Nanakuli system.

LUALUALEI NAVAL RESERVATION

The Lualualei Naval Reservation has an independent water system, including its source of supply. Water from the Navy Tunnel in the upper valley is distributed through a relatively extensive system with two reservoirs, each of a capacity of 750,000 gallons.

EWA DISTRICT

BARBER'S POINT NAVAL AIR STATION

Water for the Air Station is supplied from the Navy's Barber's Point shaft. For emergency purposes there is a line from Ewa Plantation Pumps 5, 6 and 7. Distribution is through a highly developed layout of large cast-iron mains ranging up to 24 inches in diameter. Also included in the system are two 1-million gallon reservoirs.

BARBER'S POINT AREA

Ewa Plantation Company Pumps 10, 11, 12 and 13, together with the distribution system therefrom, are shown on Plate 7. These installations are part of the over-all sugar cane irrigation system in the area.

EWA VILLAGE

An Ewa Plantation Company 12-inch main from Pumps 5, 6 and 7 carries water into Ewa Village for domestic consumption.

EWA BEACH

A system of 6-inch, 8-inch and 12-inch mains of the Suburban Water System, which is connected to and supplied from the Navy's 12-inch main at Fort Weaver Road, supplies water to the Ewa Beach area. In addition, the Suburban Water System now has under construction a 1.5-million gallon reservoir, two wells at lower Kunia, and 16- and 20-inch mains to Ewa Beach.

PEARL HARBOR-HONOLULU AIRPORT

There is an extensive Navy water system throughout the Pearl Harbor area, with interconnections with the City and County Board of Water Supply system at Red Hill and in the Honolulu Airport area.


0 1 2 3 4 MILES
PLATE 7
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
EXISTING WATER SYSTEMS
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
LEGEND
C & C PIPELINES
NAVY PIPELINES
PRIVATE PIPELINES
RESERVOIRS
PUMPS (Shaft)
TUNNELS
KAENA PT.
MAKAHA
WAIANAE CO. PUMP NO. 17
MAKAHA TUNNEL (GLOVER TUNNEL)
WAIANAE
C&C WAIANAE TUNNEL
KUNESH TUNNEL
U.S.N. LUALUALEI TUNNEL
WAIANAE CO. PUMP NO. 3
LUALUALEI
C&C LUALUALEI SHAFT
MIKILUA
WAIANAE CO. PUMP NO. 16
MAILE
NANAKULI
KUNIA ROAD
S.W.S. WELLS 0/1.5 M.G. RES.
FARRINGTON HIGHWAY
E.P. Co. PUMPS
EWA VILLAGE
U.S.N. BARBERS PT. SHAFT
BARBERS POINT N.A.S.
EWA BEACH LOTS
BARBERS PT.
PEARL HARBOR
PEARL CITY
O.S. Co. PUMP
U.S.N. WAIAWA SHAFT
AIEA
U.S.N. REDHILL SHAFT


PLATE 8
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
PROJECT INDEX MAP
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
APPROVED
Manager & Chief Engineer
0 1 2 3 4 MILES
Kamehameha Highway
Wahiawa Town
Waialua Town
PINEAPPLE PLANTATIONS
WAIALUA PLANTATION
Schofield Barracks
WAIALUA DISTRICT
WAHIAWA DISTRICT
EWA DISTRICT
MOKULEIA
Mt. Kaala
Kolekole Pass
Crest of Waianae Range
Waianae Watershed
WAIALUA DISTRICT
WAIANAE DISTRICT
WAIANAE
LUALUALEI
KAENA PT.
MAKAHA
Waianae Town
Maili
Mikilua
NANAKULI
WAIANAE DISTRICT
EWA DISTRICT
Farrington Highway
Barbers Point Naval Air Station
PROPOSED S. O. CO. REFINERY
BARBERS PT.
Waiahole Ditch
WAIAWA
WAIMALU
HALAWA
Red Hill
EWA DISTRICT
HONOLULU DISTRICT
KALAUAO
AIEA
WAIAU
Pearl City
WAIPAHU PLANTATION
Kipapa
Waikakalaua
Waipahu Town
WAIKELE
Kunia
Kunia Road
WAIAWA
PEARL HARBOR
Navy Yard
Hickam Field
WAIPIO
WEST LOCH
PUULOA
EWA PLANTATION
Ewa Beach
Ewa Town
EWA PLAIN
D-1
D-2
D-3
D-4
E-1
E-2
E-3
E-4
E-5
E-6
E-7
B-1
B-2
B-3
B-4
B-5
C-1
C-2
C-3
C-4
A-1
A-2
A-3
-4
-5
-6
-7
LEGEND
Maui-type Shaft or Drilled Wells
Drilled Wells
"Shallow Wells"
Spring Development
Reservoirs

POSSIBLE PROJECTS

An outline and general description of possible projects, herein referred to as "studies," which may be undertaken to furnish water to the Ewa-Waianae districts are shown on the following pages. The locations of these projects are shown on the "Project Index Map" (Plate 8).

We would like to emphasize that our studies are based on the following considerations:

1. No attempt was made to explore problems on water rights or to present cost estimates involved.

2. Cost estimates of transmission mains are based on buried cast-iron pipe. Cost of basal shafts is based on installations similar to the Board of Water Supply Halawa and the Navy Waiawa stations.

In presenting cost estimates, we recognize that various types of pipe may be used for transmission mains. We recommend careful investigation of these possibilities in detailed engineering studies which are beyond the scope of this report.

STUDY "A"
(page 22)

INTERIM WATER SUPPLY
FOR STANDARD OIL COMPANY OF CALIFORNIA

A-1 Sea
A-2 Shallow Wells in Ewa Coastal Plain
A-3 Suburban Water System
A-4 Navy
A-5 Ewa Plantation Company
A-6 Oahu Sugar Company
A-7 Campbell Estate or Standard Oil Company Development

STUDY "B"
(page 23)

GREATER UTILIZATION OF WATER RESOURCES
OF WAIANAE DISTRICT

B-1 Improvement of Suburban Water System
Waianae-Nanakuli Distribution and Storage System

B-2 Upper Waianae Treatment Plant
and Diversion into Suburban Water System

B-3 Extension, Bulkheading, and Lining
of Suburban Water System Waianae ("Kunesh") Tunnel

B-4 Restoration of Kamaile and Waianae Wells for Irrigation

B-5 Transfer of Glover Tunnel to Domestic Use

STUDY "C"
(page 28)

WATER DEVELOPMENT PROJECTS
AT PEARL HARBOR SPRINGS

C-1 Development of Kalauao Springs

Alternate (a) Potable Supply from Spring Pond
Alternate (b) Potable Supply Developed by Wells
Alternate (c) Irrigation-Industrial Supply from Spring Pond
Alternate (d) Reservation of Kalauao Springs for Sugar Plantation Purposes

C-2 Potable or Irrigation and Industrial Water Supply from Waiau Springs

C-3 Development of Waiawa Springs

Alternate (a) Potable Supply Developed by Wells
Alternate (b) Development of Industrial and Agricultural Water

C-4 Development of Potable Water Supply at Waikele Springs

STUDY "D"
(page 34)

POSSIBLE MAJOR MAUI-TYPE
OR DRILLED WELL STATIONS

D-1 Major Station in Schofield Plateau and Kunia Road Pipeline

D-2 Waikakalaua Gulch Basal Water Development

Alternate (a) Maui-type Shaft at Waikakalaua Site
Alternate (b) Waikakalaua Drilled Well Development

D-3 Basal Water Development at Lower Kunia

D-4 Basal Water Development by Scattered, Drilled Nonartesian Wells

STUDY "E"
(page 39)

ADDITIONAL PROJECTS
RELATIVE TO WAIANAE WATER SUPPLY

E-1 Diversion from Waiahole Ditch at Kunia

E-2 Development of Water in Mokuleia and its Transmission to Makaha

E-3 Use of Upper Makaha Tunnels

E-4 Proposed Clark Tunnel in Waianae-Makaha Ridge

E-5 Additional Shallow Wells in the Lualualei-Mikilua Region

E-6 Improvement of Suburban Water System Lualualei Shaft

E-7 Schofield Area Water Development and its Transmission to Lualualei

STUDY "A"

INTERIM WATER SUPPLY FOR STANDARD OIL COMPANY OF CALIFORNIA

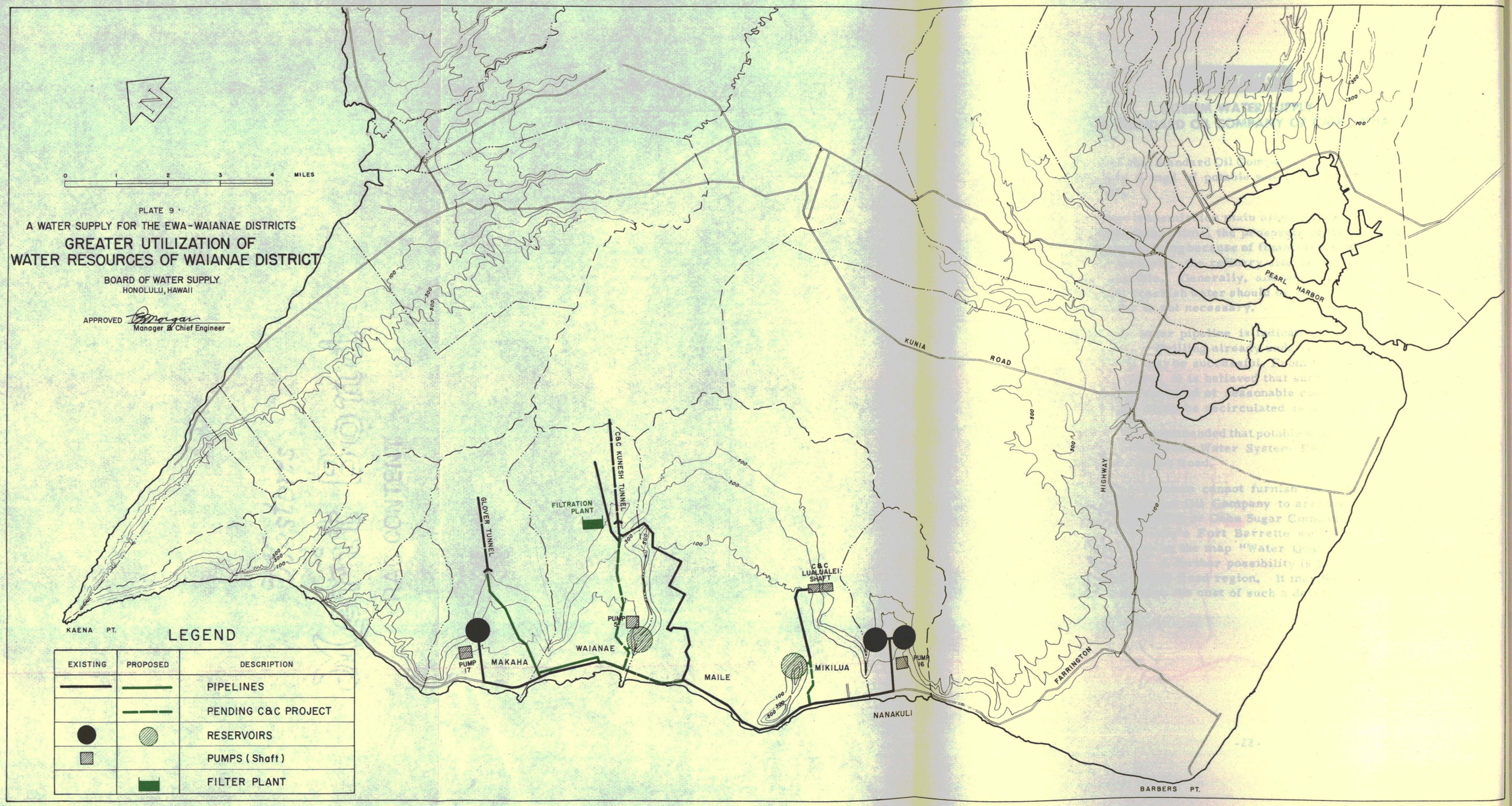
It is understood that Standard Oil Company's Barber's Point refinery will require approximately 2 mgd of potable water and about 5.5 mgd of water of lesser quality in 1959.

Although a large transmission main along Farrington Highway may have to be installed at some future time, the prospects of its being in service in the near future are not encouraging because of financial and other factors mentioned in this report. Fortunately, the refinery site is on the seacoast where sea water is readily accessible. Generally, and where conditions so dictate, sea water and shallow well brackish water should be used for all purposes for which the use of potable water is not necessary.

On Plate 8 a sea water pipeline is indicated by "A-1" and a battery of drilled wells by "A-2". Drilling already under way at the site indicates that the brackish water wells may be successful. From the experience of Ewa Plantation Company and others, it is believed that such shallow or "cap rock" brackish wells may be developed at reasonable cost. Some of this water is from basal leakage and should be recirculated as a conservation measure.

If available, it is recommended that potable water be obtained by Standard Oil Company from the Suburban Water System Ewa Beach main which is now being installed on Ewa Beach Road.

If Suburban Water System cannot furnish the potable requirements, it may be possible for Standard Oil Company to arrange for an interim supply from the Navy, Ewa Plantation or Oahu Sugar Company. There is now water of potable quality at the Navy's Fort Barrette well and at several plantation pumping stations as shown on the map "Water Quality of Developed Sources" included herein (Plate 5). A further possibility is the drilling of a well by the Campbell Estate in the Kunia Road region. It may be found advisable that the Standard Oil Company share the cost of such a development.


0 1 2 3 4 MILES
PLATE 9
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
GREATER UTILIZATION OF
WATER RESOURCES OF WAIANAE DISTRICT
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
APPROVED
Manager & Chief Engineer
KAENA PT.
LEGEND
EXISTING
PROPOSED
DESCRIPTION
PIPELINES
PENDING C&C PROJECT
RESERVOIRS
PUMPS (Shaft)
FILTER PLANT
GLOVER TUNNEL
C&C KUNESH TUNNEL
FILTRATION PLANT
PUMP 17
MAKAHA
WAIANAE
PUMP 20
MAILE
C&C LUALUALEI SHAFT
MIKILUA
PUMP 16
NANAKULI
KUNIA ROAD
HIGHWAY
FARRINGTON
PEARL HARBOR
BARBERS PT.

STUDY "B"

GREATER UTILIZATION OF WATER RESOURCES OF WAIANAE DISTRICT

In our over-all study the immediate need for water in the Waianae district became very apparent. Our proposal under Study "B" is to enlarge and improve the existing system in Waianae by the utilization of local sources of water which are either not being used at all or not being used to maximum advantage. Our studies show that an additional domestic supply of about 3.5 mgd could be developed at an estimated cost of $2,200,000, inclusive of improvements to the distribution system. We feel that the critical need for water in Waianae would be substantially alleviated by the adoption of our proposal and we therefore urge that early consideration be given to it.

PROJECT B-1
IMPROVEMENT OF SUBURBAN WATER SYSTEM WAIANAE-NANAKULI DISTRIBUTION AND STORAGE SYSTEM

The Suburban Water System is now planning to augment its upper Waianae-Nanakuli distribution system with a main from its upper Waianae "Kunesh" Tunnel to Waianae Village. The project also includes storage reservoirs on both the Nanakuli and lower Waianae mains which are to be interconnected. Pipe and storage tank capacity should be designed to carry and conserve the total of approximately 4 mgd of fresh water which is now available in upper Waianae. This project, together with Projects B-2 and B-4, which are discussed separately herein, would make it possible for the entire 4 mgd of upper Waianae water to be used for potable purposes. According to Suburban Water System, the estimated cost of this project (B-1) is $740,000.

PROJECT B-2
UPPER WAIANAE TREATMENT PLANT AND DIVERSION INTO SUBURBAN WATER SYSTEM

This project contemplates acquisition of, and improvements to, the old plantation upper Waianae water collection system; filtration and treatment of the water; and diversion into the Suburban Water System upper Waianae-Nanakuli pipeline, which is to be improved, and also into the proposed Suburban Water System main to lower Waianae.

The reliable flow from this former plantation system is approximately 1.50 mgd which is now being used for small farm irrigation and for residential areas in lower Waianae. According to the plan presented herein the equivalent of the irrigation water so diverted would be supplied by Project B-4.

The estimated cost of this project, which includes the rehabilitation of ditches, flumes and pipelines, and the installation of a 2-mgd treatment plant, is estimated at $200,000.

PROJECT B-3
EXTENSION, BULKHEADING AND LINING OF SUBURBAN WATER SYSTEM WAIANAE ("KUNESH") TUNNEL

This 10,340-foot tunnel, which has a portal elevation of 418 feet, taps dike compartments as indicated schematically on Plate 10. The tunnel was constructed by Suburban Water System and, as is characteristic of such dike-piercing projects, considerable "flush flow" was recorded during the first few years of its existence because of the draining out of the accumulated water. The flow has now diminished to a minimum of about 2.5 mgd which we believe will continue indefinitely if the tunnel is left in its present form.

It is recommended that a thorough study be made to determine possibilities of increasing the productivity of the tunnel and to more effectively conserve its supply. In this respect, the following suggestions are presented:

1. That the tunnel be extended into the Schofield Barracks Army Reservation or by "herring bone" branches from the existing tunnel. Although such extension should be regarded as experimental, it is likely that worthwhile quantities would be developed.

2. That a study be conducted to determine the feasibility of bulkheading the outermost dike-storage compartment as a possible means of increasing storage in the dike-walled compartments. The cost of effecting such storage may be far under the cost of installed equivalent surface storage.

3. That, as part of the dike-storage study, lining of certain nonproductive portions of the tunnel be considered. Investigation may indicate that these sections of the tunnel, although nonproductive, would allow appreciable quantities of water to leak out of the tunnel.

The probable cost of the work outlined above can only be estimated very generally. A rough total would run in the neighborhood of $500,000.

PROJECT B-4
RESTORATION OF
KAMAILE AND WAIANAE WELLS FOR IRRIGATION

This project proposes to reinstall pumps in the former sugar plantation's principal wells in lower Waianae, particularly in the former Kamaile station, and at former plantation Wells 1, 3, 4 and 10. It is believed that the reactivation of these wells would make available a minimum of 3 or 4 mgd for irrigation purposes.

Interconnection with the Suburban Water System potable water system should be provided so that any excess potable supply may be introduced into the irrigation distribution system.

