HAWAII WATER PLAN

OAHU WATER MANAGEMENT PLAN

Prepared for:
Department of General Planning
City & County of Honolulu

By:
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Commission on Water Resource Management
Department of Land and Natural Resources
State of Hawaii

March 1990

JOHN WAIHEE
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CITY & COUNTY OF HONOLULU

DEPARTMENT OF GENERAL PLANNING

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Preface

In 1987, the State Legislature passed the State Water Code (HRS Chapter 174C) to protect and manage Hawaii's surface and ground water resources. Part III of the State Water Code calls for the formulation of a Hawaii Water Plan, an integrated program for the protection, conservation, and management of the waters of the State. The **Oahu Water Management Plan** is one of seven subplans which collectively comprise the Hawaii Water Plan.

The Oahu Water Management Plan, adopted by City and County ordinance and endorsed by the Mayor on July 25, 1990, will serve as a continuing long-range guide for water resource development in the City and County.

On August 22, 1990, the State Commission on Water Resource Management accepted the Oahu Water Management Plan for incorporation into the Hawaii Water Plan, with the following stipulations:

(1) The Oahu Water Management Plan (OWMP) will be reviewed and revised by the City and County and resubmitted to the Commission by July 1, 1991. The Commission would provide the City and County with supplemental assistance funds for this initial plan revision period. Thereafter, because the OWMP obtains its primary directions from the Hawaii Water Plan, periodic plan reviews and revisions, at the City and County's expense, will be timed to coincide with the review process of the Hawaii Water Plan.

(2) Amendments to the City and County's OWMP are to be adopted by ordinance and transmitted to the Commission within ten working days from their date of adoption for review, acceptance, and incorporation into the Hawaii Water Plan.

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EXECUTIVE SUMMARY

Oahu Water Management Plan
Technical Reference Document

1. Introduction

In 1987, the State Water Code was enacted by the Legislature to further fulfill the 1978 State Constitutional Amendment that,"the State has an obligation to protect, control and regulate the use of Hawaii's water resources for the benefit of its people." To implement the policies of the State Water Code, the State Commission on Water Resources Management was formed to administer its provisions and prepare a Hawaii Water Plan. The overall Hawaii Water Plan will integrate the accompanying county water use and development plans, and water resource protection, water quality, and water projects plans to better address statewide the problems involving water conservation and supply.

As specified by the State Water Code, a water use and development plan is to be adopted by ordinance and is intended to set forth the allocation of water to land use in each county. The water use and development plan for the City and County of Honolulu will be called the Oahu Water Management Plan. The Plan describes in detail the nature and extent of Oahu's present water supply, water usage, and water developments. Based on the inventory compiled, an assessment of future water demand is compared with the projected available supply to determine the extent of future need. Programs and allocations that can provide optimal use of water resources are then suggested and explored. The end product of this research and analysis is an ordinance which shall be integrated with the City's land and water use planning process.

2. Setting

Although comprising only 10 percent of the land area in the State of Hawaii, Oahu has approximately three-fourths of the State's population (838,500 in 1988). Due to its location on the fringe of the tropics and its steep backbone of rugged mountains, Oahu is able to intercept moisture-laden tradewinds and receives more than adequate rainfall to support this large population.

Oahu is comprised of the remnants of two elongated shield volcanoes, the Koolau and Waianae volcanic ranges, joined by a broad convex plateau. The former range averages about 2,500 feet in elevation, the latter about 3,000 feet. Extensive erosion has cut back the windward flank to form the "pali", an important factor in determining Oahu's water resources. Later lava flows created the flat floors of Nuuanu, Manoa, and Kalihi Valley, as well as such familiar landmarks as Diamond Head, Punchbowl, and Koko Head.

Hawaii's unique setting, climate, and geology all contribute to a hydrology which is extremely diversified. Basal water bodies which underlie Oahu's coastal plain exist because of the difference in density between fresh water and sea water. Basal water is the most significant source on Oahu, contributing to more than 90 percent of the water supply. Caprock water is created by leakage from the basal aquifer into permeable aquifers within the caprock which is a thick sequence of sediments forming a coastal plain. Dike water occurs in the mountains, impounded in volcanic conduits which typically cut across existing older lava flows. Perched water, a much more minor source also found in the Koolau's, sits on layers of impermeable material and can be developed by tunnels or collected around spring openings.

Brackish water abounds in the basal and caprock aquifers, where some mixing is inevitable despite differences in density. This is why careful extraction is necessary to insure water quality. The BWS prefers to distribute water containing less than 125 parts per million (ppm) of chloride ion, although 250 ppm is the upper limit.

The flow of perennial streams on Oahu occurs largely on the windward side. On the leeward side streams are more intermittent. No large quantities of surface water development are presently being considered from these streams since ground water development is presently more advantageous. The amount of stream flow reaching the sea is minimal because of the permeability of the volcanic rocks and residual soils which make up the island. Fortunately, then, most stream flow percolates to become ground water.

Population and Economic Analysis. Oahu's water needs are largely a function of its resident and visitor population and economic activities. The resident population on Oahu has increased approximately 26.0 percent from 1960 to 1970; 20.9 percent from 1970 to 1980; and 10.0 percent from 1980 to 1987. Population is expected to rise 23 percent by the year 2010, reaching approximately 999,500.

Tourism remains the island's leading economic force, with Waikiki the primary destination for most of Hawaii's millions of tourists. However, most new growth in tourism will take place outside of Waikiki, moving to the West Beach, Kahuku, and Makaha areas. By 2010, Oahu's visitor count is expected to be 113,400 daily. Oahu's construction industry continues to thrive, and is followed by defense spending as the second and third largest economic sectors in the City and County of Honolulu.

Approximately 32 percent of the City and County of Honolulu's 135,414 acres are in agricultural use. On Oahu, Hawaii's two primary agricultural exports are sugarcane and pineapple. The wavering profitability of sugarcane, however, means that future gains in agriculture are expected to be minimal. Only diversified agriculture has fared well with increases of 17 percent in 1988.

Land Use. Water use planning is intended to better coordinate Oahu's limited water resources with land use. On Oahu, the principal determinants of land use are State

Land Use Districts, and City and County of Honolulu General Plan, Development Plans, and Land Use Ordinances.