The project would also include extension of the system into upper Makaha Valley and rebuilding of the flume and pipeline which formerly distributed this water as far east as Mikilua. The restoration of these wells would make it possible to transfer to domestic use the water now being supplied to small farm irrigation from the Glover Tunnel in Makaha (Project B-5) and the upper Waianae former plantation tunnels (Project B-2). It would also make up for the portion of the City and County's Kunesh Tunnel water in upper Waianae (Project B-1) that cannot be distributed at present because of the inadequacy of the Suburban Water System lines.

The total cost of Project B-4, including installation of pumps, construction of the flume and pipeline, and sufficient storage capacity to conserve as much water as practicable, is estimated at $800,000.

Before this project is undertaken, a determination should be made as to whose responsibility it is to furnish water for irrigation.

PROJECT B-5
TRANSFER OF GLOVER TUNNEL
TO DOMESTIC USE

It is proposed that after the completion of Project B-4 the Glover Tunnel in upper Makaha be connected with the Suburban Water System potable water system.

The reliable flow is approximately 600,000 gallons per day with some increase during periods of good rainfall. Although the quality of this supply has not been investigated, it is believed that only chlorination may be necessary.

As part of the project the feasibility of bulkheading the tunnel to increase storage in the dike compartments should be investigated. No geologic log is available so the practicability of such a project remains to be determined.

The total cost of Project B-5, including a pipeline connection with Suburban Water System, a reservoir and an allowance for bulkheading is estimated at $400,000.

PLATE 10

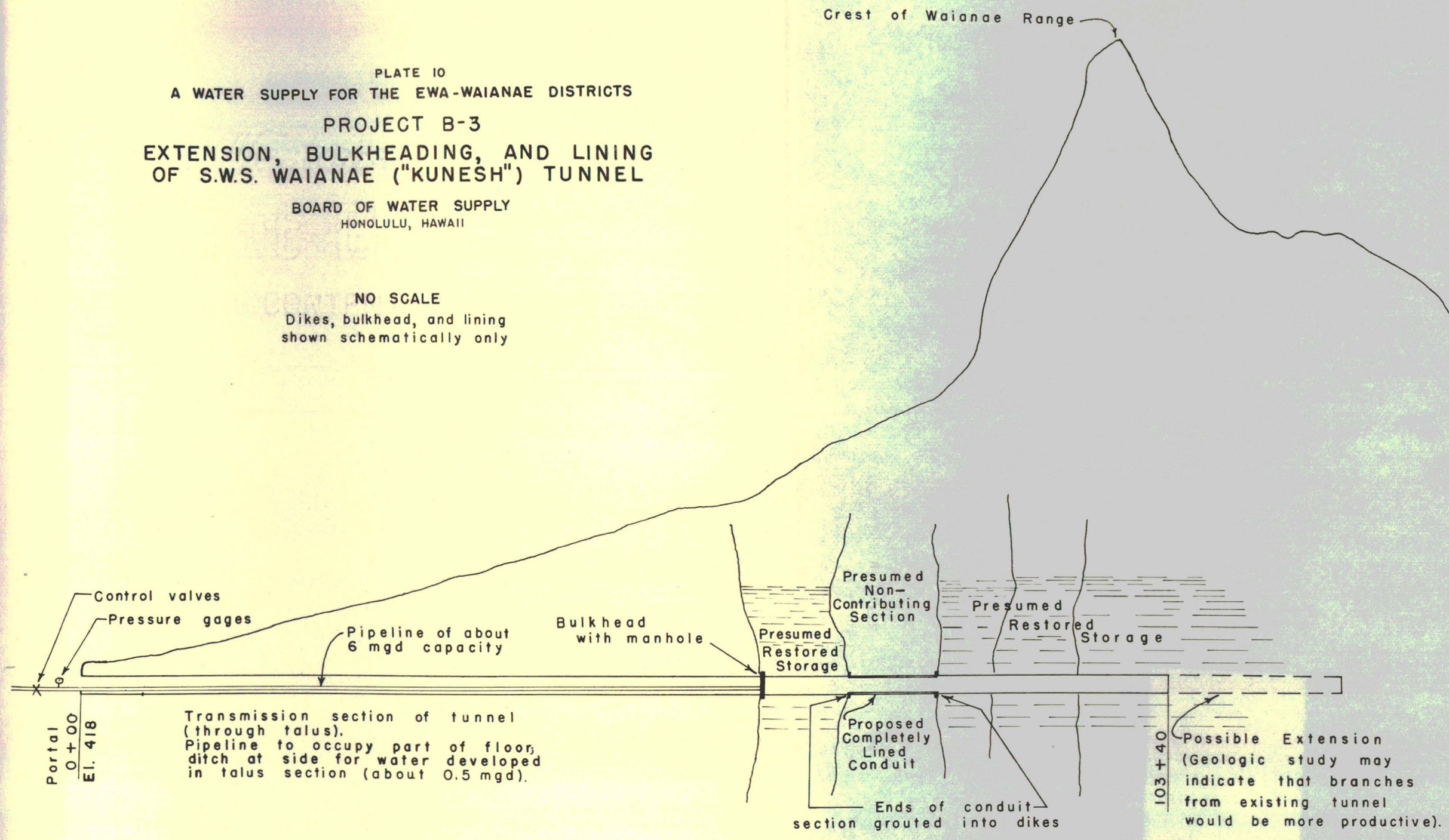
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

PROJECT B-3

EXTENSION, BULKHEADING, AND LINING OF S.W.S. WAIANAE ("KUNESH") TUNNEL

BOARD OF WATER SUPPLY
HONOLULU, HAWAII

NO SCALE
Dikes, bulkhead, and lining shown schematically only



STUDY "C"

WATER DEVELOPMENT PROJECTS AT PEARL HARBOR SPRINGS

According to U. S. Geological Survey records, a minimum of about 50 mgd is discharging from the Pearl Harbor Springs group. Of this amount, and after making allowance for plantation uses, only about 12.5 mgd is recoverable for potable purposes by basic treatment involving simple filtration and chlorination. The remaining portion of the flow is not only heavily contaminated but is so high in hardness and chloride that to render it acceptable for domestic use would be too costly. Though limited in possibilities for potable development, the Springs remain a large potential source of industrial-irrigation water. In this regard, the question as to who should be responsible for the furnishing of nonpotable water should be clarified.

Our study covers two basic methods for the recovery of potable water at the springs. The first method, as mentioned above, is direct diversion and filtration of the visible flow where practicable. The second, as discussed later in this section, envisions the possible interception of water by wells located a short distance upstream of the spring discharge. While we feel that a minimum of about 12.5 mgd may be obtained by filtration the quantity of good quality water expected from wells is problematical, pending field tests recommended in this report. We believe, however, that a minimum of about 10 mgd could be developed by this method.

Although present indications are that Pearl Harbor Springs is not the answer to the ultimate needs of the Ewa-Waianae districts, some of the advantages of recovering and utilizing a supplementary supply therefrom, particularly under an incremental plan of development, should not be overlooked.

In outlining possible alternate methods of developing a potable supply from the springs, we are deleting the method which calls for softening and chloride reduction. Removal of chlorides on a limited basis by municipalities is possible by the use of zeolites, but the cost would unquestionably be too high for consideration in this study.

It should be mentioned that the U. S. Geological Survey is currently conducting a comprehensive survey of the salinity of the spring leakage at scattered points along the shoreline. The results of this study may indicate that additional quantities of potable water may be developed. However, the chloride content of this supply would probably be in the neighborhood of the U. S. Public Health Service limit of 250 ppm.

PROJECT C-1
DEVELOPMENT OF KALAUAO SPRINGS

ALTERNATE (a)—POTABLE SUPPLY FROM SPRING POND

As shown in the sketch on Plate 11, Project C-1 (a) proposes to recover water of the Kalauao group of springs for potable use by impounding and treatment. On the basis of limited bacteriological and chemical data available, Kalauao Springs appears to be the only source in the entire Pearl Harbor group where the natural discharge at the spring outlet can be directly diverted and economically treated for domestic purposes.

The project calls for impounding of the spring water and its diversion to a filtration plant. The treated water would be pumped into a pipeline which would carry it, together with water from other sources, to the Ewa-Waianae area.

The minimum that would be recoverable, after allowing for continuation of Oahu Sugar Company's pumping by its "Honolulu Plantation" Pump 6, would be approximately 7 mgd. The treated water is expected to have a chloride content of about 130 ppm and hardness of 140 ppm.

The total cost of the installation, including impounding, filter plant, pumping station and connection to the Ewa-Waianae trunk main, is estimated at $650,000.

ALTERNATE (b)—POTABLE SUPPLY DEVELOPED BY WELLS

This alternate is shown on Plate 12 and contemplates the development of a potable water supply of approximately 6 mgd minimum by wells drilled some distance mauka of Moanalua Road. The necessary distance and other details would be determined from the results of operation of a pilot well proposed to be installed and operated by the Board of Water Supply under provisions of the Federal Water Pollution Control Act. The details of such a well are described under Project C-3 in this report.

The estimated cost of this project, including a pipeline to Kamehameha Highway, is $130,000.

Our proposal to intercept ground water in this manner before it is discharged into Pearl Harbor brings to mind the recommendation by Dr. Chester K. Wentworth for the "repair" of Pearl Harbor Springs. Fundamentally, Dr. Wentworth's plan calls for the construction of concrete cut-off walls extending to two or three feet below sea level. Trenches would be excavated along the mauka length of these walls to serve as collection chambers from which the

water would be pumped into the distribution system. We recognize that, hydrologically, Dr. Wentworth's scheme has possibilities. In order that a comparison may be made with other proposals, its engineering and cost implications should be further explored. Our recommendation calling for the installation of a test well is based on the expectation that good quality water would be recovered at relatively low cost. We feel that, at the conclusion of field tests, we would be in a better position to make a general appraisal of the various schemes suggested for the development of Pearl Harbor Springs.

ALTERNATE (c)—IRRIGATION-INDUSTRIAL SUPPLY FROM SPRING POND

Although it now appears that it would be practicable to recover the Kalauao Spring flow in potable quality as contemplated by Alternate (a), it may be that further investigation at Kalauao, Waiau and Waiawa will show that the entire Ewa-Waianae water plan should include two mains from the Pearl Harbor district; that is, a comparatively large main for industrial and agricultural water and a smaller main for potable water from other sources.

The cost at Kalauao in such case, eliminating the filter and treatment plant in Alternate (a), is estimated at $150,000.

ALTERNATE (d)—RESERVATION OF KALAUAO SPRINGS FOR SUGAR PLANTATION PURPOSES

As a fourth alternate, it may be found, after a consideration of all other proposals made herein, that the entire Kalauao Spring source should be utilized by Oahu Sugar Company to make up for possible contributions by the Company toward the Ewa-Waianae supply from other plantation sources.

PROJECT C-2
POTABLE OR IRRIGATION AND INDUSTRIAL WATER SUPPLY FROM WAIAU SPRINGS

All of the water of the Waiau group of springs is under the control of Hawaiian Electric Company, Ltd., by its own ownership and by arrangements with the Navy and others. The entire supply from the springs and from a supplementary tunnel and wells is involved in the operation of Hawaiian Electric Company's Waiau generating plant.

The total minimum flow is about 28 mgd, of which approximately 6 mgd originates from the basal water tunnel and wells as shown on Plate 13. The bacteriological and microscopical quality of this water is surprisingly good. However, its chloride content is in the neighborhood of 200 ppm and its hardness and total solids characteristics are barely acceptable by U. S. Public Health standards. On the other hand, the quality of the remaining 22 mgd indicates heavy contamination, both chemically and bacteriologically. Our lab-

oratory analyses show that it would probably be too costly to treat this water for domestic use.

It would be desirable if the 6 mgd minimum (10 mgd average) or thereabouts from the tunnel and wells could be made available for Ewa-Waianae purposes, but it is realized that this would probably involve important rearrangements within Hawaiian Electric Company's plant.

If water can be made available from this source, either for Ewa-Waianae potable uses or for industrial and agricultural uses /by a special pipeline as referred to under Project C-1 (c)/, the introduction of the water into the pipeline could be very simply handled. Cost estimates, however, would be dependent upon negotiations with affected parties.

PROJECT C-3
DEVELOPMENT OF WAIAWA SPRINGS

ALTERNATE (a)—POTABLE SUPPLY DEVELOPED BY WELLS

The salinity of Waiawa Springs is far in excess of the allowable under U. S. Public Health Service standards. Furthermore, there is every reason to believe that bacterial contamination is heavy. Therefore, it is proposed that one of the wells indicated on Plate 14 be drilled and tested over a wide range of depth and output in order to determine the feasibility of developing water of potable quality back of the springs.

The well should be of approximately 20 inches diameter and drilled from about 50 feet above sea level to approximately 10 feet below sea level. It should be cased into the aquifer and a production test made with the largest pump that can be made available for the purpose. Consideration should then be given to drilling the well to greater depth and repeating the test if the results of the first test are encouraging. It may be found that further deepening would be desirable.

As part of the pilot project, three drill holes should be located about 100 feet from the pilot well so that drawdown observations may be made during the tests.

In the event that the pilot project shows that water of potable quality could be developed in this manner, it would be practicable to proceed with one or more additional wells as indicated on Plate 14. The water would be pumped into the pipeline on Farrington Highway which, as proposed under Projects C-1 and C-2, could originate at either Kalauao or Waiau Springs.

It is believed that at least 6 mgd could be developed by such an installa-

tion and that there would remain available a supply for Oahu Sugar Company's continued operation of Pump 9. It is also believed that there would still be adequate spring water for lotus and watercress irrigation. In any event, suitable negotiation and adjustment would have to be made with the landowners and a joint operational agreement worked out with Oahu Sugar Company.

The cost of the pilot well and the ultimate installation, including introduction of the water into the Ewa-Waianae pipeline on Farrington Highway, is approximately $150,000. The cost of the pilot well installation itself is estimated at $15,000.

ALTERNATE (b)—DEVELOPMENT OF INDUSTRIAL AND AGRICULTURAL WATER

In the event that it should prove impracticable to develop potable water at this locality, it would still remain feasible to develop nonpotable water for industrial and agricultural purposes if there are to be dual water systems. In such case a minimum of about 7 mgd of nonpotable water could be pumped from a pond-sump created by an earth dam similar to that shown on our sketch illustrating Project C-1 (a) without interfering with present plantation needs.

The cost of impounding, pump and pipeline to an Ewa-Waianae pipeline on Farrington Highway is approximately $200,000.

PROJECT C-4
DEVELOPMENT OF POTABLE WATER SUPPLY AT WAIKELE SPRINGS

A reliable minimum of approximately 5 mgd flows into Waikele Stream from the portion of Waikele Springs makai of Oahu Sugar Company Pump No. 8.

It is believed that approximately 5 mgd could be developed by a basal water tunnel as indicated on Plate 15, but the necessary length of tunnel cannot be predicted. The flow would consist of a portion of the measured spring flow and other basal water.

Because of the nature of occupancy of the surroundings above the tunnel, the water would probably have to be chlorinated.

The cost of the project with tunnel as shown (approximately 750 feet), chlorination facilities, and pump and pipeline to deliver the water into an Ewa-Waianae pipeline on Farrington Highway is estimated at $500,000.

PLATE II

A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

PROJECT C-1 ALTERNATE (a)
DEVELOPMENT OF POTABLE WATER SUPPLY FROM POND AT KALAUAO SPRINGS

BOARD OF WATER SUPPLY
HONOLULU, HAWAII

MAP COMPILED FROM VARIOUS SOURCES

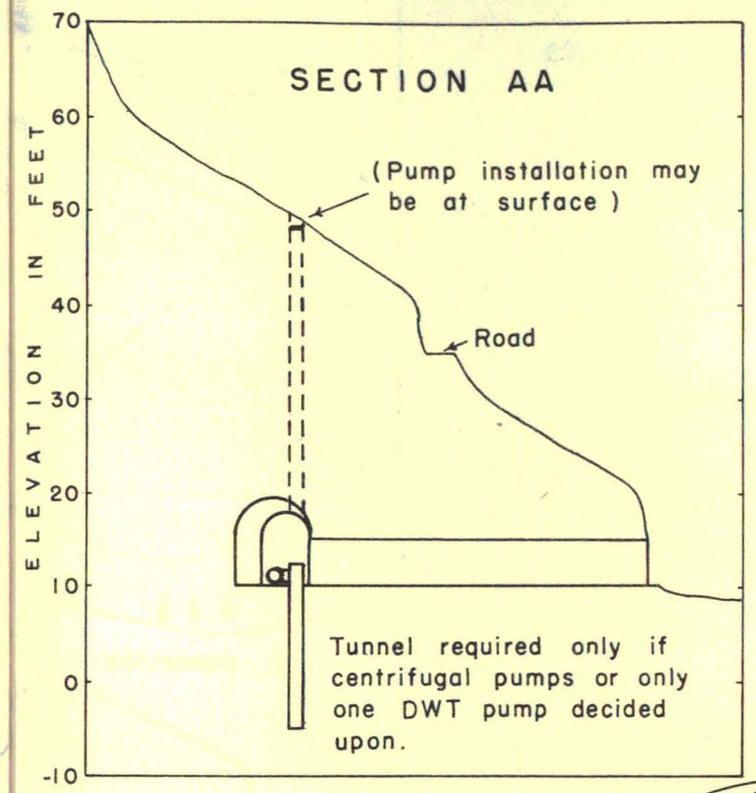
PLATE 12

A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

PROJECT C-I ALTERNATE (b)
DEVELOPMENT OF POTABLE WATER SUPPLY BY WELLS MAUKA OF KALAUAO SPRINGS

BOARD OF WATER SUPPLY
HONOLULU, HAWAII

MAP COMPILED FROM VARIOUS SOURCES



NOTE:
Scale of plan and section of tunnel and wells exaggerated

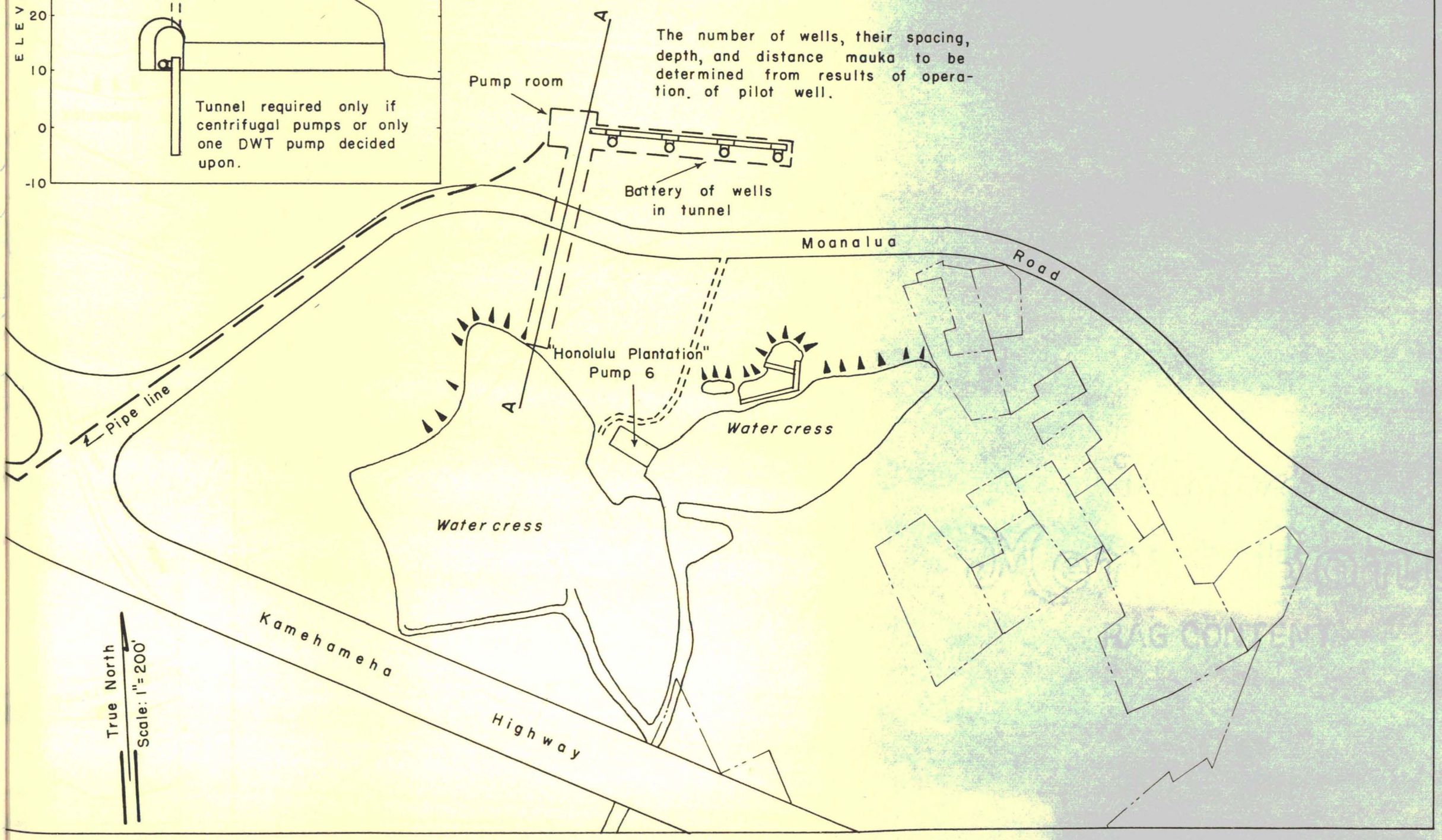


PLATE 13

A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

PROJECT C-2
WATER SUPPLY FROM WAIAU THROUGH HAWAIIAN ELECTRIC CO.

BOARD OF WATER SUPPLY
HONOLULU, HAWAII

MAP COMPILED FROM VARIOUS SOURCES

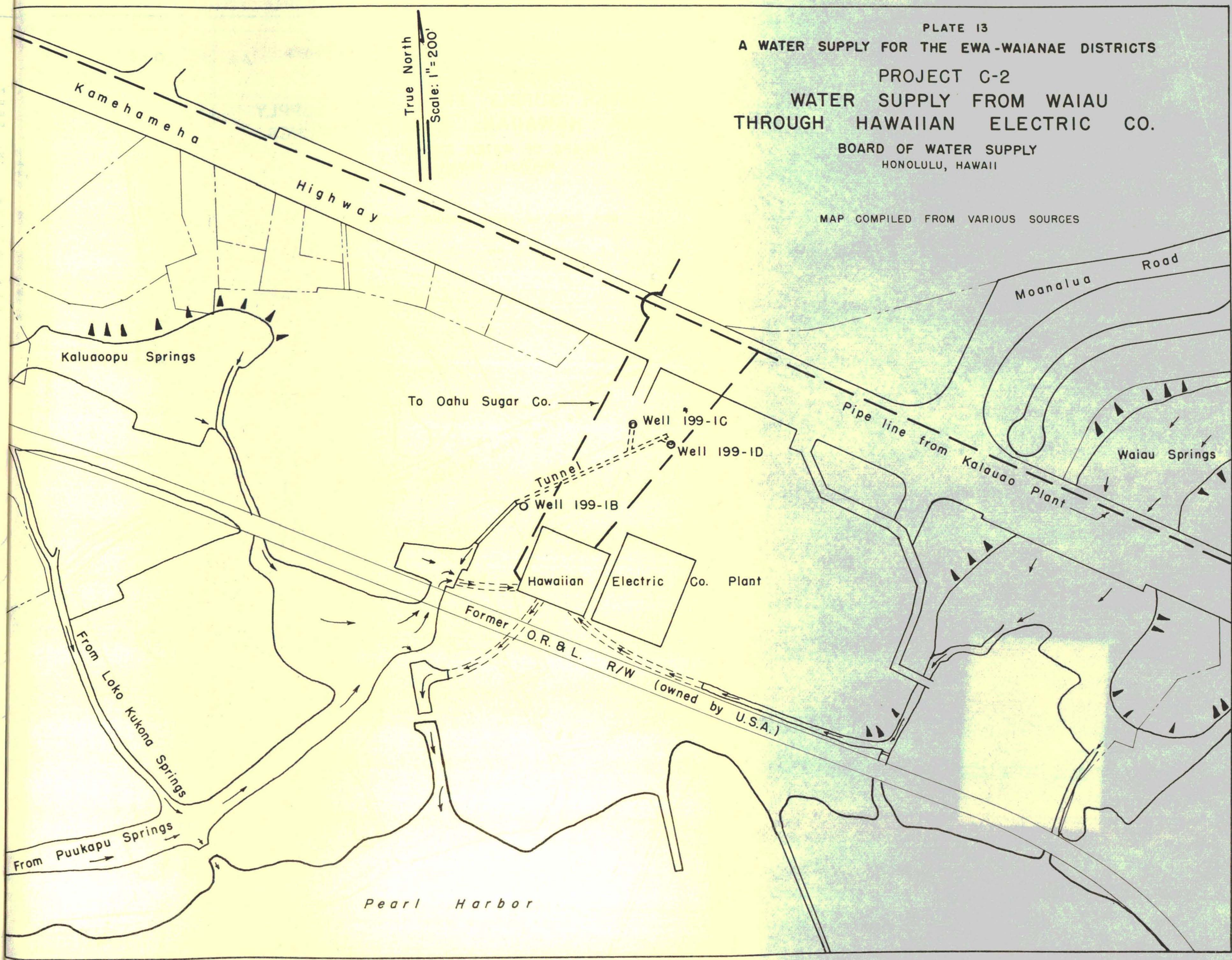
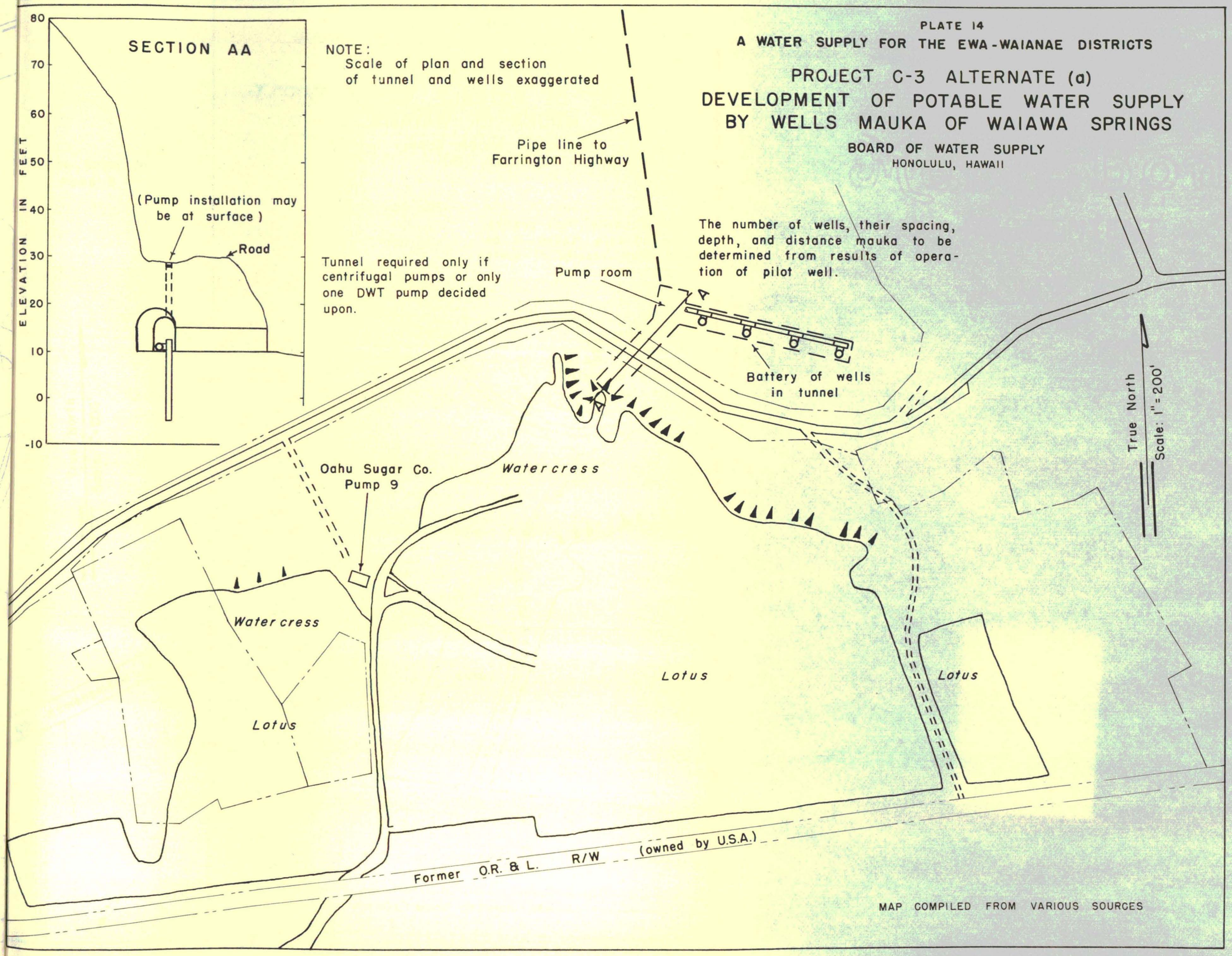


PLATE 14

A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

PROJECT C-3 ALTERNATE (a)
DEVELOPMENT OF POTABLE WATER SUPPLY BY WELLS MAUKA OF WAIAWA SPRINGS

BOARD OF WATER SUPPLY
HONOLULU, HAWAII



MAP COMPILED FROM VARIOUS SOURCES

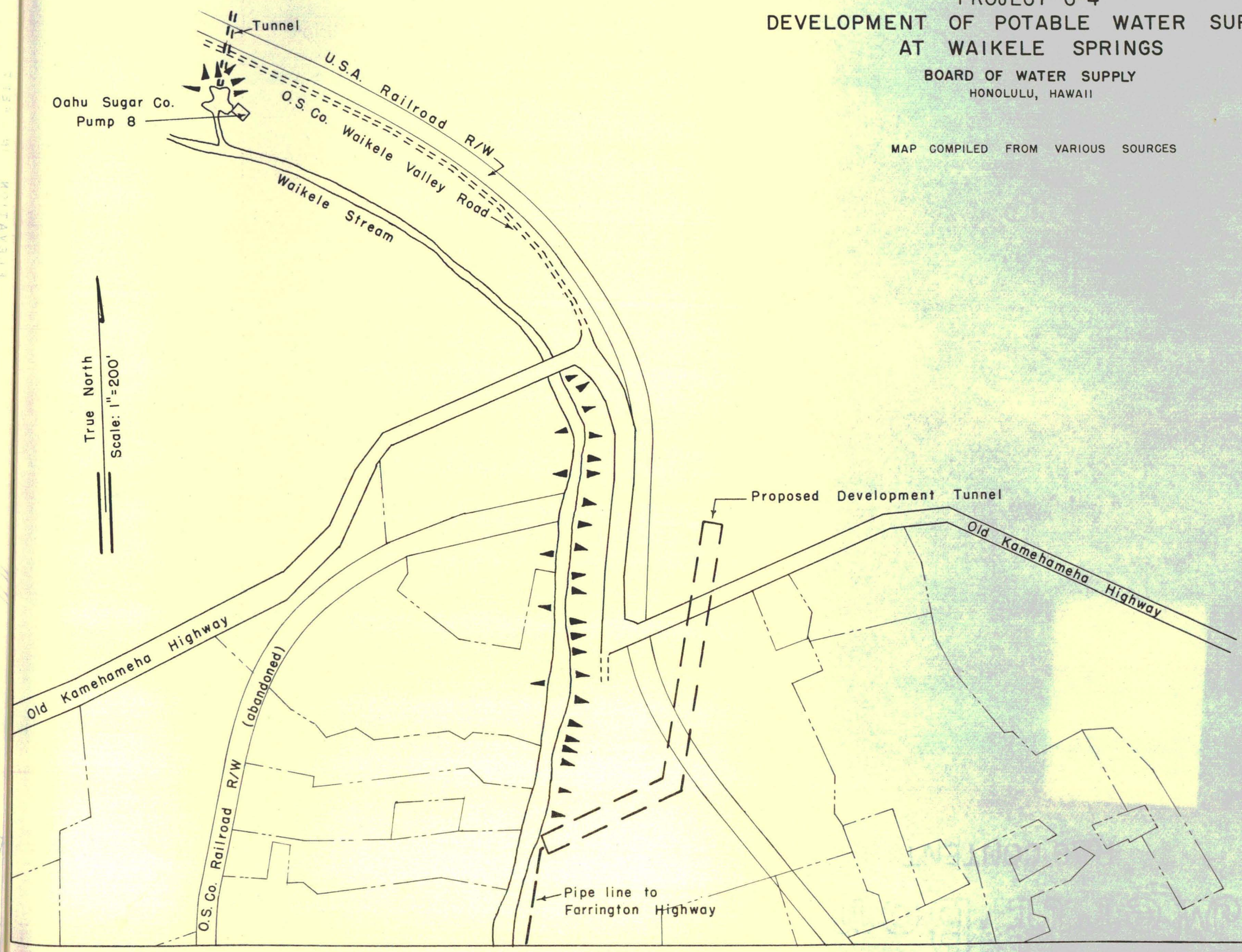
PLATE 15

A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

PROJECT C-4
DEVELOPMENT OF POTABLE WATER SUPPLY AT WAIKELE SPRINGS

BOARD OF WATER SUPPLY
HONOLULU, HAWAII

MAP COMPILED FROM VARIOUS SOURCES



STUDY "D"

POSSIBLE MAJOR MAUI-TYPE OR DRILLED WELL STATIONS

This study is confined to a general discussion on a number of possible projects for the development of ground water by Maui-type or drilled well stations, the relative merits of which are listed below and in the section on "Economic Analysis."

PROJECT D-1
MAJOR STATION IN SCHOFIELD PLATEAU AND KUNIA ROAD PIPELINE

Project D-1, as indicated on Plate 8, shows a possible station in the Schofield plateau similar to the Army's Schofield shaft and well installation.

Estimated costs for alternate schemes are included in Plan IV which is discussed on page 49 in this report.

Assuming that necessary property rights could be obtained, it is believed that as much as 30 mgd could be taken from this source without exceeding the safe yield of the Schofield high-level ground-water body.

This project has been included in our study with some reservation because of the excessive costs anticipated. Not only will the cost of the pipeline to the Ewa-Waianae region be appreciable, but a continuous power cost will be necessary to pump water against a high head. However, the potentialities of this source should not be ignored because some day circumstances may be such as to justify its development.

PROJECT D-2
WAIKAKALAUA GULCH BASAL WATER DEVELOPMENT

A major basal water development of at least 30-mgd capacity in Waikakalaua Gulch at approximately the 350-foot contour seems to be the most attractive proposal at present. The location seems ideal in respect to its tributary (and particularly upgradient) portion of the Pearl Harbor ground-water lens where the water table stands at approximately 20 feet at the locality. Furthermore, it is believed that such a development would have only minimal effect on existing stations makai of the site. This, however, is a subject that must

be studied further and, since it comes within the scope of the investigation now being conducted by the U. S. Geological Survey, more information will be available as the study progresses. Therefore, final consideration of this project should be deferred until the study is completed.

In addition to the advantages mentioned above, the location has what appears to be probable advantages in simplified land ownership which should facilitate the acquisition of necessary property rights. It would also be in step with the gradual transition from deep artesian well stations to Maui-type stations as already exemplified by such installations as the Navy Red Hill, Navy Halawa, Board of Water Supply Halawa, Navy Barber's Point, Honolulu Plantation Aiea, and Ewa Plantation Company shafts.

The suggested location is mauka of the points at which the "valley fill" in Waikakalaua and Kipapa gulches intersect sea level, thus assuring an unobstructed drawdown radius. Field checks indicate that there is every reason to believe that the water would be of good quality.

The site is suitable for either a conventional Maui-type shaft and tunnel as shown on Plate 16, or a drilled well project as shown on Plate 17.

ALTERNATE (a)—MAUI-TYPE SHAFT AT WAIKAKALAUA SITE

From the standpoint of developing the ultimate yield of a water source, a Maui-type shaft is preferable because it would be comparatively simple to continue the infiltration tunnel at the time of the initial construction. In this way it would be possible to develop a total of perhaps 30 mgd, even though there may be little probability that more than 10 mgd will be required for many years to come. Furthermore, a Maui-type development would require only a minimum number of pumps.

On the other hand, a Maui-type shaft and tunnel would have a high initial cost.

The cost of a Maui-type development of 40-mgd capacity, including all mechanical and electrical equipment, is estimated at $2,000,000. This estimate is based on a type of construction similar to that of the Board of Water Supply Halawa and Navy Waiawa stations.

The cost of a 20-mgd capacity pipeline to Farrington Highway is estimated at $1,250,000, while about $1,450,000 would be required to install a pipeline to carry 40 mgd.

ALTERNATE (b)—WAIKAKALAUA DRILLED WELL DEVELOPMENT

As an alternative to a Maui-type shaft, a drilled well development could

be decided upon with deep well turbine pumps either of the conventional shaft-driven or submersible motor type. Since each well would have a capacity within a range of 3 to 4 mgd, a multiple installation would be required. Such an installation would have the obvious advantage of construction by increments.