As a statement of Oahu's long-range social, economic, environmental, and design objectives, the City and County of Honolulu General Plan regulates the quantity and quality of future growth. Its objectives to the year 2010 direct the controlled development of secondary urban centers in Kapolei and the Ewa and Central Oahu areas. Development Plans prepared for the eight Development Plan areas contain detailed schemes for implementing General Plan objectives and guiding the sequence, pattern, and characteristics of future development. The City's Land Use Ordinance (LUO) regulates these land uses by providing development and design standards for the location, height, bulk and size of structures, yard areas, off-street parking facilities, and open spaces, as well as standards for the use of structures and land in agriculture, industry, business, residences or other purposes.

3. Existing Water Use and Development

Water Use on Oahu. In 1988, there was an estimated 408 million gallons per day (mgd) of water used on Oahu. Of this total, 92 percent was ground water and 8 percent was from surface water sources (for agricultural use). Oahu's major water users include sugar plantations (44 percent or 181 mgd), the Honolulu Board of Water Supply (37 percent or 150 mgd), the military (6 percent or 26 mgd), and miscellaneous private users whose wells pumped out 13 percent (51 mgd) of the total.

A classification system of aquifers on Oahu has been established by the State as a framework for ground water protection strategy. As part of the State's Water Resource Protection Plan, sustainable yields for ground water sources on Oahu have been estimated at 495 mgd. (Sustainable yield refers to the forced withdrawal rate of ground water that could be sustained indefinitely without affecting either the quality of the pumped water or the volume rate of pumping.) Of this total, approximately 339 mgd of ground water was withdrawn in 1988, leaving 156 mgd to accommodate future demands. In the Honolulu Sector, an equilibrium exists between natural recharge and current removals of ground water. In the Pearl Harbor Sector, Oahu's largest ground water supply, the present pumpage for domestic and irrigation demands is approaching sustainable limits and is strictly regulated by the State. Two areas with potentially developable sustainable yield include Windward Oahu and the North Shore. In developing these resources, the relationship between aquifers need to be considered as well as potential reductions in stream flow where ground water accounts for the base flow of streams.

The potential threat to certain ground water resources by proposed withdrawals has prompted the State Commission on Water Resource Management to designate three water management areas (Pearl Harbor, Honolulu, and Waialua) which cover the central corridor and southern portions of Oahu. The Sierra Club Legal Defense Fund

is requesting a similar designation for the Windward area as well, despite its existing surplus.

Municipal Systems- Board of Water Supply (BWS). To provide Oahu's municipal water supply, the BWS maintains 57 well stations with 145 individual wells, 5 major shafts, 22 tunnels, 3 springs, and 1 stream. Stream and spring sources provided only one percent of supply while 99 percent came from ground water sources. The major challenges facing the BWS is keeping pumpages within authorized levels while still accommodating urban growth. They also must monitor domestic water quality at all water source sites.

The other important goal of the BWS is the installation and operation of an integrated islandwide water system. As growth occurs in the Ewa Plain, water exports that will accommodate new development must be coordinated with additional and existing sources. The BWS already has a system of interconnections which facilitate inter-district water transfer. Water drawn from wells and shafts is directed by connecting laterals into transmission pipelines, then channeled into smaller distribution pipes which deliver water throughout the community. Much of the new water transfer is expected to come from the Windward district.

Agricultural Systems. Sugar plantations are the largest water users on Oahu, withdrawing about one-third of all Oahu ground water in 1988. Another 33 mgd more of surface water also supplies Waialua Sugar Company. Water use has actually declined with the advent of drip irrigation which applies water to a smaller area at the root of the cane. The same technique is used on pineapple, which is traditionally cultivated under semi-arid conditions and uses only 7 mgd for about half as many acres.

Diversified agriculture, centered primarily on the Windward and Waianae coasts, produces most of Hawaii's eggs and milk, a variety of vegetables, as well as livestock, flowers and nursery products. Surface water at farms on the Windward side comprises about 70 percent of the total water used. Waianae is much drier and obtains most of its water from the municipal supply. Watercress production in the Pearl Harbor Wetlands is an exceptional location where naturally occurring spring water and sunlight are abundant and feed 23 acres with 50,000 gallons of water per day per acre.

The State promotes diversified agriculture by establishing agricultural parks on State land. Waimanalo Agricultural Park began operating in 1987 and three more are planned in Waianae, Kahuku, and Waiahole. Water usage for these areas will be approximately 2 mgd.

Of the State's 437 acres in aquaculture, 374 acres are on Oahu. While some types of aquaculture use brackish or seawater, growing fresh-water prawns take 14,000 gallons per day per acre. In the long-term, many acres of sugarcane land may be converted to aquaculture if its success continues to grow.

Military Systems. With the exception of Kaneohe Marine Corps Air Station, all the major military installations use their own wells or purchase water from other military sources. Water usage in 1988 by the military totalled 25.5 mgd. With its large Navy presence, the Pearl Harbor Water Management Area accounted for 95 percent of this amount.

Private, Domestic, Commercial, and Industrial Systems. Self-supplied water use in 1985 amounted to 10.03 mgd for industrial uses, 34.42 mgd for thermoelectric cooling, and 28.54 mgd for commercial uses. Industrial water needs could expand as demands increase for electric power generation, although attempts should be made to recycle this water, as is done by sugar mills with wash water. The major independent Laie water system supplies all agricultural and domestic use for the area, approximately 4 mgd total.

4. Future Water Needs and Development

Municipal. Future municipal water demand (water that is provided by the Board of Water Supply) has been forecast based on existing per capita consumption by Development Plan Area and the population projections calculated by the State. Municipal water demand on Oahu is anticipated to increase from the current 149.9 mgd to 198.7 mgd by 2010, with a potential demand of 208.3 mgd if the upper limit of the General Plan population range is attained. This amounts to a 33 to 39 percent increase, higher than the 19.2 percent increase in population, but attributable to the scheduled development of the drier Ewa region. Though Ewa is expected to house three times as many people by 2010, its water demands will increase nearly five-fold.

Agricultural. Because of sugar's uncertain future due to rising production costs and increased competition, sugar companies are actively experimenting with replacement crops such as macadamia nuts, coffee, tea, cocoa, and citrus. As acreage in sugar decreases, there could be a gradual relocation of diversified agriculture to Oahu to avoid inter-island shipping costs. Sugar companies are also being pressured by developers as the need for urbanization and housing increases. For all of these reasons, sugar export value is expected to decrease by 26 percent between 1990 and 2010, and this decrease will result in a reduced demand for water since sugar is such a major water consumer.

On the other hand, the pineapple industry is relatively stable, boosted by growth in the fresh fruit market. Diversified agriculture acreage is expected to grow from 4,280 acres in 1983 to 7,070 acres in 1995. Crops cultivated will include flowers/nursery, guava, papaya, bananas, feed/forage, taro, and vegetables/melons. The accompanying water demands will rise from 25.5 mgd to 43.4 mgd.

Military. Any increases in military demand will principally be a function of how many new housing units are planned and under construction at bases on Oahu. Assuming a decision is made within the next year to station the Missouri battleship group at Pearl Harbor, 1,200 additional housing units will be needed.

Private Systems. No major expansions of private systems are expected except for the Zion system in Laie which will be increasing its water supply by about one mgd to accommodate new residential and commercial developments. Major Ewa developments will require about 31 mgd of potable and non-potable supply.

Proposed Water Developments. BWS capital improvements between 1990 and 1995 include proposed source developments of 16 wells and springs, 7 reservoirs and 19 interconnecting and supplemental transmission mains. If the proposed development projects proceed as scheduled and the estimated sustainable yields are achieved, these sources would add 19.05 mgd capacity to the BWS system. Many additional well sites have been proposed in the Windward area but may not materialize because of environmental factors.

Regarding agriculture, military, and private systems, plans only call for additional private source development in Ewa. Most of these new facilities will be dedicated to the BWS for ongoing maintenance.

Alternative Strategies for Meeting Future Demand. Wherever possible, the use of non-potable instead of potable water for agricultural and industrial purposes is encouraged to extend freshwater supplies. Sometimes brackish water that is not quite drinkable can be blended with low salinity water to create a potable supply under 200 ppm (chloride level). There are five brackish water sites in the Pearl Harbor area which could possibly be implemented in these ways and therefore deserve consideration as alternative sources.

A recent test project in Ewa supports the potential benefits of wastewater effluent re-use which could replenish non-potable water and lower its salinity in the aquifer while producing usable biomass. Wastewater percolated through basalt rock nearly achieves potable quality and only needs monitoring to prevent contamination of the soil.

Desalting is a technology which can transform brackish water into potable quality water. A test plant soon to be completed in Ewa will produce 1 mgd of fresh water through reverse osmosis or electrodialysis at reasonable cost.

The BWS monitors water usage carefully, metering all water services to determine discrepancies in the system. Of far greater difficulty and importance is influencing per capita consumption to offset population increases. The BWS can accomplish this through public information campaigns, modified water rate structures, and/or amendments to the plumbing code which would require installation of water saving devices.

5. Plan Implementation

Summary of Future Oahu Water Demand. Future water demand on Oahu is primarily dependent on the two major water users--the Board of Water Supply which provides municipal supply, and the two sugar plantations. External market forces as well as urbanization threaten the viability of sugarcane on Oahu. The State projects a 26 percent or 1.5 percent annual decline over the next twenty years, potentially releasing 43 mgd for other uses. The closure of one or both of the plantations would release substantial quantities of water adequate to meet Oahu's future needs.

Municipal water demand is driven primarily by population increases and associated land use allowances for increased residential and other urban activities. The overall impact on water resources, however, may not be significant if such increased use is offset by a reduced demand for agricultural water use. Projected declines in sugar acreage would free up water for urban uses, and lessen the need to develop new water sources.

Adequacy of Future Supply. Oahu should have an adequate supply of water to meet islandwide needs at least until the year 2010. Overall, increases in municipal demand are expected to be largely offset by reductions in plantation water requirements. Based on the State projections for declines in the sugar industry, an estimated 31 to 40 mgd of additional water will be required by the year 2010.

	1988 Use (mgd)	Percent	2010 GP Limit (mgd)	Percent
Board of Water Supply	150	37%	208	46%
Sugarcane Plantations	181	44%	138	31%
Military	26	6%	29	7%
Private Use and Industrial	51	13%	73*	16%
	408	100%	448	100%

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*includes sugar replacement crops

As provided by the State Water Resource Protection Plan, the total sustainable yield of ground water which can be developed without affecting the aquifers is estimated at 495 mgd. Present ground water withdrawals total 339 mgd, which should leave a remaining supply of approximately 156 mgd which theoretically could be safely developed.

For surface water supply, much less is known about available use and consumption, especially in Windward Oahu where stream diversions are commonplace for diversified agriculture. Present and potential usage will need to be determined.

Water Allocation Plan. Future municipal water needs by Development Plan area and the additional amounts of water needed in each area to satisfy the upper limits of the General Plan population range by 2010 are presented in the table below. The DP

areas requiring the greatest amounts of water by the year 2010 are Ewa, the Primary Urban Center, and Central Oahu. However, the Pearl Harbor Water Management Area which provides potable water to the Ewa area is rapidly approaching its maximum sustainable yield. The Primary Urban Center is also far from self-sufficient.

Development Plan Area	1988 Use	2010 Demand (GP Limit)	Additional Water Needs
Primary Urban Center	83.7	96.8	13.1
Ewa	9.4	42.4	33.0
Central Oahu	15.1	20.7	5.6
East Honolulu	9.0	10.9	1.9
Koolaupoko	17.6	18.1	0.5
Koolauloa	1.8	2.5	0.7
North Shore	3.6	5.4	1.8
Waianae	9.6	11.5	1.9
Totals:	149.9	208.3	58.5

In the Ewa and Central Oahu DP areas, the allocation of water to meet the projected municipal demand of 33.0 and 5.6 mgd, respectively, should first be accommodated with the transfer of water allocations from lands withdrawn from sugar. Assuming that 5,000 sugarcane acres are withdrawn from cultivation, 35 mgd should be released and available to support urban and residential development. Upon successful demonstration of the State's desalting plant, expansion of the plant to its 10 mgd capacity would provide additional potable supply to meet the urban demands in the Ewa area.

To satisfy the future additional water demands in other areas, it may be necessary to rely on the development of new water sources in other areas of substantial undeveloped ground water supply. Such areas include the North Shore and Wahiawa aquifers and the Windward region which has a potential yield of about 43 mgd. The BWS has developed over the years an extensive water distribution network. This system could take advantage of the exploration and development of these sources to provide the necessary additional supply for the Primary Urban Center and other areas over the next twenty years.