The principal disadvantage of a multiple drilled well development is the relatively large land area necessary to locate the wells.

In estimating the cost of a drilled well installation, it is assumed that each well would be 20 inches in diameter with its top at the 350-foot elevation and extending to 100 feet below sea level, the casing terminating at sea level. Each well is also assumed to have a minimum productive capacity of 3 mgd. For a 20-mgd installation the total cost, including pumps, housing, and all electrical equipment, is estimated at $500,000. A 40-mgd station would cost twice that much.

PROJECT D-3
BASAL WATER DEVELOPMENT AT LOWER KUNIA

It is believed that additional basal water could be developed at location D-3 (Plate 8), provided the project were designed for only a limited production. Suburban Water System has just completed two drilled wells at the location and a maximum production of approximately 4 mgd is anticipated.

No large development should be made in the locality, however, until the completion of the current U. S. Geological Survey study. It is possible that the results of this study will indicate that a 15 to 20 mgd development may be permissible.

The cost of the two cased wells and the installed pumps at the new Suburban Water System installation totaled $50,000.

Pipeline cost to Farrington Highway should be added.

PROJECT D-4
BASAL WATER DEVELOPMENT BY SCATTERED, DRILLED NONARTESIAN WELLS

It is thought that in addition to the wells mentioned in Projects C-1, C-3, and D-3, additional nonartesian wells could be drilled at other localities, particularly in the general area back of Pearl Harbor Springs.

Output from these wells is not expected to be substantial in comparison to the ultimate total water requirement in the Ewa-Waianae districts. Their development is being suggested primarily to serve subdivisions and other local developments whose needs may not be economically met by main extensions from the Ewa-Waianae system.

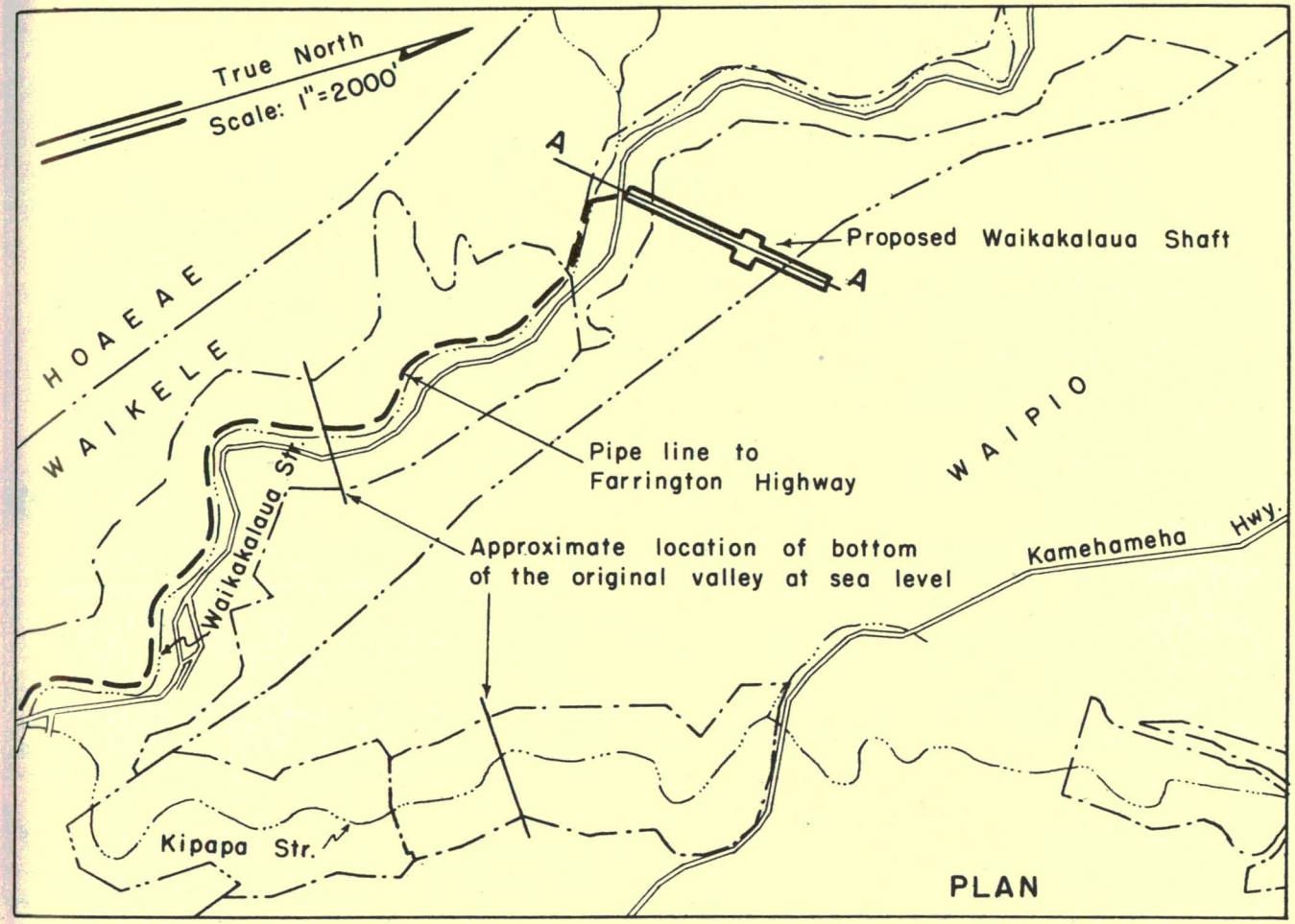


PLATE 16

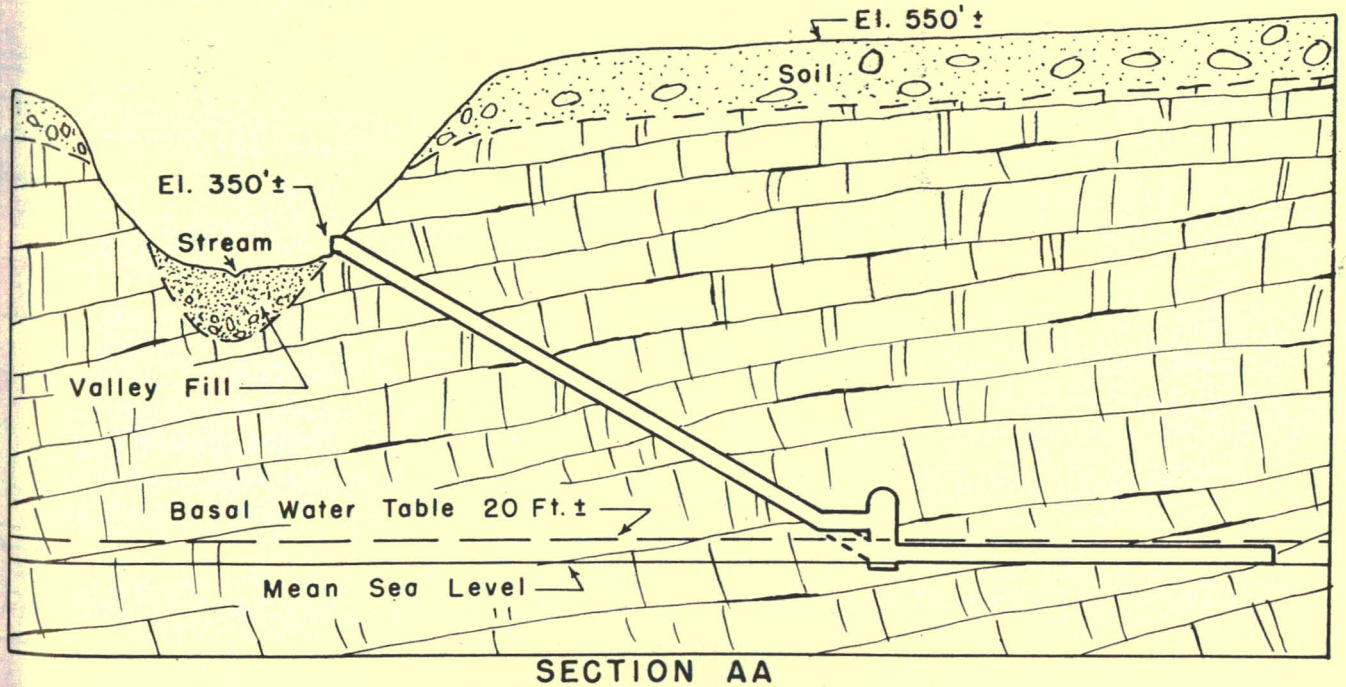
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

PROJECT D-2 ALTERNATE (a)

MAUI-TYPE SHAFT IN WAIKAKALAUA GULCH

BOARD OF WATER SUPPLY

HONOLULU, HAWAII



SECTION AA

SCALE: Horizontal 1"=500' (Dimensions of inclined shaft,
Vertical 1"=200' pump room and tunnel exaggerated)

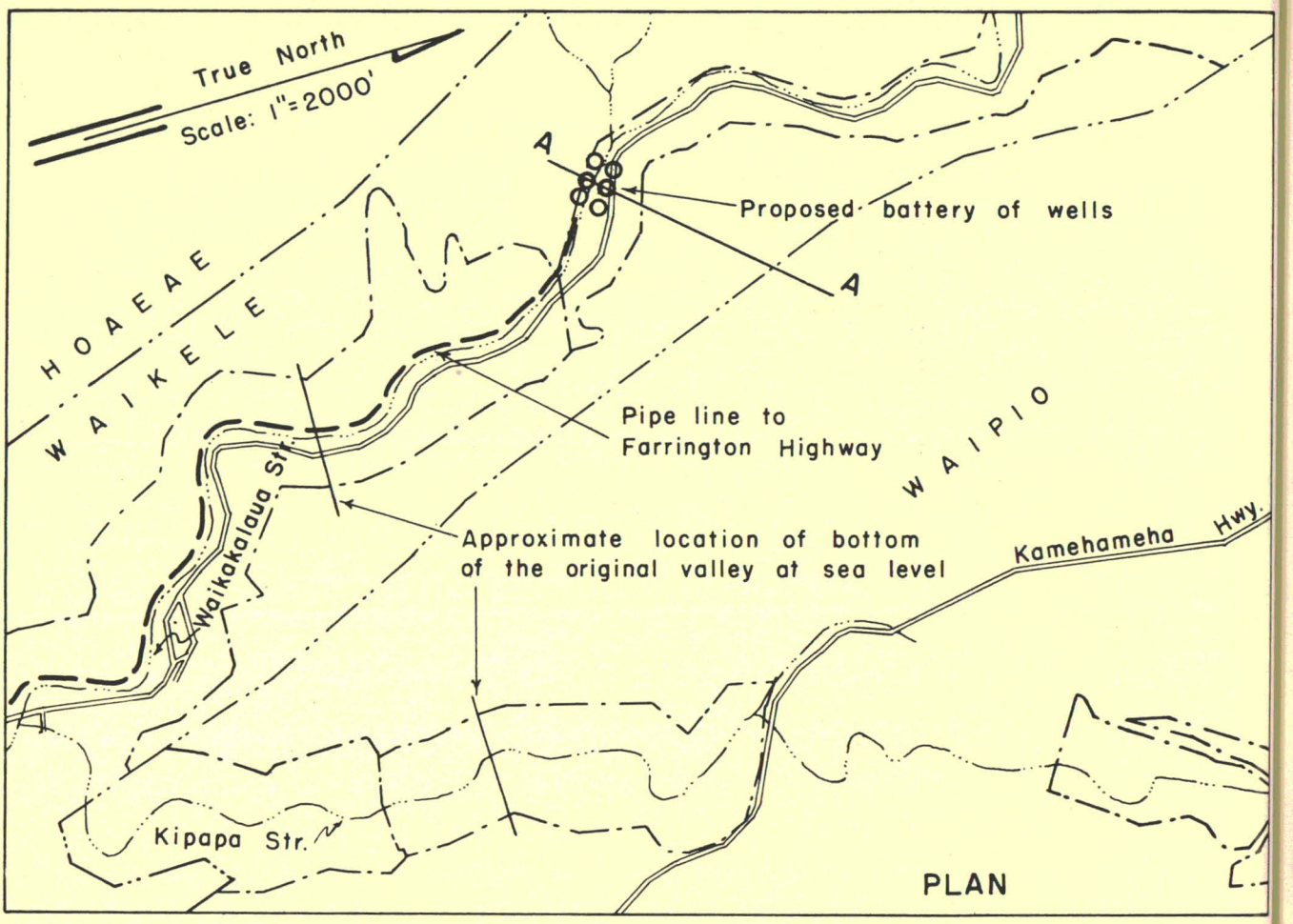
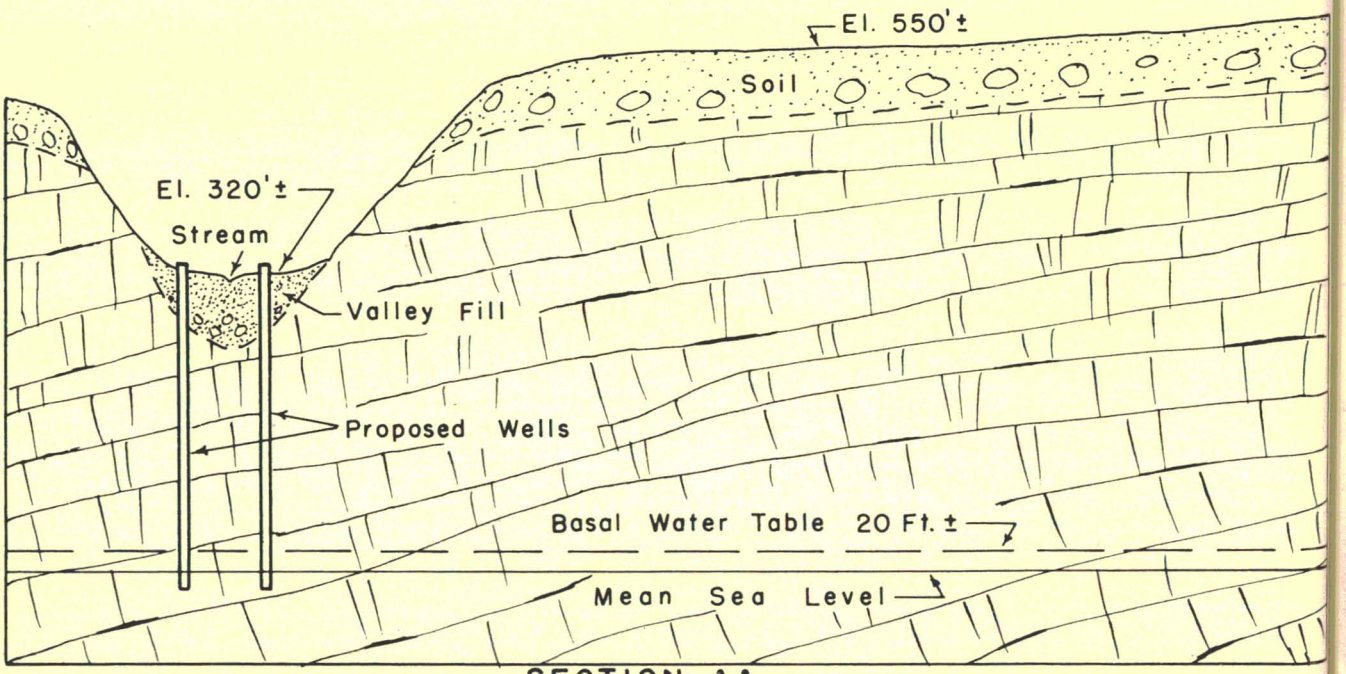


PLATE 17

A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS

PROJECT D-2 ALTERNATE (b)
WAIKAKALAUA DRILLED WELL DEVELOPMENT

BOARD OF WATER SUPPLY
HONOLULU, HAWAII



SECTION AA

SCALE: Horizontal 1" = 500' (Dimensions of wells exaggerated)
Vertical 1" = 200'

STUDY "E"

ADDITIONAL PROJECTS RELATIVE TO WAIANAE WATER SUPPLY

Under this study, comment is offered on six additional projects which, although mentioned at various times, are considered as either impracticable of accomplishment, or incidental to other projects, or of such low priority as to not warrant detailed analysis at this time. Location of the several projects mentioned is shown on the accompanying Project Index Map (Plate 8).

PROJECT E-1
DIVERSION FROM WAIAHOLE DITCH AT KUNIA

The portion of the Waiahole Ditch flow owned by the Territorial government amounts to a minimum of approximately 3 mgd which is leased to Oahu Sugar Company's subsidiary, Waiahole Water Company. Under the lease, which now has a revocable license status, the Territory has the right to withdraw the Territorial share at any time and also to make joint use of Waiahole Ditch subject to sharing in the expense of operation thereof.

For the purpose of this report, it is believed that the Territory's share of the Waiahole ditch water should be considered dedicated to the future needs of Suburban Water System in Koolaupoko. The amount of water involved is small in proportion to that required for the Ewa-Waianae districts, and it seems obvious that capital and operating costs incidental to use of the water in said districts would be disproportionate.

PROJECT E-2
DEVELOPMENT OF WATER IN MOKULEIA AND ITS TRANSMISSION TO MAKAHA

This project is shown only because it has been mentioned from time to time.

Although there are several excellent wells in the Mokuleia area, they are of limited productivity and, according to present information, it is unlikely that a sufficient production could be developed at any battery of wells to justify the high cost of delivering the water into the Waianae distribution system at Makaha.

PROJECT E-3
USE OF UPPER MAKAHA TUNNELS

The several old plantation tunnels at the upper end of Mākaha Valley have a reported aggregate flow of about 100,000 gpd. At the present time, it is believed that no use is being made of this water, although it may be diverted into the irrigation system of the Waianae Development Company, Ltd. A survey should be made to determine the practicability of collecting the water and delivering it into the Suburban Water System distribution system.

PROJECT E-4
PROPOSED CLARK TUNNEL IN WAIANAE-MAKAHA RIDGE

Certain reports have mentioned the proposal made by Geologist W. O. Clark (deceased) relative to a water development tunnel as indicated by "E-4" on our Project Index Map.