In addition to allocations based on population and land use policies, consideration is warranted for major public projects which can also require substantial amounts of water. The identification of significant projects to be undertaken by the City and County of Honolulu and their water requirements will help to provide indications of where future water demands are most significant and the potential critical areas requiring more detailed evaluation and increased water supplies.

A substantial number of City-sponsored affordable housing projects are planned within the next decade which could result in approximately 18,200 new residential units and a potable and non-potable water demand of 10.4 mgd. Since two-thirds of these units

planned in Ewa would replace sugarcane lands, the associated water allocations should be transferred to the municipal supply.

Proposed parks and other public golf courses planned throughout the island to address recreational demand and help provide drainage, buffers, and open space to residential areas are anticipated to require about 8.3 mgd. Whenever feasible, the use of non-potable water for irrigation will be pursued. Other major City projects which require some quantities of water include wastewater treatment plants and the H-POWER resource recovery plant.

ORDINANCE NO. 90-62 BILL NO. 47 CD-1 (1990)

A BILL FOR AN ORDINANCE TO ADD A CHAPTER TO THE REVISED ORDINANCES OF HONOLULU 1978, AS AMENDED, ESTABLISHING THE OAHU WATER MANAGEMENT PLAN.

BE IT ORDAINED by the People of the City and County of Honolulu:

SECTION 1. The Revised Ordinances of Honolulu 1978, as amended, is hereby further amended by adding a new chapter to be appropriately designated by the Corporation Counsel and to read as follows:

"CHAPTER __

WATER MANAGEMENT

ARTICLE 1. GENERAL PROVISIONS

Sec. __-1.1. Purpose.

The State Water Code (Chapter 174C, Hawaii Revised Statutes) mandates the preparation and adoption of a water use and development plan by each county as part of the Hawaii Water Plan. In adopting the plan, the City and County of Honolulu recognizes that water is a limited resource, the development and use of which must be carefully planned.

The water use and development plan for the City and County of Honolulu, which is called the Oahu Water Management Plan (OWMP), is intended to fulfill the requirements set forth by the State Water Code.

The OWMP consists of policies and strategies which guide the activities of the City and County of Honolulu and advises the State Commission on Water Resource Management in the areas of planning, management, water development and use and allocation of Oahu's limited water resources.

Sec. __-1.2. Definitions.

Whenever used in this chapter unless the context otherwise requires:

"Board" means the Board of Water Supply of the City and County of Honolulu.

"City" means the City and County of Honolulu.

"Commission" means the Commission on Water Resource Management.

"Department" means the Department of General Planning of the City and County of Honolulu.

"Development Plans" mean the Development Plans of the City and County of Honolulu as defined by Section 5-409 of the Charter.

"Domestic Use" means any use of water for individual personal needs and for household purposes such as drinking, bathing, heating, cooking, noncommercial gardening and sanitation.

"General Plan" means the General Plan of the City and County of Honolulu as defined by Section 5-408 of the Charter.

"Groundwater" means any water found beneath the surface of the earth, whether or not in perched, dike-confined, or basal supply; in underground channels or streams; in standing, percolating, or flowing condition; or under artesian pressure.

"Hawaii Water Plan" means the integrated program of the Commission for the protection, conservation, and management of the waters of the state, with such amendments, supplements, and additions as may be necessary, mandated by the State Water Code.

"Municipal Use" means the domestic, industrial and commercial use of water through public services available to persons of a county for the promotion and protection of their health, comfort and safety, for the protection of property from fire, and for domestic use.

"Oahu Water Management Plan" (The Plan) means the water use and development plan mandated by the State Water Code.

"Oahu Water Plan" means the Board's municipal water use plan for Oahu.

"State Water Code" means Chapter 174C, Hawaii Revised Statutes.

Sec. __-1.3. Consistency requirements.

This water use and development plan shall be consistent with (1) the water resource protection and water quality plans of the

Hawaii Water Plan; (2) City land use plans and policies including the General Plan, Development Plans and zoning; and (3) state land use classification and policies.

Sec. __-1.4. Preparation.

The Department shall be responsible for the preparation of the Oahu Water Management Plan.

Sec. __-1.5. Supporting document.

The Technical Reference Document of the Oahu Water Management Plan contains the supporting data, analyses and conclusions which are the bases for the Oahu Water Management Plan.

Sec. __-1.6. Revisions.

The Department, working in conjunction with the Board, shall be responsible for reviewing and making necessary revisions to the bases and conclusions of the Technical Reference Document of the Oahu Water Management Plan. The Department shall complete such a review and make the necessary revisions within one year after the effective date of this section, and thereafter, the Department shall review and make necessary revisions to the Technical Reference Document every two years. Major revisions to the Technical Reference Document during the annual review which affects the policies and strategies of the Oahu Water Management Plan shall be approved by the City Council.

ARTICLE 2. OAHU WATER MANAGEMENT PLAN

Sec. __-2.1. Intent.

The Oahu Water Management Plan is intended to insure:

(1) The optimum utilization of the existing water supply in order to minimize the need for the development of additional potable groundwater sources.

(2) The preservation of the aquifers for the benefit of future generations, in perpetuity, by proper management of Oahu's groundwater sources.

(3) The timely development of additional potable groundwater sources and alternative sources to provide for additional consumer demand.

(4) That growth in consumer demand will be compatible with available water supply.

Sec. __-2.2. Water management policies.

This section sets forth the policies for water use and development within each development plan area. These are established in recognition of the vital role of water in supporting land use activities on the island of Oahu. Potable groundwater is the premium water resource on Oahu because over the long-term it is the most economical to develop and requires no treatment, but this resource is finite in nature and the limit of feasibly developed potable water sources is rapidly being approached.

These policies shall apply to all City agencies in the performance of their powers, duties and functions as related to both public and private development.

In addition, all City actions in regard to the use and commitment of water resources to meet existing or projected demands on the public water system on the Island of Oahu shall be guided by the Board of Water Supply's Oahu Water Plan.

Policy 1

Facilities for the provision of water shall be based on the General Plan population projections and the land use policies contained in the Development Plans and depicted on the Development Plan Land Use Maps.

Policy 2

System flexibility shall be maintained to facilitate the provision of an adequate supply of water consistent with planned land uses. The municipal water system shall be developed and operated substantially as an integrated islandwide water system.

Policy 3

Close coordination shall be maintained between federal, State and County agencies which are involved in the provision or management of water to ensure optimal distribution of the available water supply.