It is believed that Mr. Clark's recommendation was made prior to the planning and construction of the Glover Tunnel project (B-5) in Makaha, and that the Glover Tunnel flow probably includes water that otherwise could have been developed by the proposed Clark tunnel. Such a tunnel would undoubtedly intercept a considerable portion of the water that would be obtainable from the restoration of the Kamaile pumping station as proposed under "B-4," but it is thought extremely unlikely that the proposal would result in sufficient "new water" over and above that available at the Glover Tunnel and the Kamaile wells to justify its cost. The project, however, undoubtedly justifies further consideration at some future date.

PROJECT E-5
ADDITIONAL SHALLOW WELLS IN THE LUALUALEI-MIKILUA REGION

This heading speaks for itself. The several dozen private shallow wells in the Lualualei-Mikilua region are invaluable to the farmers cultivating a total of several hundred acres.

No such development by public water agencies is recommended, but it is suggested that all of the shallow wells be studied and that a report be made relative to the digging of additional private wells. Such wells are not only of im-

mediate importance, but would be valuable in augmenting the irrigation water project (B-4) which is discussed herein.

PROJECT E-6
IMPROVEMENT OF SUBURBAN WATER SYSTEM LUALUALEI SHAFT

The water of this shaft, although exceeding the Public Health Service chloride limit of 250 ppm, is the only domestic water supply for certain farmers in the Mikilua region.

There are no known reports available offering recommendations for augmenting the output or improving the quality of the water from this shaft. It is believed that such a study would be most desirable.

When the Waianae Water System studies are completed, it may prove to be advisable to utilize the Lualualei shaft water in the irrigation water distribution plan.

PROJECT E-7
SCHOFIELD AREA WATER DEVELOPMENT AND ITS TRANSMISSION TO LUALUALEI

This project merits future study, but at this writing, those most familiar with the water resources of the locality doubt that any significant quantity of water could be developed within some distance of the crest of the Waianae Range. (It is believed, however, that considerable quantities are available closer to Wahiawa as indicated under Project D-1.)

Attention is also invited to the comment made in Project B-4 relative to the possibility of extending the City and County Waianae tunnel.

SALT WATER CONVERSION

During the last few years a great deal of interest has been centered on research and developmental programs to convert salt or brackish water to fresh water on a scale competitive with municipal water production. The great stimulus in the effort to economically recover fresh water from salt water was provided by the Federal Government when it passed the Saline Water Act in 1952. At the present time, at least twenty-one separate demineralization projects are being sponsored by the Department of the Interior, nine of which are being conducted by various universities throughout the country.

Up to now the general processes which have been most widely mentioned are thermal distillation, solar distillation, and electric membrane separation. Results to date bear some promise, but the general feeling is that there is no ground for optimism in the early perfection, at least within the next 10 or 15 years, of a process within economic practicability. As a matter of fact, the House Committee on Interior and Insular Affairs, following extensive hearings on the Interior Department's saline water research program, reported in April 1957 that "conversion cost trends have been upward and in the direction away from the objective of finding economic conversion processes."

It is difficult to evaluate just how far along the various methods are progressing and what the exact prospects are in each case. Thermal distillation seems to show the greatest promise of producing fresh water in large quantities at low cost. However, prospects of its approaching a production cost factor comparable to that of present-day municipalities are still remote.

Another process that has undergone much field study is solar distillation. Although this method has the distinct advantage of being operated by low-cost energy, it still remains impracticable for large-scale conversion because of the large land area required.

Although the performance of electric and osmotic membranes has been encouraging, large-scale conversion at low cost is still not foreseeable. The use of electric membranes, or electrodialysis, is effective on brackish water only. At least six research projects using electric membranes are now in progress. However, cost data resulting from the work conducted to date still far exceed what is considered reasonable for large-scale recovery.

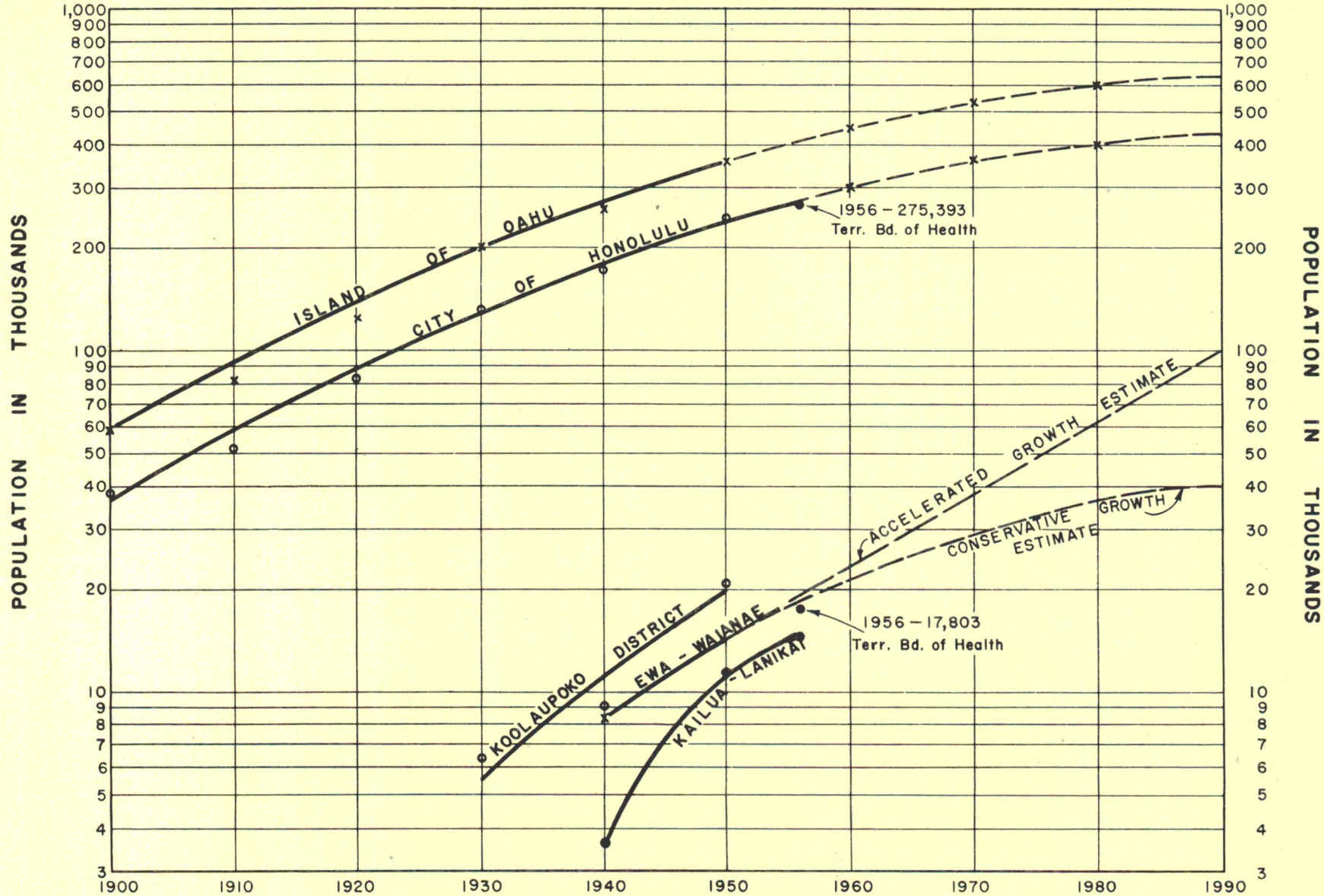
The tremendous range in unit cost figures as submitted by various investigators throughout the country points out a lack of uniformity in basic assumptions and the unfeasibility of attempting to translate laboratory-scale results to production-cost figures. In most cases the reported unit costs represent cost of energy alone. In no case was cost of distribution included. It is apparent, therefore, that there is a great need to standardize on cost-estimating methods and assumptions.

For sea water demineralization, the most prevalent cost figures per 1,000 gallons are $2.00 for multiple-effect evaporation, $1.25 for vapor compression distillation, $1.37 for flash-type distillation, and $2.00 for solar distillation. The electric membrane method for brackish water conversion ranges from $0.50 to about $1.00 per 1,000 gallons. These figures, as cautioned by the Committee on Interior and Insular Affairs, "are those of the researchers or investigators and must be presumed to reflect the optimistic views natural to a proponent." By adding to these figures the cost of distribution, which is the greater portion of the total cost of usual water works operation, the total unit cost would be such that a figure comparable to the cost of municipally furnished water is still far out of sight.

As mentioned earlier, the recent report of the House Committee on Interior and Insular Affairs emphasized that conversion cost trends have gone upward during the last few years. In this regard it may be well for us to bear in mind the conclusion of the committee when it warned that "we still have a long way to go before general use of converted sea water becomes a reality and suggests to the Secretary of the Interior that, in these days when water is becoming more and more critical in many parts of the Nation, there is danger in raising false hopes that may contribute to a false sense of security and de-emphasize the immediate need for conserving and making better use of the water we have."

While we have little reason to be optimistic about sea water conversion at the present time, we probably have less reason to be pessimistic about its practical realization within the lifetime of most of us. The main consideration is that our immediate planning cannot place sufficient reliance upon sea water conversion as an answer to our needs. However, the problem must be approached with faith in the great advances of modern technology, and our planning must be flexible enough to recognize the vast potential of the sea as the answer to our long search for an endless supply of fresh water.

POPULATION TRENDS - CITY OF HONOLULU AND ISLAND OF OAHU



NOTE: For the purpose of this study the Ewa-Waianae area consists of U.S. Census Tracts 38 & 39 only. The Kailua-Lanikai area is U.S. Census Tract 30. Territorial Board of Health figures exclude military personnel included in U.S. Census data.

BOARD OF WATER SUPPLY
HONOLULU, HAWAII

SOURCE: U. S. Census and Territorial Board of Health.

ECONOMIC ANALYSIS

ESTIMATED POPULATION GROWTH

At present there is a lack of long-range planning for the Ewa-Waianae areas with the exception of the work done by Harland Bartholomew and Associates for the Campbell Estate and Capital Investment Company. Accordingly, estimates relative to the probable growth in population and land and water use in the area under study can only be based on broad assumptions.

1. The years ahead may show a gradual decline in agricultural pursuits on the island of Oahu, and that this decline will be supplanted by a parallel growth in agriculture on the outside islands.

2. Economic growth in the Ewa-Waianae area may also be contingent upon the development of light industries. Examples include the manufacture of electronic components, Hawaiian arts and crafts, provisions for a much-expanded Hawaiian clothing industry, paper box and paper products manufactured from sugar cane bagasse, and the production of movies for television entertainment. Operation of the new Standard Oil refinery may develop some secondary chemical industries. For water planning purposes, these industrial developments may be located in well-planned "industrial parks" which have proved to be successful on the Mainland.

3. Along with the development of light industries, many installations catering to the tourist industry may also be developed in the Ewa-Waianae areas, both on the beach and in the mountain areas.

4. The ultimate population in the area under study can only be estimated roughly. By analyzing population growth in various developed areas on Oahu, a density figure of fourteen persons per acre was finally selected. This figure is about two-thirds of the density in the Aina Haina area. By using this figure and making the usual allowances for streets, playgrounds, schools, etc., the net area thus arrived at would theoretically support an ultimate population of 225,000 people.

Plate 18 shows present and estimated future populations in certain areas on Oahu. As shown on the chart, the population of the Ewa-Waianae area under a conservative growth pattern might reach 40,000 persons by 1990. This would roughly parallel the trend expected for Honolulu. However, an accelerated

growth may occur, whereby the population in 1990 might approximate 100,000 persons, or about 45 per cent of the probable ultimate population.

Therefore, it appears advisable to limit the initial water development for the Ewa-Waianae area to 20 mgd, or about 50 per cent of the estimated ultimate requirement. Based on what might be considered an optimistic rate of growth, the proposed initial development would provide an adequate water supply for the next 30 years, or the usual life of a bond issue. In other words, our estimates indicate that a 20-mgd supply should be adequate to serve the 16,500 acres and a population of 100,000 people until about 1990.

It is emphasized that this study excludes the extensive areas of sugar cane lands presently located within the area under study. Many leases now devoted to sugar cane production will not expire until 1970 and thereafter. If and when cane lands are converted to urban-type developments, it is believed that the existing plantation sources of supply have sufficient water of potable quality to meet the new needs that will arise.

ECONOMICS OF SOURCE DEVELOPMENT

Since the aim of this report is to present a preliminary over-all appraisal of the Ewa-Waianae water supply situation, no attempt has been made to determine economic plant capacity for variable supply sources such as Kalauao Springs, Project C-1. For example, the most efficient plant size or filter capacity might well be 15 mgd in order to process a mean annual supply from the springs of 10 mgd.

The most efficient plant capacity for various supplies is herein defined as that plant size, filter capacity, etc., which will develop the largest amount of water at the lowest unit cost.

ECONOMICS OF INITIAL DEVELOPMENT

As indicated on the population trend chart (Plate 18), the curve referred to as "accelerated growth estimate" (approximately paralleling the rate experienced in the Koolaupoko district) indicates that it might take about 30 years before water needs approach 50 per cent of the ultimate demand of 40 mgd on an annual average basis.

If the actual growth in the area should more nearly parallel the projected growth of the city of Honolulu, the indications are that only about 20 per cent of the ultimate demand would be needed by 1990.

It is suggested that if Maui-type shafts are selected for development, they should be installed for full ultimate demand during the initial installation. On the other hand, it may be advisable to develop well fields incrementally. The necessary transmission mains, storage reservoirs and distribution systems may be so designed as to provide for ultimate development of 40 mgd by the use of line booster pumping stations at later dates and as required.

It is noted here that our computations are based on an average daily requirement of 20 mgd. Experience with water works design indicates that during any one year the maximum day's demand may well be 150 per cent of the annual average. Therefore, in order to meet peak-hour demand and certain emergencies such as fires, main breaks, and station breakdown, a minimum storage of 50 per cent of the average daily requirement, or 10 mgd, should be provided.

ECONOMIC COMPARISON OF BASIC DEVELOPMENT PLANS

As a basis for economic comparisons, four principal plans are suggested which embody the two major elements of source development and trunk-line distribution. All of the plans are patterned after the fundamental concept that the system be designed for a 20-mgd capacity, or one-half ultimate, with the understanding that the ultimate capacity of 40 mgd is to be realized through the use of line booster stations. The town of Waianae has been selected as the terminal point of the principal transmission system.

In evaluating the suggested plans listed in Table 3, the basic criterion of cost per million gallons of water developed was used. The quantities shown in Column 3 are assumptions only. Whether it would be possible to fully develop the amounts indicated remains problematical. At this moment it appears that a development in lower Kunia, while economically attractive, has least promise of success because of possible effects on existing installations in the general vicinity. In contrast, a development at Waikakalaua seems most desirable from a hydrologic-geologic standpoint. In any event, our recommendation is that none of the projects be initiated until the U. S. Geological Survey has completed its studies.

The plans shown in Table 3 cover major projects only. In the final analysis, it may be necessary to consider sources of lesser magnitude on an incremental contributory basis if output from the larger projects does not meet expectations. A filtered supply at Kalauao Springs and the tunnel and well supply at Waiau are examples of such secondary sources.

The following is a brief description of the various plans, the cost breakdown of which is shown in Table 3. No order of priority is given.

PLAN I—DEVELOPMENT OF PEARL HARBOR SPRINGS

This plan calls for the development of a minimum of 20 mgd of potable water at all of the major springs, as described earlier in this report, and the distribution of this supply through a major transmission main of 20-mgd capacity. The essential elements of this plan are shown on Plate 19. The shaded areas represent line boosters and reservoirs which should be installed some years after the initial development and as required.

The total estimated cost of this development, inclusive of a minimum number of necessary booster stations and reservoirs, is $8,000,000.

For an ultimate demand of 40 mgd, the anticipated potable water supply from Pearl Harbor Springs alone is inadequate. As shown on Plate 19 it is proposed to develop an additional 20 mgd by means of a well field at lower Kunia. This proposal also calls for the construction of additional booster stations and reservoirs. The total cost of this development which represents the combined exploitation of Pearl Harbor Springs and lower Kunia is estimated at $10,000,000.

PLAN II—DEVELOPMENT AT WAIKAKALAUA

The proposed Waikakalaua development, which could be of a Maui-shaft type or a group of deep wells, is shown on Plate 20. In either case the transmission system would be identical.

For an initial requirement of 20 mgd, no booster stations are required, although a few reservoirs would be necessary. The total estimated costs of the alternative developments are as follows:

Alternate (a), with a Maui-type shaft	$9,500,000
Alternate (b), with a well field	8,000,000

For an ultimate development of 40 mgd, a number of booster stations and reservoirs must be added. Provisions must also be made to increase the productive capacity of the shaft or wells, whatever the case may be. In such an event, the total estimated costs are as follows:

Alternate (a)	$10,700,000
Alternate (b)	9,700,000

PLAN III—LOWER KUNIA WELLS

As shown on Plate 21 this plan contemplates a well field development at lower Kunia with a distribution system large enough to carry 20 mgd without the aid of booster stations. The cost of this scheme, including a minimum number of reservoirs, is estimated at $7,000,000.

For an ultimate production of 40 mgd, it is proposed to connect the lower Kunia system to a well development at nearby Waikakalaua as shown on Plate 21. Since production at lower Kunia is not expected to exceed 20 mgd, the remaining 20 mgd must come from Waikakalaua. The added cost of the Waikakalaua development, connecting trunk main, reservoirs, and booster stations to make possible the transmission of 40 mgd is estimated at $3,000,000 bringing the total estimated cost of the ultimate development to $10,000,000.

PLAN IV—SCHOFIELD HIGH-LEVEL WATER

Two alternate schemes for the development of high-level water at Schofield are being suggested merely to show all possibilities regarding major water sources. Obviously, the high cost of these proposals would put them at a distinct disadvantage on any priority rating.

Alternate (a) is shown on Plate 22 and calls for the development of water from a field of scattered deep wells. Under this plan it would be necessary to pump water from an elevation of 275 feet to a transmission tunnel located at the 1,000-foot elevation. The tunnel itself would extend over 10,000 feet under Kolekole Pass. For a 20-mgd system, no booster stations would be required. The total cost of the development, inclusive of reservoirs, is estimated at $9,500,000. A 40-mgd system would necessitate additional wells, reservoirs, and booster stations, thereby bringing the total cost to about $11,600,000.

Alternate (b), as shown on Plate 23, is based on a method of development identical to that in Alternate (a). The only difference is that the transmission main is located along Kunia Road instead of through the Kolekole Pass tunnel. The estimated cost of a 20-mgd system is $10,500,000, while a 40-mgd system would cost a little less than $13,000,000.

A summary of the economic comparisons of the aforementioned plans is shown in Table 3.

COMPARISON OF ESTIMATED REVENUE WITH TOTAL COST

Comparison between estimated annual revenue and cost for each of the suggested plans in Table 3, with the exception of Plan IV (b), are shown on Plates 24-28 inclusive. Two sets of curves were plotted for each plan, each with identical operating costs but different fixed charges. The solid lines indicate operating and fixed costs under a condition of no subsidy while the broken lines show corresponding costs under a subsidy of 7 1/2 million dollars as provided by Acts 150 and 289 of the 29th Legislature. All capital charges in excess of 7 1/2 million dollars are assumed to be borne by the municipal water department through the sale of revenue bonds.

Estimates of operating expenses include the following:

1. Electric power based on current Hawaiian Electric Company rate schedules.

2. Transmission and distribution costs.

3. Customers' accounting and collecting expenses.

4. Administrative and general expenses.

Revenue estimates are based on the present Board of Water Supply rate schedule. In computing anticipated revenues an accelerated growth in population was assumed.

A study of Plates 24-28 will show that even with revenue at its maximum a utility furnishing water to the Ewa-Waianae districts must operate at a deficit for at least 10 years. Under an appropriation of 7 1/2 million dollars, deficit operation would still occur during the first 3 to 6 years. In general, it is our opinion that the funds set up under Acts 150 and 289 are necessary, particularly in view of the possibility that future population (or equivalent industrial expansion) of the Ewa-Waianae districts would not increase as rapidly as expected.

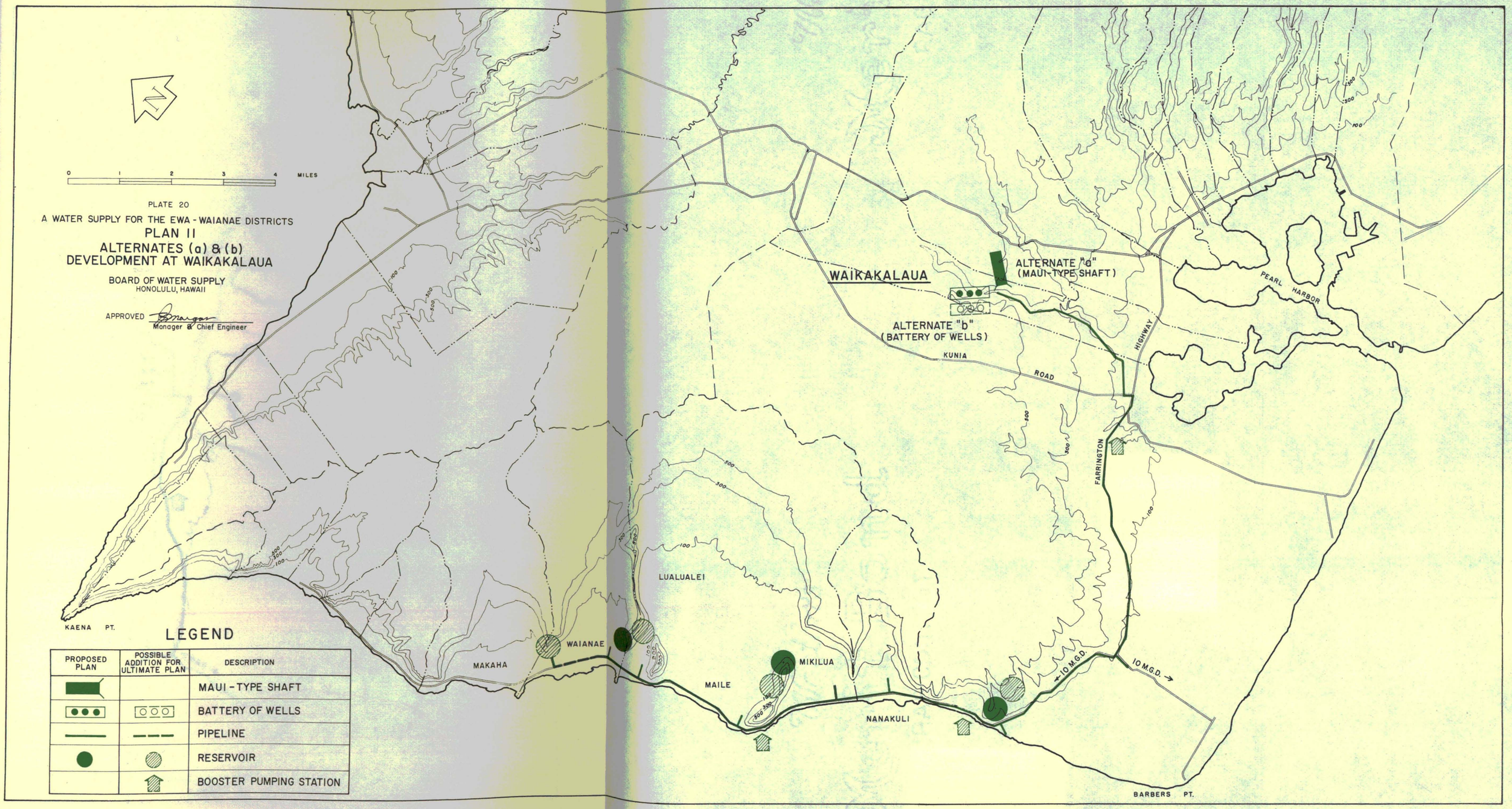
Table 3 ECONOMIC COMPARISONS

Plan	Source Description	Assumed Development (mgd)	Estimated Construction Costs: Development of Source	Estimated Construction Costs: Connecting Pipeline to Main Transmission	Estimated Construction Costs: Transmission and Storage	Estimated Construction Costs: Total Cost	Estimated Annual Cost**: Average Principal and Interest Charges*	Estimated Annual Cost**: Operating Expenses	Estimated Annual Cost**: Total Annual Cost	Cost per Million Gallons
I	Pearl Harbor Springs (Well-Field Development)	20	$ 710,000	$ 140,000	$ 7,185,000	$ 8,035,000	$485,000	$255,600	$740,600	$101
	Pearl Harbor Springs plus lower Kunia (Well Field)	40	1,210,000	480,000	8,365,000	10,055,000	-	-	-	-
II a	Waikakalaua (Maui-type Shaft)	20	2,000,000	1,450,000	6,035,000	9,485,000	572,000	200,200	772,200	106
	Waikakalaua (Maui-type Shaft, Greater Use)	40	2,000,000	1,450,000	7,215,000	10,665,000	-	-	-	-
II b	Waikakalaua (Well-Field Development)	20	500,000	1,450,000	6,035,000	7,985,000	482,000	225,900	707,900	97
	Waikakalaua (Well Field, Larger Capacity)	40	1,000,000	1,450,000	7,215,000	9,665,000	-	-	-	-
III	Lower Kunia (Well-Field Development)	20	500,000	340,000	6,035,000	6,875,000	415,000	187,500	602,500	83
	Lower Kunia plus Waikakalaua (Well Field)	40	1,000,000	1,590,000	7,215,000	9,805,000	-	-	-	-
IV a	Schofield Plateau (Wells), Kolekole Route	20	1,200,000	---	8,235,000	9,435,000	570,000	369,700	939,700	129
	Schofield Plateau (Wells), Kolekole Route	40	2,400,000	---	9,215,000	11,615,000	-	-	-	-
IV b	Schofield Plateau (Wells), Kunia Road Route	20	1,200,000	---	9,176,000	10,376,000	626,000	330,200	956,200	131
	Schofield Plateau (Wells), Kunia Road Route	40	2,400,000	---	10,356,000	12,756,000	-	-	-	-

* 30-year bond life, interest at 4 1/2 per cent.

** Annual costs for 40 mgd ultimate development are omitted because it is unlikely that the 40 mgd requirement will occur in the 30-year period set aside for the initial development of 20 mgd.


0 1 2 3 4 MILES
PLATE 19
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
PLAN I.
DEVELOPMENT OF
PEARL HARBOR SPRINGS
AND FUTURE CONNECTION
TO WELLS AT LOWER KUNIA
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
APPROVED
Manager & Chief Engineer
KALAUAO
WAIAU
WAIAWA
PEARL HARBOR
HIGHWAY
WAIKELE
LOWER
KUNIA WELLS
KUNIA
ROAD
FARRINGTON
LUALUALEI
WAIANAE
MAKAHA
MAILE
MIKILUA
NANAKULI
10 M.G.D.
10 M.G.D.
KAENA PT.
BARBERS PT.
LEGEND
PROPOSED PLAN
POSSIBLE ADDITION FOR ULTIMATE PLAN
DESCRIPTION
SPRINGS
BATTERY OF WELLS
PIPELINE
RESERVOIR
BOOSTER PUMPING STATION


0 1 2 3 4 MILES
PLATE 20
A WATER SUPPLY FOR THE EWA - WAIANAE DISTRICTS
PLAN II
ALTERNATES (a) & (b)
DEVELOPMENT AT WAIKAKALAUA
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
APPROVED
Manager & Chief Engineer
WAIKAKALAUA
ALTERNATE "a"
(MAUI-TYPE SHAFT)
ALTERNATE "b"
(BATTERY OF WELLS)
KUNIA ROAD
FARRINGTON HIGHWAY
PEARL HARBOR
LUALUALEI
WAIANAE
MAKAHA
MAILE
MIKILUA
NANAKULI
10 M.G.D.
10 M.G.D.
KAENA PT.
BARBERS PT.
LEGEND
PROPOSED PLAN
POSSIBLE ADDITION FOR ULTIMATE PLAN
DESCRIPTION
MAUI - TYPE SHAFT
BATTERY OF WELLS
PIPELINE
RESERVOIR
BOOSTER PUMPING STATION

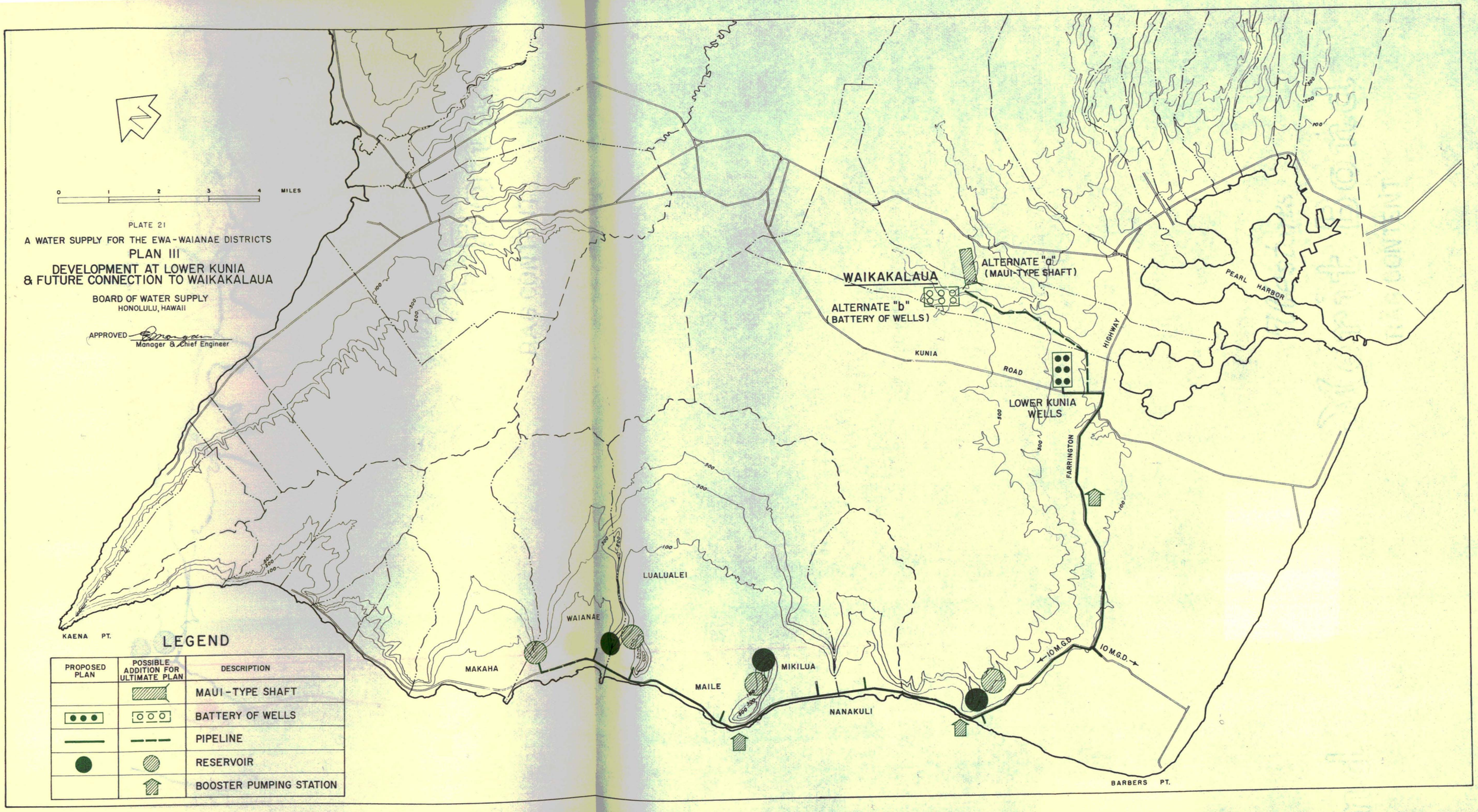

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PLATE 21
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
PLAN III
DEVELOPMENT AT LOWER KUNIA
& FUTURE CONNECTION TO WAIKAKALAUA
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
APPROVED
Manager & Chief Engineer
WAIKAKALAUA
ALTERNATE "a"
(MAUI-TYPE SHAFT)
ALTERNATE "b"
(BATTERY OF WELLS)
KUNIA
ROAD
HIGHWAY
FARRINGTON
LOWER KUNIA
WELLS
PEARL
HARBOR
LUALUALEI
WAIANAE
MAKAHA
MAILE
MIKILUA
NANAKULI
10 M.G.D.
10 M.G.D.
KAENA PT.
BARBERS PT.
LEGEND
PROPOSED PLAN
POSSIBLE ADDITION FOR ULTIMATE PLAN
DESCRIPTION
MAUI-TYPE SHAFT
BATTERY OF WELLS
PIPELINE
RESERVOIR
BOOSTER PUMPING STATION