Policy 4

The quality and integrity of the water supply shall be maintained by providing for the monitoring and protection of the water supply in accordance with the requirements of the State Water Code.

Policy 5

The development and use of non-potable water sources shall be maximized in a manner consistent with the protection of groundwater quality.

Policy 6

Water conservation shall be strongly encouraged.

Policy 7

Alternative water sources shall be developed wherever feasible to ensure an adequate supply of water for planned uses on Oahu.

Sec. __-2.3. Water management strategies.

Based on the findings and projections in the Technical Reference Document of the Oahu Water Management Plan, Oahu should have an adequate supply of water to meet islandwide needs at least until the year 2010. This has been determined after evaluating the anticipated demand for water use from municipal, agricultural, military, and private users; the available remaining groundwater which can be safely developed; the planned and proposed water-source development projects; and alternative water development projects now underway.

Based on these findings, the plan or strategy for water management shall be to continue to develop available groundwater sources but to preserve as much of the groundwater supply as possible, through the more efficient use of the existing water supply, an ongoing water conservation program and by the continued development of alternative sources of water.

The following strategies shall be applied in the development and use of water resources on Oahu:

Strategy 1

Develop water resources in consonance with the General Plan population projections and the land use policies contained in the Development Plans and depicted on the Development Plan Land Use Maps. Priority shall be given to affordable housing projects shown on the Development Plan Land Use Maps or processed under Chapter 201E, Hawaii Revised Statutes.

Strategy 2

Continue to safely develop the remaining available groundwater in accordance with the requirements of the State Water Code.

Sub-Strategy A

The Commission should continue to refine the accuracy of the sustainable yields in the Water Resources Protection Plan at the aquifer level to better guide decisions regarding future exploration and development of water sources.

Sub-Strategy B

The Commission in consultation with the Board should formulate a plan for the future exploration, monitoring and development of groundwater resources based on the identified sustainable yields.

Strategy 3

Use surface water more effectively and efficiently.

Sub-Strategy A

The Commission should compile an inventory of surface water use on Oahu for the purpose of determining existing use and projecting future use, given the present lack of information.

Sub-Strategy B

The Commission should certify the unreported and undetermined quantities of surface water use in Windward Oahu as part of its water registration program.

Strategy 4

Continue to refine the near and long-term projections of agriculture on the island to more accurately project the future net release of water currently committed to agricultural use.

Sub-Strategy A

The State Department of Agriculture should inventory and project diversified agriculture including the irrigated acreage, method of irrigation, source of water and the quantity and quality of water use.

Sub-Strategy B

The Commission should seek to establish the necessary Commission procedures to more readily transfer water allocations from agricultural to municipal use, especially where urban or other agricultural uses replace sugarcane lands.

Strategy 5

Maintain an ongoing water conservation program through the Board, using such approaches as pricing, public information, educational programs, water saving devices, and use restrictions and allocations.

Strategy 6

Develop and use non-potable water sources, wherever feasible, for the irrigation of agricultural crops, parks and golf courses, landscaping and for certain industrial uses.

Sub-Strategy A

Support the exchange of non-potable water, wherever feasible, for potable water which is being used for irrigation to preserve more of Oahu's potable supply for domestic use.

Sub-Strategy B

Pursue opportunities to blend brackish water with potable water to produce a greater supply of potable water.

Sub-Strategy C

Support and pursue the reuse of treated wastewater effluent for irrigation or groundwater recharge wherever feasible.

Strategy 7

Continue efforts to develop economical methods for demineralizing brackish water and desalting sea water.

Sub-Strategy A

Support the demonstration and expansion of the State's desalinization pilot project.

Sub-Strategy B

Continue research to develop more economical methods for desalting sea water for municipal purposes (e.g., an open cycle method of ocean thermal energy conversion or OTEC).

ARTICLE 3. SEVERABILITY

The invalidity of any word, section, clause, paragraph, sentence, part or provision of this chapter shall not affect the validity of any other part of this chapter which can be given effect without such invalid part or parts."

SECTION 2. This ordinance shall take effect upon its approval.

INTRODUCED BY:

Councilmembers

DATE OF INTRODUCTION:

March 29, 1990

Honolulu, Hawaii

APPROVED AS TO FORM AND LEGALITY:

Sandra A Simms
Deputy Corporation Counsel

APPROVED this 25 day of JUL, 1990.

FRANK F. FASI, Mayor
City and County of Honolulu

(@060690/na)

1. INTRODUCTION

1.1 PURPOSE

In 1978, the State of Hawaii Constitution was amended to mandate that "the State has an obligation to protect, control, and regulate the use of Hawaii's water resources for the benefit of its people." After nine years and lengthy deliberations on the implementation of this mandate, the State Water Code was enacted by the Legislature as Act 45, Session Laws of Hawaii 1987. As mandated by the Constitution, the State Commission on Water Resource Management through the State Water Code is empowered to set forth overall water conservation, quality and use policies; define beneficial and reasonable uses; protect ground and surface water resources, watersheds and natural stream environments; and establish criteria for water use policies and procedures for regulating all users of Hawaii's water resources.

One of the primary objectives of the State Water Code is the need for a program of comprehensive water resources planning to address the problems of supply and conservation of water. The Hawaii Water Plan is intended to fulfill this comprehensive planning requirement through four component parts: a water resource protection plan, water use and development plans for each County, a water projects plan, and a water quality plan. The water use and development plan for the City and County of Honolulu will be called the Oahu Water Management Plan. As one of the component plans, the Oahu Water Management Plan is intended to set forth the water use and development planning considerations for the City and County of Honolulu.

1.2 SCOPE

As required by the State Water Code, the County water use and development plans are to include:

(1) Status of water and related land development including an inventory of existing water uses for domestic, municipal, and industrial uses, agriculture, aquaculture, hydropower development, drainage, reuse, reclamation, recharge, and resulting problems and constraints;

(2) Future land uses and related water needs; and

(3) Regional plans for water developments including recommended and alternative plans, costs, adequacy of plans, and relationship to water resource protection and quality plan.

The State Water Code (Chapter 174C, Hawaii Revised Statutes) further requires that the water use and development plan be adopted by ordinance and set forth the allocation of water to land use within the City and County of Honolulu. The Plan is to be consistent with the State water resource protection and quality plan, State land

use classification and policies, and County land use plans and policies. Finally, the Plan is to be updated and modified as necessary by the City and County of Honolulu in order to maintain consistency with land use policies and zoning.

An Inventory Report was prepared as part of the first phase of the Oahu Plan. The Inventory Report described the background and setting for the water use planning considerations in the City and County of Honolulu. The report described in detail the nature and extent of Oahu's water supply, and existing water uses and water developments on Oahu, including municipal, plantation agriculture, military, private domestic, individual household, small irrigation, and others. (See Figure 1)

The second phase in the preparation of the Plan included an assessment of future water demand as compared with the future available supply of water on Oahu. The projected demand for water was examined based upon City and State land use policies. Programs which would provide for optimal use of the available supply have been explored, including the provision of additional potable water through source development and desalting technology, greater use of non-potable water sources, redistribution of the available supply, improved conservation efforts, and other alternatives for meeting the anticipated water demand.

The first and second phase efforts have been compiled into this Technical Reference Document containing the basic research and analysis supporting the Oahu Water Management Plan. As required by the State Water Code, the Oahu Water Management Plan will be adopted by ordinance and will provide the overall policies and strategies for water management in the City and County of Honolulu.

The Technical Reference Document and proposed Water Management Plan ordinance will be made available for public and agency review in conjunction with public meetings and hearings as may be required for final adoption by the Honolulu City Council.

OAHU WATER MANAGEMENT PLAN

STUDY PROCESS/METHODOLOGY

WILSON OKAMOTO & ASSOCIATES, INC.
PLANNERS - ENGINEERS - ARCHITECTS

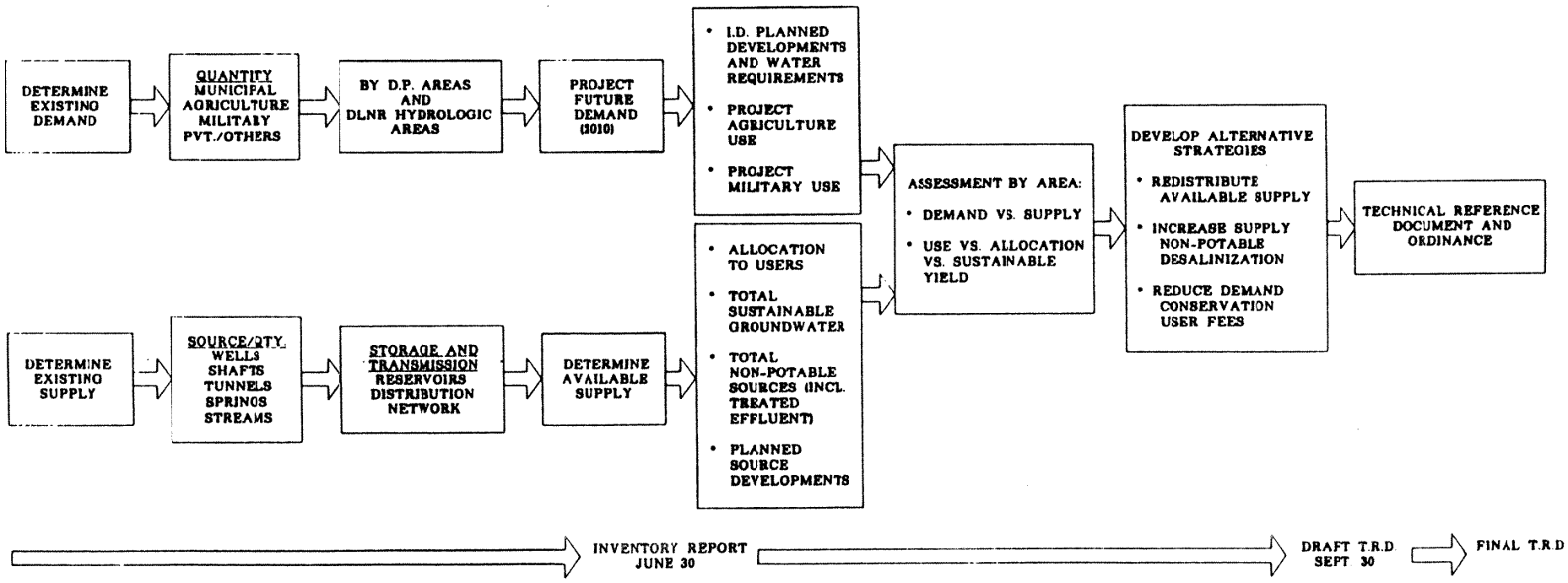


Fig. 1

2. PLANNING

2.1 SETTING

The City and County of Honolulu encompasses 620.5 square miles and includes the island of Oahu, the third largest island in the Hawaiian Chain and most of the Northwestern Hawaiian Islands stretching from beyond Niihau to tiny Kure Atoll, 1,367 miles from Honolulu. The island of Oahu, with approximately 594 square miles, comprises less than ten percent of the land area of the State of Hawaii. Its importance is not based upon its size, but upon its relationship to the economic and political activity of the state. As the center of business and government, the City and County of Honolulu is the State's economic mainstay, supporting tourism, military, agriculture, manufacturing, and research and development. Although Honolulu is the smallest of the four Counties in geographical size, it has approximately three-fourths of the State's population with an estimated resident population of 830,000 in 1987.

2.2 CLIMATE

The climate of Oahu, mild and equitable throughout the year, is due to the island's location on the northern fringe of the tropics within the belt of cooling northeasterly trade winds. Humidity of the area is generally within the 60 to 80 percent range. The average temperature in the lowlands is 75 degrees Fahrenheit, decreasing 4 degrees Fahrenheit with each 1,000 feet increase in elevation.

The coldest month, January, averages 72 degrees Fahrenheit and the warmest, August, 78.5 degrees Fahrenheit. Maximum temperatures rarely exceed 90 degrees Fahrenheit, and minimum temperatures hover around 50 degrees Fahrenheit.

Annual average rainfall on Oahu ranges from less than 20 inches on the leeward coast to almost 300 inches near the central crest of the Koolau Range. Because the rugged, steep Koolau Range intercepts prevailing trade winds, the moisture carried by these winds is lifted, cooled, and thereby condensed into rain. Rainfall is heaviest high in the mountains and decreases leeward.

Trade winds prevail throughout the year, but are least continuous from October through April, Hawaii's winter season. During these months, tropical storms occasionally bring heavy rains, which account for practically all the rainfall on the leeward plains.