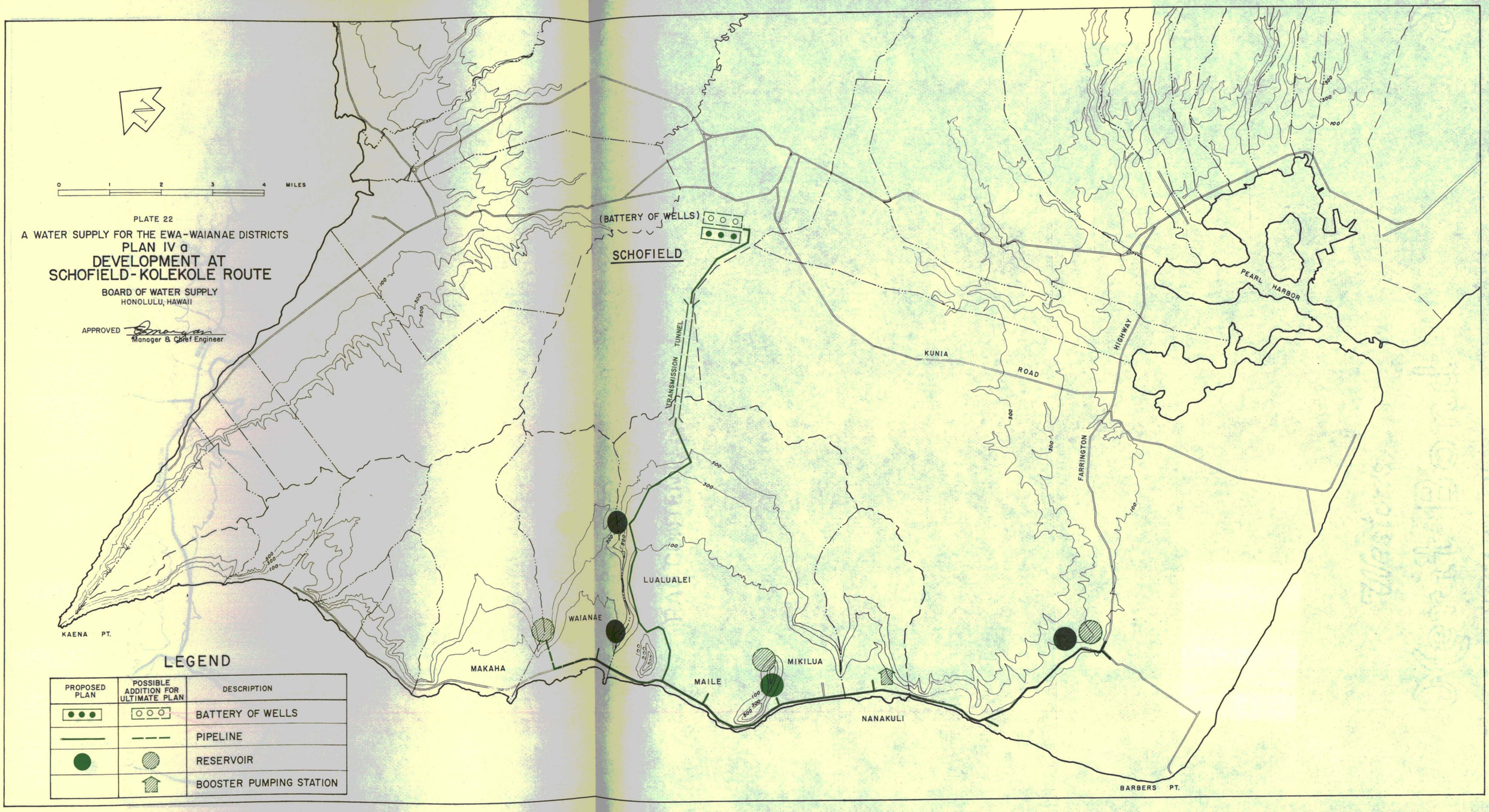
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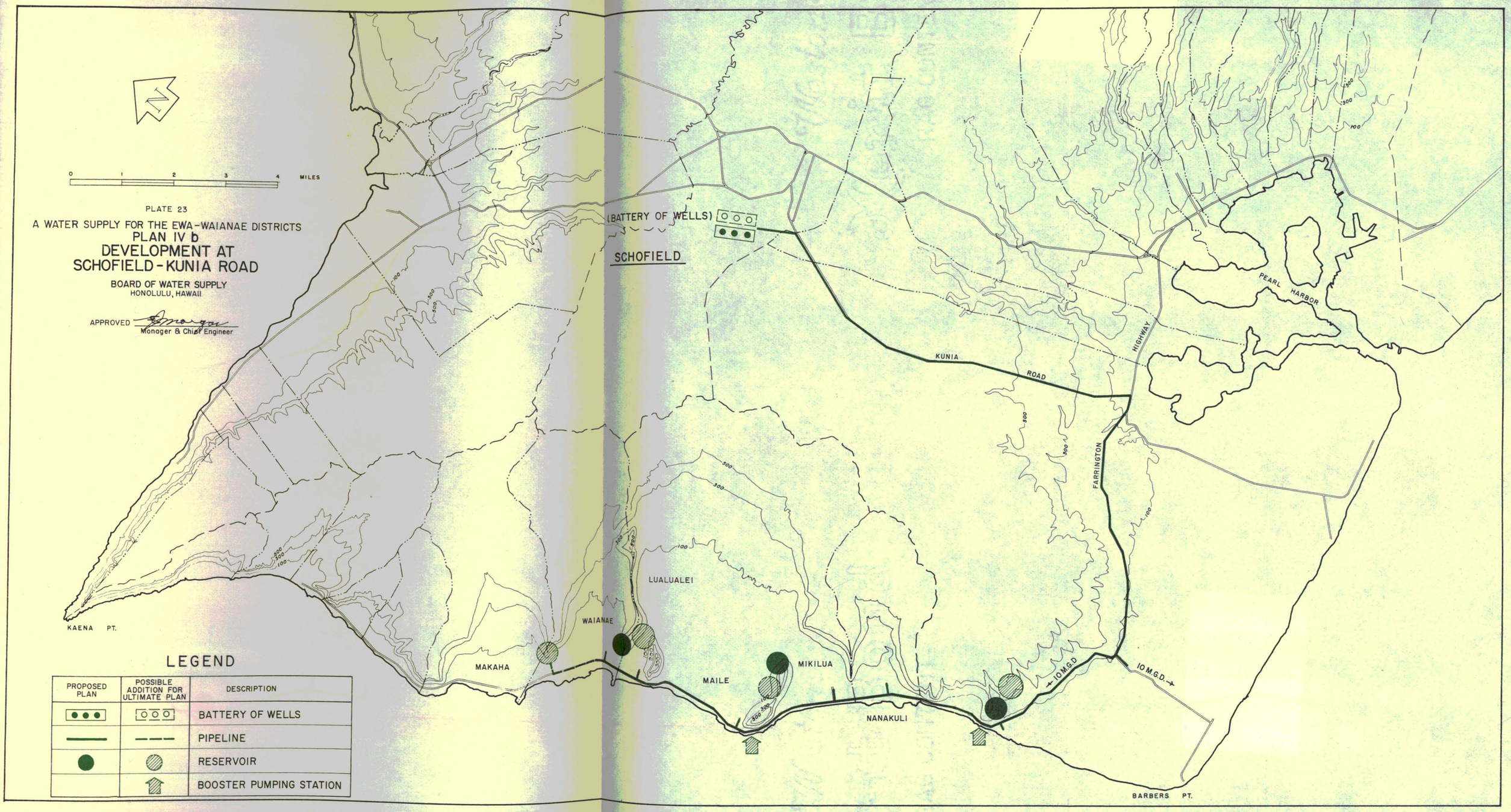
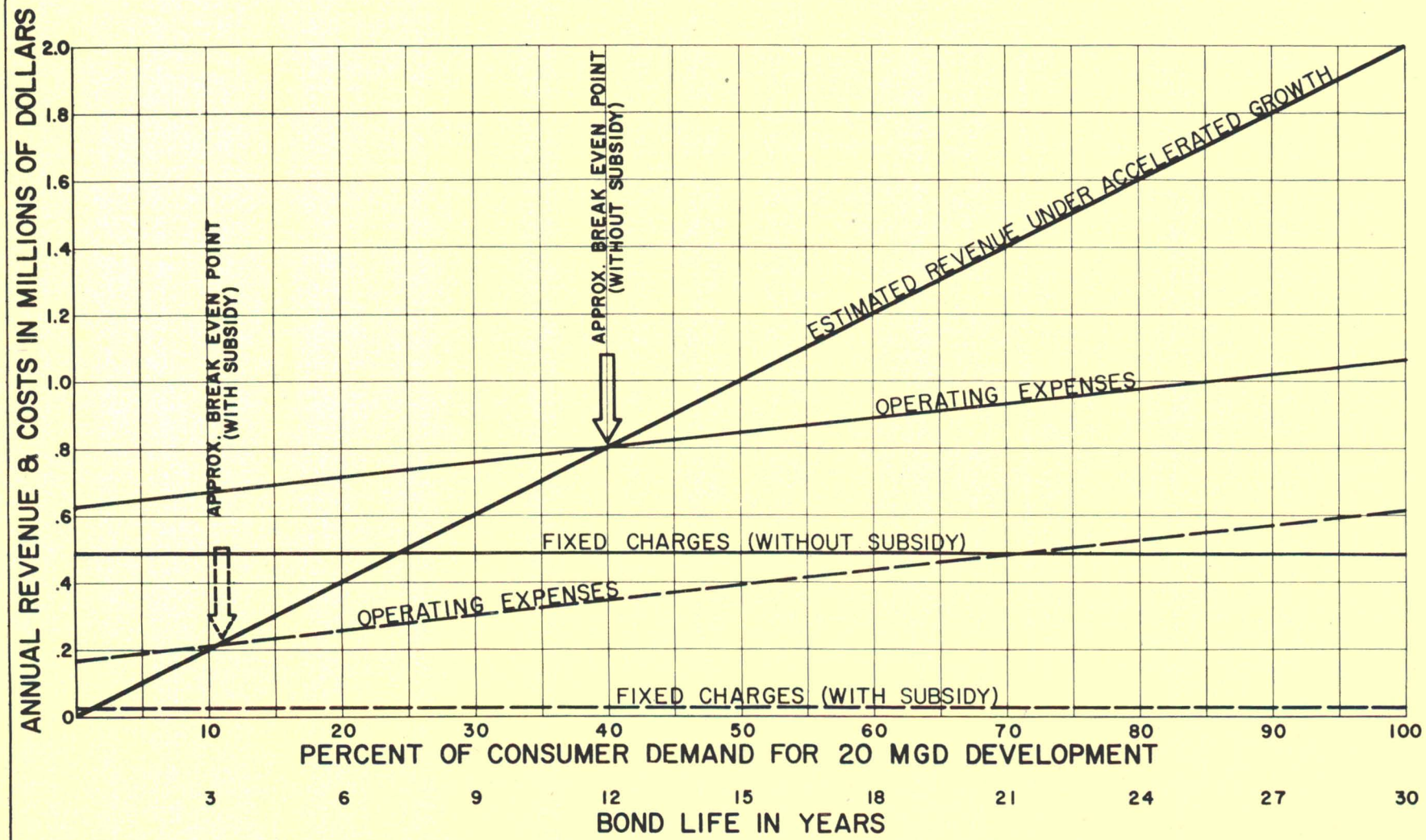
PLATE 22
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
PLAN IV a
DEVELOPMENT AT
SCHOFIELD-KOLEKOLE ROUTE
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
APPROVED
Manager & Chief Engineer
(BATTERY OF WELLS)
SCHOFIELD
TRANSMISSION TUNNEL
KUNIA ROAD
FARRINGTON HIGHWAY
PEARL HARBOR
LUALUALEI
WAIANAE
MAKAHA
MAILE
MIKILUA
NANAKULI
KAENA PT.
BARBERS PT.
LEGEND
PROPOSED PLAN
POSSIBLE ADDITION FOR ULTIMATE PLAN
DESCRIPTION
BATTERY OF WELLS
PIPELINE
RESERVOIR
BOOSTER PUMPING STATION


0 1 2 3 4 MILES
PLATE 23
A WATER SUPPLY FOR THE EWA-WAIANAE DISTRICTS
PLAN IV b
DEVELOPMENT AT
SCHOFIELD-KUNIA ROAD
BOARD OF WATER SUPPLY
HONOLULU, HAWAII
APPROVED
Manager & Chief Engineer
(BATTERY OF WELLS)
SCHOFIELD
KUNIA ROAD
HIGHWAY
FARRINGTON
PEARL HARBOR
KAENA PT.
LUALUALEI
WAIANAE
MAKAHA
MAILE
MIKILUA
NANAKULI
10 M.G.D.
10 M.G.D.
BARBERS PT.
LEGEND
PROPOSED PLAN
POSSIBLE ADDITION FOR ULTIMATE PLAN
DESCRIPTION
BATTERY OF WELLS
PIPELINE
RESERVOIR
BOOSTER PUMPING STATION