2.3 GEOLOGY

The islands of the Hawaiian Archipelago are emerged volcanoes on a great submarine ridge that extends northwesterly and southeasterly for 1,600 miles in the central Pacific Ocean. This ridge, rising from ocean depths of 20,000 feet, was formed from

immense quantities of lava, flow upon flow, spewing forth from various points and fissures along a major fracture zone.

The sequential formation of the archipelago is indicated by the occurrence of submerged older islands in the northwest portion of the chain and by the youngest island at its southeast end, where volcanic activity continues. Eight of the islands are of sufficient elevation to intercept trade wind moisture and large enough to permit settlement.

Comparatively rapid weathering of their volcanic rock structure has reduced the size and altered the form of the islands. Oahu is comprised of the remnants of two elongate shield volcanoes, the Koolau and Waianae volcanic ranges, joined by a broad convex plateau. The eroded remains of the Koolau volcanic shield, stretching nearly straight northwest-southeast for 37 miles from Kahuku to Makapuu, is Oahu's principal mountain range. The older Waianae volcano, an arcing mountain range 20 miles long from Kaena Point to the Ewa Plains, makes up the western bulwark of the island.

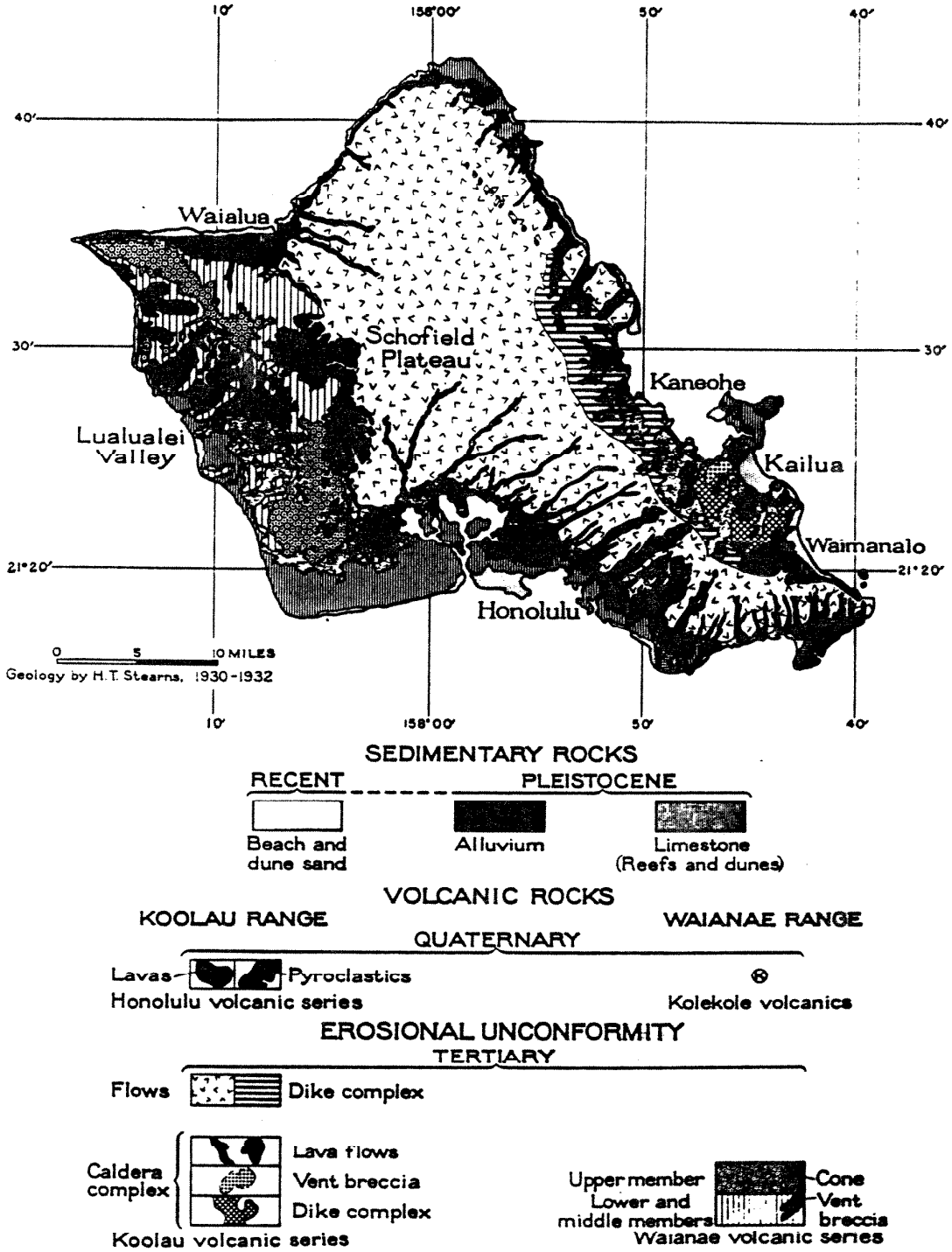
The peaks of the Koolau Range average about 2,500 feet in elevation. The highest point, Konahuanui, overlooking Nuuanu and Manoa Valleys in Honolulu, rises to 3,150 feet. The Waianae Range peaks are somewhat higher, averaging nearly 3,000 feet. The highest point on the island is Mount Kaala in the Waianae Range, at 4,025 feet elevation.

The Waianae volcanos emerged first and was partially eroded before the Koolau volcano emerged to the east, sending lava flows westward to overlap and bank against the Waianae flank. The shield building phases of the Waianae and Koolau volcanoes are known as the Waianae Volcanic Series and Koolau Volcanic Series, respectively (See Figure 2).

A long period of volcanic quiescence followed, during which erosion occurred and sediments accumulated along the shores. Deep valleys were incised into the bedrock by the major streams and subsequently filled with sediments. The Koolau caldera was reduced to near sea level, and extensive erosion cut back the windward flank to form the "pali." This geologic period, as well as the succeeding period, was very important in determining Oahu's water resources. During the later period, localized spasmodic volcanic activity occurred over the southeastern portion of the Koolau volcano, along with erosion of bedrock surfaces and deposition of marine and terrestrial sediments. The ash, cinders, and lava flows of this later period are called the Honolulu Volcanic Series.