A WATER SUPPLY FOR EWA - WAIANAE DISTRICTS

COMPARISON OF ESTIMATED ANNUAL REVENUE & COST

PLAN I - PEARL HARBOR SPRINGS WELL FIELD DEVELOPMENT

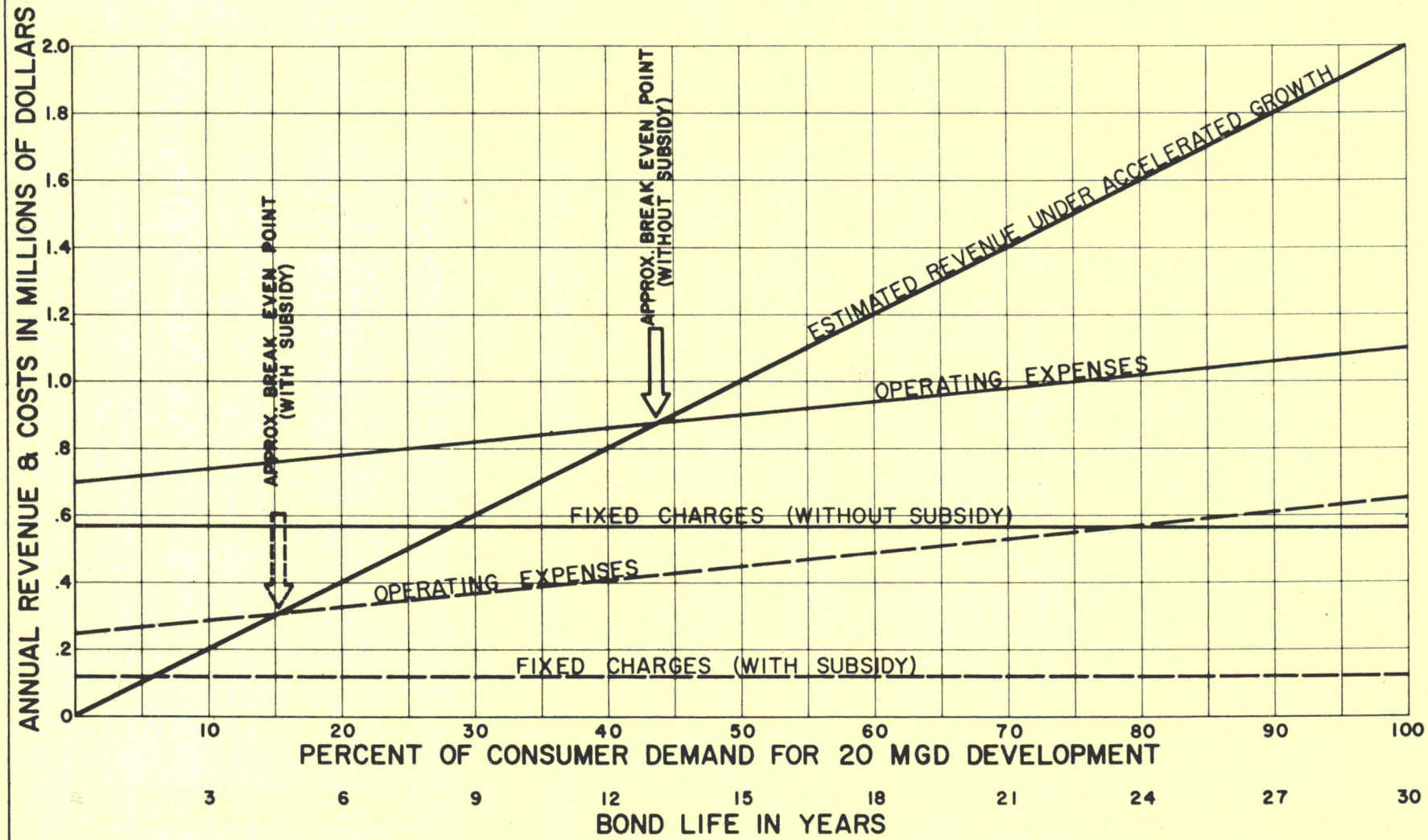


BOARD OF WATER SUPPLY
HONOLULU, HAWAII

A WATER SUPPLY FOR EWA - WAIANAE DISTRICTS

COMPARISON OF ESTIMATED ANNUAL REVENUE & COST

PLAN IIa — WAIKAKALAUA MAUI-TYPE SHAFT DEVELOPMENT

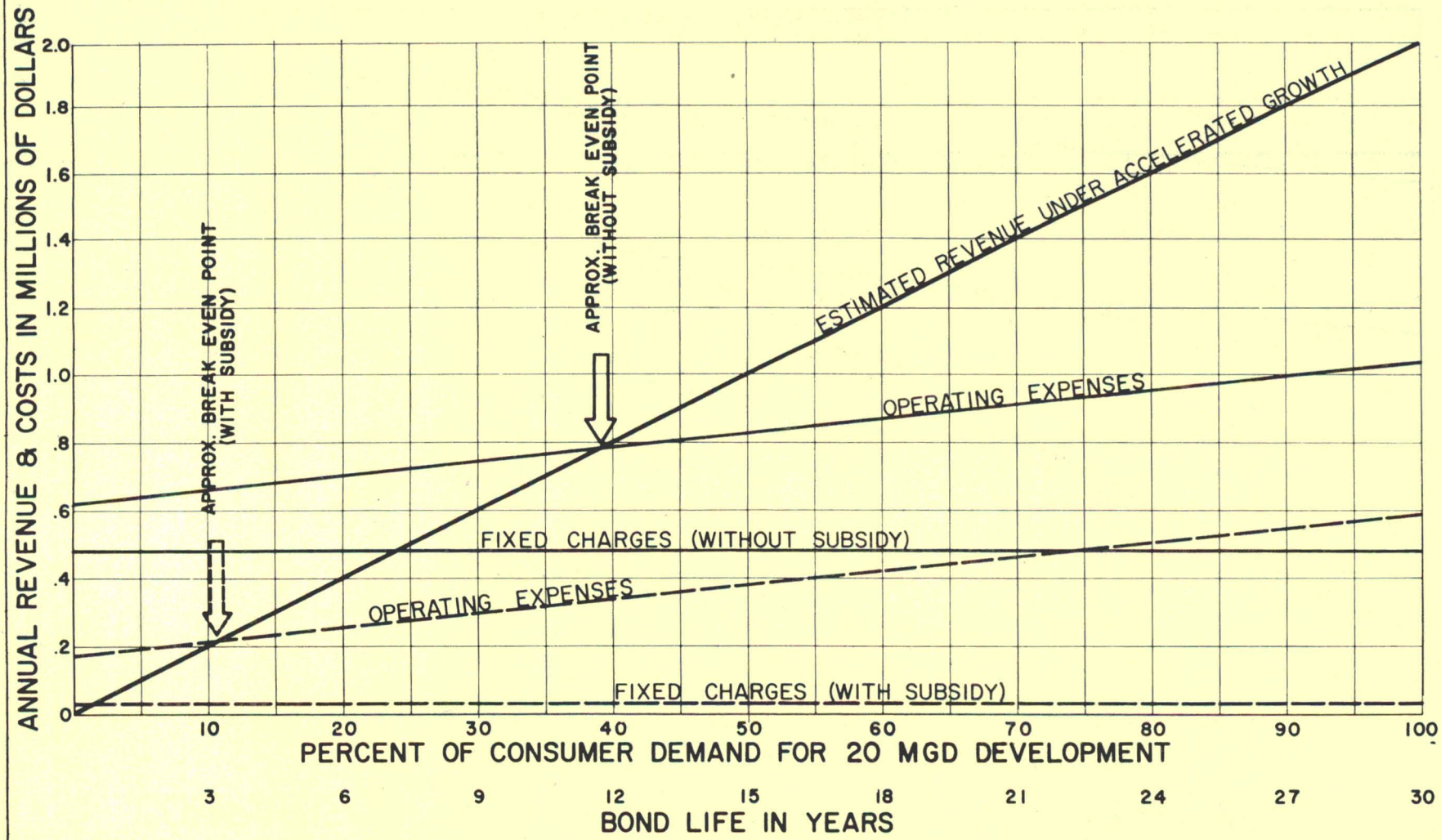


BOARD OF WATER SUPPLY
HONOLULU, HAWAII

A WATER SUPPLY FOR EWA-WAIANAE DISTRICTS

COMPARISON OF ESTIMATED ANNUAL REVENUE & COST

PLAN IIb — WAIKAKALAUA WELL FIELD DEVELOPMENT

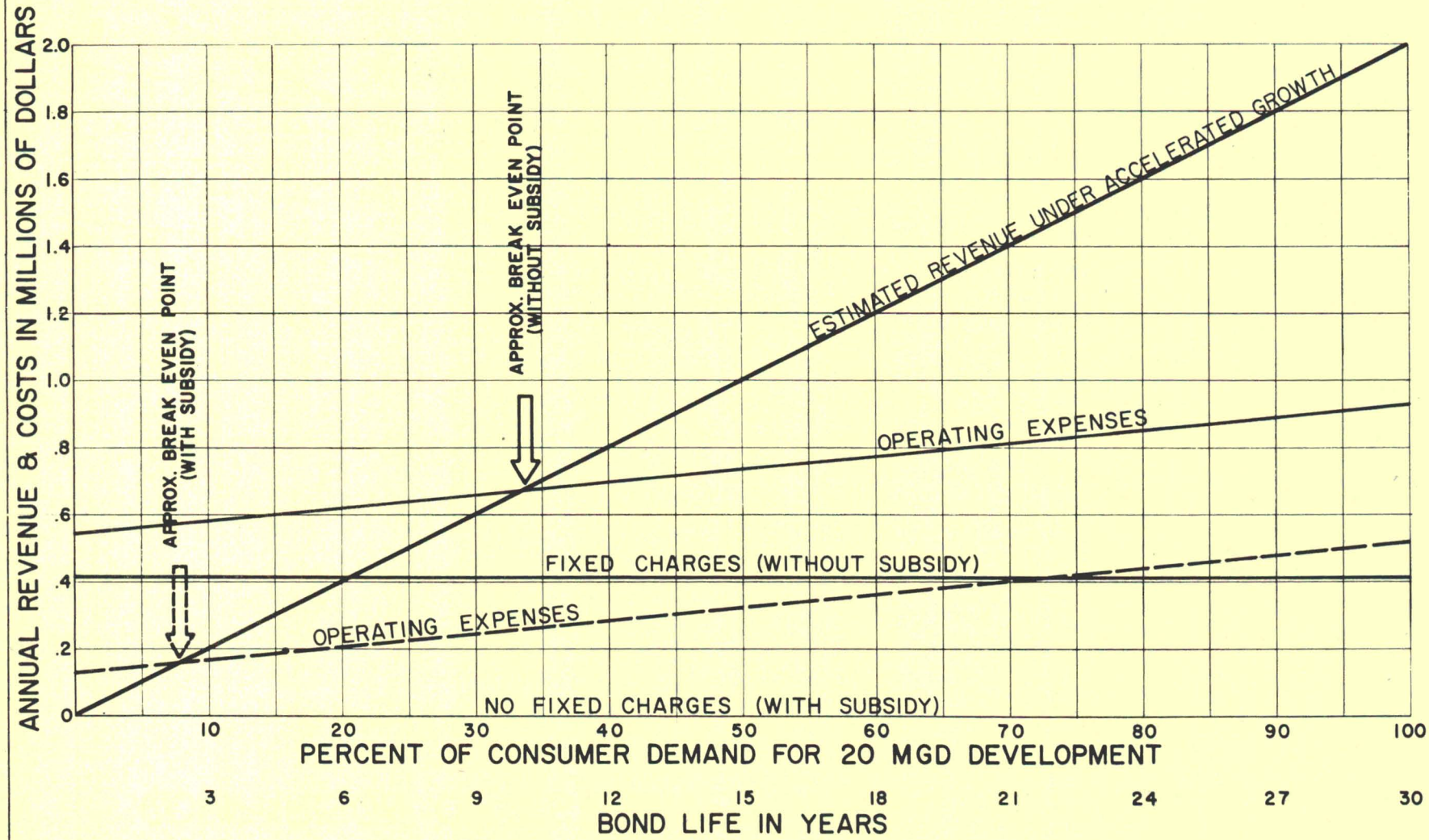


BOARD OF WATER SUPPLY
HONOLULU, HAWAII

A WATER SUPPLY FOR EWA-WAIANAE DISTRICTS

COMPARISON OF ESTIMATED ANNUAL REVENUE & COST

PLAN III – LOWER KUNIA WELL FIELD DEVELOPMENT

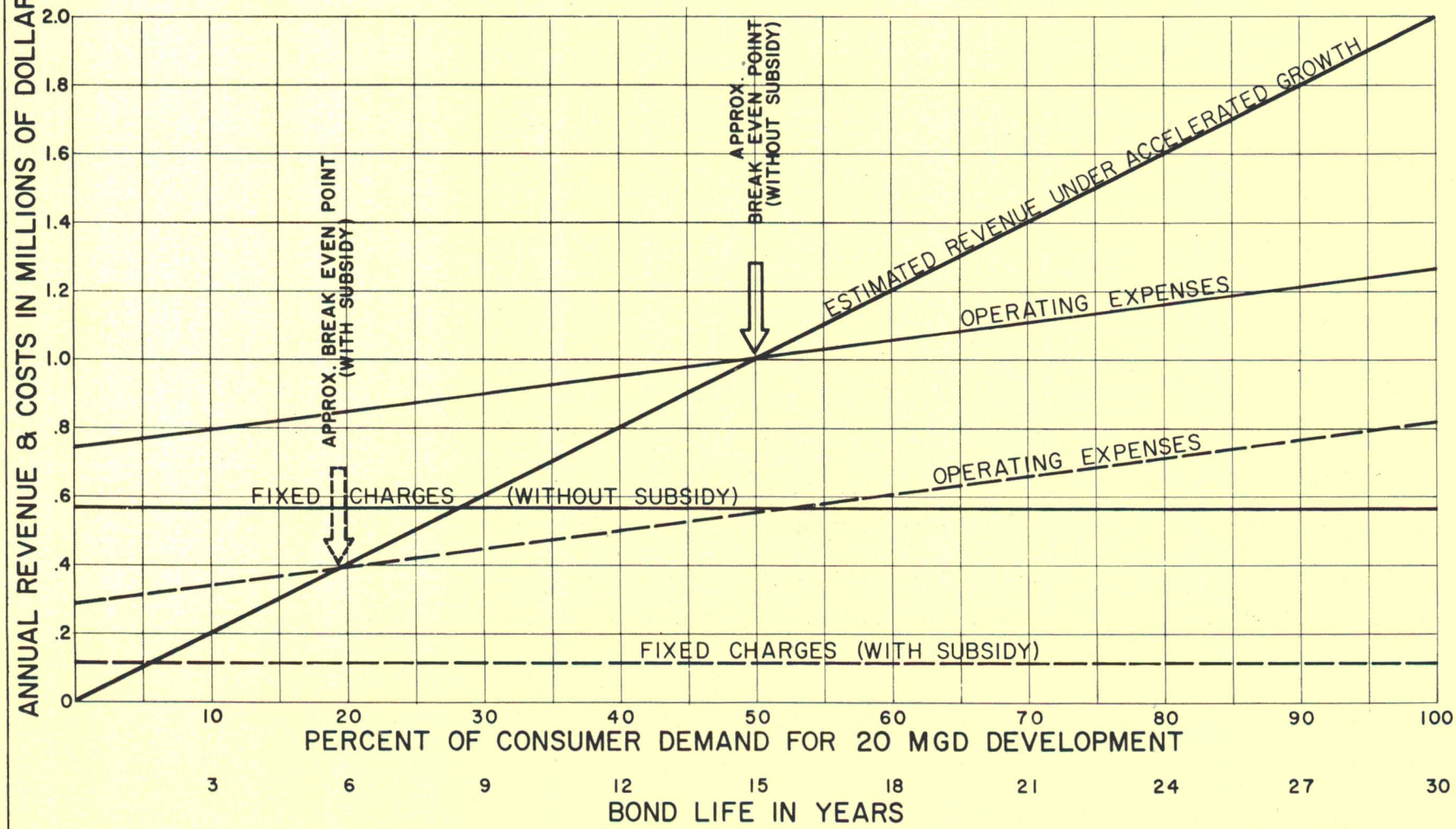


BOARD OF WATER SUPPLY
HONOLULU, HAWAII

A WATER SUPPLY FOR EWA - WAIANAE DISTRICTS

COMPARISON OF ESTIMATED ANNUAL REVENUE & COST

PLAN IVa — SCHOFIELD WELL FIELD DEVELOPMENT (KOLEKOLE ROUTE)



BOARD OF WATER SUPPLY
HONOLULU, HAWAII

METHODS OF FINANCING IMPROVEMENTS

The purpose of this section is to present some of the more important methods used in the financing of water system improvements. It should be pointed out that some of the methods listed are applicable only to smaller tracts while others can be applied to major projects of the Ewa-Waianae magnitude. Some of the methods may be combined depending upon the circumstances. For information purposes, all of the methods are listed with the recommendation that the responsible agency review carefully all pertinent facts before choosing the method considered most appropriate.

METHOD 1. ACREAGE CONTRIBUTION PLAN

This plan was used for the Waialae-Koko Head area. Here, the Board of Water Supply and landowners entered into a voluntary agreement whereby:

a. The Board of Water Supply loaned its credit by the issuance of revenue bonds and installed the water system.

b. The landowners contributed two cents per square foot for each lot, but only as the land was leased, rented or sold.

Comment: This plan will succeed only if the water department has a financial base large enough to float the revenue bond issues needed and to carry the repayment load if the development is slow. If the Waialae-Koko Head project is successful, the owners will end up by paying for approximately one-third of the total cost of the primary system.

Under this plan the water department pays for the major water distribution system only. In addition to the two cents per square foot contribution, the developer pays for all costs of water mains, boosters and reservoirs necessary for the tract proper.

METHOD 2. REVENUE BONDS

Since the creation of the Board of Water Supply in 1929, all major water development and distribution projects have been financed by bond issues. The

plan has been very successful.

Comment: Revenue bond issues are successful only in densely populated areas where income from the sale of water is assured and sufficient to retire the bonds.

METHOD 3. GENERAL OBLIGATION BONDS

General obligation bonds have been issued by the Territory and County governments for many projects. They are possible if the issuing agency has sufficient bonding capacity.

Comment: General obligation bonds are usually used where the benefits expected accrue to a large segment of the community. Some of these benefits include providing employment for an expanding population, broadening the economic and tax base, and attracting new industries.

METHOD 4. LOS ANGELES ACREAGE SUPPLY CHARGE

The following is from the rules and regulations of the Los Angeles Department of Water and Power:

"Rule No. 4

"On applications made for an extension of the water distributing system of the Bureau of Water Works and Supply, or for water service, in territory not heretofore served, where said territory will be served from the pumped system, or from the gravity system where additional expense at that time for main distribution lines, pumping plants, reservoirs, etc. is involved, the applicant shall be required, in addition to all other charges herein provided for, to pay a ratable charge which shall be based upon the total cost of the supply main, distributing line or trunk line serving the territory in which the property upon which each extension or water service desired is located; and it shall be the duty of the Chief Engineer and General Manager of the Bureau of Water Works and Supply to determine the ratio which said property bears to the total area to be served by the area of said supply and main distributing line or trunk line, and to fix the amount of said charge accordingly, hereinafter designated as the 'Acreage Supply Charge.' However, any populated area in the City of Los Angeles not now served by this Bureau may be served by the installation of mains, services, fire hydrants, pumping plants, tanks, or reservoirs without paying such Acreage Supply Charge provided funds of the Bureau are available and a survey shows that the income from the sale of water alone will be greater than 12 1/2% of the total investment in such installation and the operating charges of the same will be less

than 40% of the gross income from the sale of water alone."

Comment: In Los Angeles, the basic or major water system is installed by the department through the issuance of revenue bonds. It is our opinion that Rule No. 4 would work only if the new area to be developed is adjacent to or at a reasonable distance from an established system.

METHOD 5. THE GLENDALE CALIFORNIA PLAN

"When application is made for a water main extension the applicant, in addition to all other charges herein provided for, shall be required to pay a supply main charge. Such charge shall be based upon the cost of the supply main serving the territory in which the property for which the water main extension is applied for is located. The general manager and chief engineer shall determine the ratio which the property bears to the total area of the territory served or to be served by such supply main and the benefit which it will receive from such supply main and shall fix the amount of the charge accordingly."

Comment: This plan will work only if the area to be developed is at a reasonable distance from an established system.

METHOD 6. MARIN MUNICIPAL WATER DISTRICT PLAN

"Section 7. Prior to installation, the owner, subdivider or other person ordering the extension, shall advance to the District a sum of money equal to the estimated cost of such extension of facilities. The money advanced by the owner or subdivider to cover the cost of such extension of facilities will be refunded to him by the District at the rate of one-third of the revenue collected from all metered water services directly connected to the said extended facilities. The refund payments will be made yearly until the amount so paid by the owner or subdivider has been refunded without interest; provided, however, that no payment will be made from revenues derived after the expiration of five years from and after the completion of the actual installation of the pipelines and facilities, and in no event more than five years and three months after the date of the commencement of the work of installation of such pipelines and facilities."

Comment: This plan will work only if the area to be developed is reasonably close to a source of supply.

METHOD 7. SEVENTY PER CENT REFUND PLAN

The Board of Water Supply has a number of successful 70 per cent refund

projects whereby:

a. The developer installs the water system from the point of water availability to the tract and within the tract.

b. For the extension from the municipal water system to the tract, the water department makes a 70 per cent refund of all revenue received from the installation for a 10-year period, or as soon as the land developer has been refunded 100 per cent of his investment in the water system.

Comment: This plan is successful only if the tract is at a reasonable distance away from an established system.

METHOD 8. PLAN USED BY SOME PRIVATE MAINLAND INDUSTRIAL SITE DEVELOPERS

Mr. H. L. Perkins of the Central of Georgia Railway Company, Atlanta, Georgia:

> "We have purchased property at several points along our railroad and developed it into industrial districts. All of the districts have been located within or adjacent to a city that already had water systems. Some cities have extended their mains without cost to us. We have some industries who use a large amount of process water in their operations and they usually locate adjacent to or near a large stream. In some instances they obtain water from underground sources which is, generally speaking, plentiful in our area. The industry provides their own treatment facilities when there is a need for such."

Mr. A. C. Hopkins of the Delaware Lackawanna and Western Railroad Company, New York:

> "When we are looking for an extension of a water line to serve a particular proposed industry we look to the local community to extend the existing lines because they naturally want the new industry and also because they will be paid for the use of the water. Sometimes it is necessary to get the industry to contribute to the extension of a particular pipe line in order that they may have use thereof. Sometimes, of course, an industry, with permission from the state, will develop its own source of water along a stream or river."

Comment: Mainland industrial site developers usually locate along rivers where there is an ample supply of water. In these cases, the development cost is low and the private developer does not hesitate to pay for all costs.

METHOD 9. IMPROVEMENT DISTRICT

Under present laws, a developer may proceed under the improvement district statute as follows:

a. Section 153-8, R. L. H. 1955, as amended by Act 154, S. L. H. 1957. A project may be initiated either by the owners of 60 per cent of the area to be benefited or by the City and County with the approval of 60 per cent of the owners.

or

b. Section 153-9, R. L. H. 1955, as amended by Act 154, S. L. H. 1957. A project may be initiated by the owners of 100 per cent of the area to be improved. Owners must pay for 100 per cent of the cost.

Under this section, improvements cannot be approved by the Board of Supervisors if the cost of improvement exceeds 50 per cent of the market value of the land, plus the cost of the proposed improvements, unless a deposit is made to cover the excess cost of the improvement over the 50 per cent limitation.

METHOD 10. MOLOKAI IRRIGATION PROJECT

Funds for the development of the Molokai water project were made available by the Legislature as follows:

In 1943, Act 227 provided a $2,500,000 general obligation bond issue with the stipulation that all costs incidental thereto are to be reimbursed to the Territory from project receipts. In 1955, Act 273 provided a $2,500,000 general obligation bond issue without specific reference to reimbursement.

METHOD 11. PLAN OF THE 1957 LEGISLATURE

After numerous meetings, the members of the Legislature decided on a plan whereby available funds would be expended on each of the islands for "Major Permanent Improvements" instead of the numerous "pork barrel" requests of past sessions.

For the Ewa-Waianae area the Legislature authorized the following general obligation bond issues:

a. By Act 150, providing for Territorial improvements, a $4,500,000 issue was authorized for the "Planning and construction of water system to transport water from Pearl Harbor Basin to Waianae areas,

to be constructed by the City and County of Honolulu."

b. By Act 289, providing for City and County improvements, a $3,000,000 issue was authorized for the "Pearl Harbor Basin to Waianae Area Water System."

The intent of the Legislature with respect to feeder mains is recorded in Oahu Select Committee Report No. 523 and House County and Municipal Affairs Committee Report No. 939 which state that the cost of the "feeder lines" is to be borne by revenue bonds issued by the Suburban Water System or by the Board of Water Supply if the Suburban Water System should be integrated into the Board of Water Supply.

METHOD 12. THE CALIFORNIA WATER PLAN

This plan proposes the transportation of water from the northern areas of surplus to the southern areas of deficiency over great distances. The project will cost close to two billion dollars.

Because of the magnitude of the project, cost, rights involved and areas affected, the state of California looks upon this project as one it should solve.

Funds for the project are tentatively scheduled as follows:

Tideland Oil Fund	$150,000,000
Governor's Water Development Fund . .	250,000,000
General Fund	400,000,000
Remainder from sale of water and power generated	Needs study.

Some comments by Mr. Carl F. Wente, Chairman of Executive Committee, Bank of America, follow:

"Money must be borrowed and the amount is large. I doubt if straight revenue bonds in amounts large enough to provide the money could be sold. Those receiving the benefits should pay for them. Payment should be fixed at the point of delivery and price of water should be assessed according to cost of water and delivery point."

METHOD 13. COMBINATION PLAN

In extraordinarily large development projects and where the governmental agency feels that it has some responsibility due to benefits which might accrue to the community, a "combination plan" may be used. The California Water Plan may be considered a combination plan.

Generally, a combination plan embraces financial support from all interested parties.

CONCLUSION

The financing of a water project depends, among other things, upon the answers to the following questions:

a. How close is the area to be developed to a source of supply?

b. How large is the area and what will the water development cost be per square foot?

c. Will the revenue derived from the project be sufficient to retire the bonds?

Ewa and Waianae are areas of deficiency. Large quantities of water must be transported great distances. Furthermore, there are large intervening areas where water will not be used for many years because of topography.

Because of these circumstances, it may turn out that a "combination plan" of financing the improvements is the most practical.

PRINCIPAL SOURCE MATERIAL

1. Published and staff reports, Honolulu Board of Water Supply, 1929 to date.

2. Various reports and data from USGS, Oahu Sugar Company, Ewa Plantation Company, U. S. Navy, and Suburban Water System.

3. "The Geology of the Honolulu Artesian System" and "The Geology of the Honolulu Ground Water Supply," by Dr. H. S. Palmer, Professor of Geology, University of Hawaii, published by the Honolulu Sewer and Water Commission and the Honolulu Board of Water Supply in 1926 and 1946, respectively.

4. The Bulletins of the Hawaii Division of Hydrography (a joint enterprise of the USGS and the Territory of Hawaii) prepared under, and written principally by, District Geologists Dr. H. T. Stearns and Dr. G. A. Macdonald, and published 1935-1947.

5. Numerous papers and manuscripts by Dr. C. K. Wentworth, Geologist, Honolulu Board of Water Supply, 1934-1951, and Dr. Wentworth's "Geology and Ground Water Resources of the Honolulu-Pearl Harbor Area, Oahu, Hawaii" published 1951.

6. Report on "The Development of Honouliuli Lands," prepared for the Estate of James Campbell by Harland Bartholomew and Associates, December 1955.

7. Report of the Honolulu Sewer and Water Commission to the Territorial Legislature, January 1929.

8. Waianae Irrigation Project (Progress Report), Hawaii Irrigation Authority, April 1957.

9. "Water Supply and Waste-Water Disposal," by Gordon M. Fair and John C. Geyer, 1954, John Wiley and Sons, Inc.

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