Spectacular landmark features such as Diamond Head, Punchbowl, and Koko Head resulted from steam explosions of molten lava brought into sudden contact with water. Characteristically, portions of the crater rims were built higher by prevailing winds at the time of formation. The hot, water-rich ash solidified into a tough brown rock know as tuff.

The flat floors of Nuuanu Valley, Manoa Valley, and Kalihi Valley resulted from late



Source: Modified after Stearns, 1946

GEOLOGY OF OAHU

Fig. 2

lava flows. Kaimuki was the site of quiet volcanic activity of sufficient duration to form a low shield volcano 240 feet high and nearly two miles wide and to cause a shift in the Palolo Stream channel.

During the same geologic epoch, marked changes in sea level resulted from the formation and melting of great glaciers. Erosional and depositional platforms of marine and terrestrial sediments interbedded with lava flows were created around Oahu. The valley-filling sediments coalesced to form the fringing coastal plain, thereby fixing the artesian characteristics and dimensions of Oahu's fresh water lens.

These geologic events have shaped Oahu as it is today--rugged, irregular mountains with knife edge ridges along the topographic crests, steep cliffs, sheer headlands, gentler lee slopes--the whole of which is fringed by gentle coastal plains, yielding at the water's edge to fringing coral reefs.

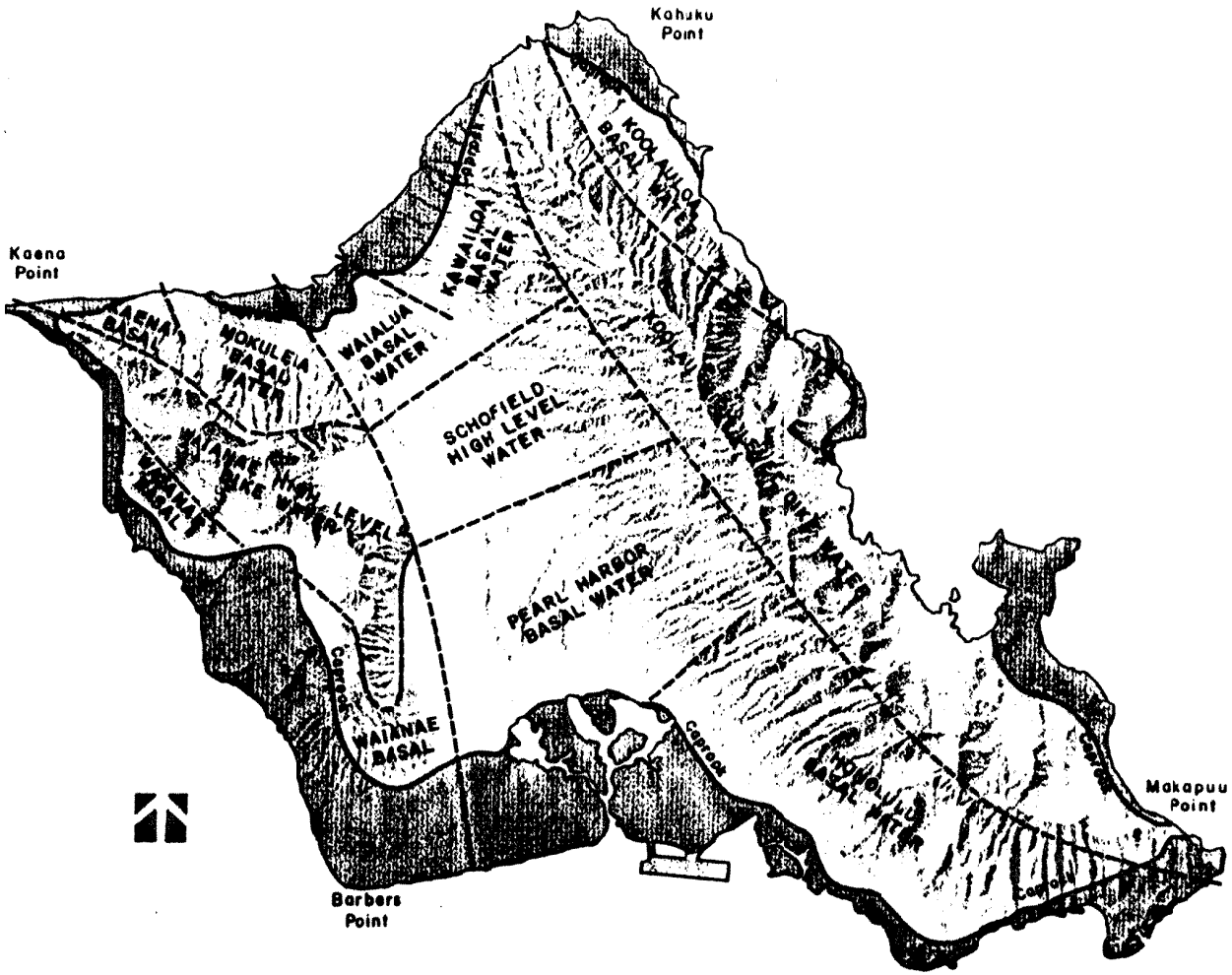
2.4 HYDROLOGY

Hawaii's water resources are extremely diversified, between islands as well as within islands, and in many respects appear anomalous. There are perennial streams and flash streams, rain forests and cactus deserts. There are ground water tunnels high in the mountains and low near sea level.

Despite such diversity, a continuous cycle of water can be easily traced on small oceanic islands like Hawaii. Its pattern will vary at different times and places according to variations in geology, landform, soils, and rainfall. The cycle is also modified by human activities, such as diverting mountain stream water for irrigation, pumping ground water, changing infiltration by resurfacing the land, altering evapotranspiration and runoff patterns by agricultural and urban development, and disposing of sewage effluent into the ocean. The volcanic rock and their residual soils have a very great capacity to absorb and percolate water, and consequently, only a relatively small proportion of the rainfall runs over the surface to the sea. Most of it infiltrates into the ground, creating the large ground water bodies on which Oahu depends for its water supply (See Figure 3).

There are several types of general ground water bodies on Oahu. The most important and most extensive is the "basal fresh water lens" that floats on sea water under much of the southern and northern portions of the island. Caprock sources are also found on Oahu. Less widespread, but of singular importance in some areas, is ground water restrained between impermeable vertical rock structures called "dikes" in the rugged core of the mountains. The third type, of minor significance on Oahu, is ground water held up, or "perched," on horizontal impermeable beds such as volcanic ash (See Figure 4).

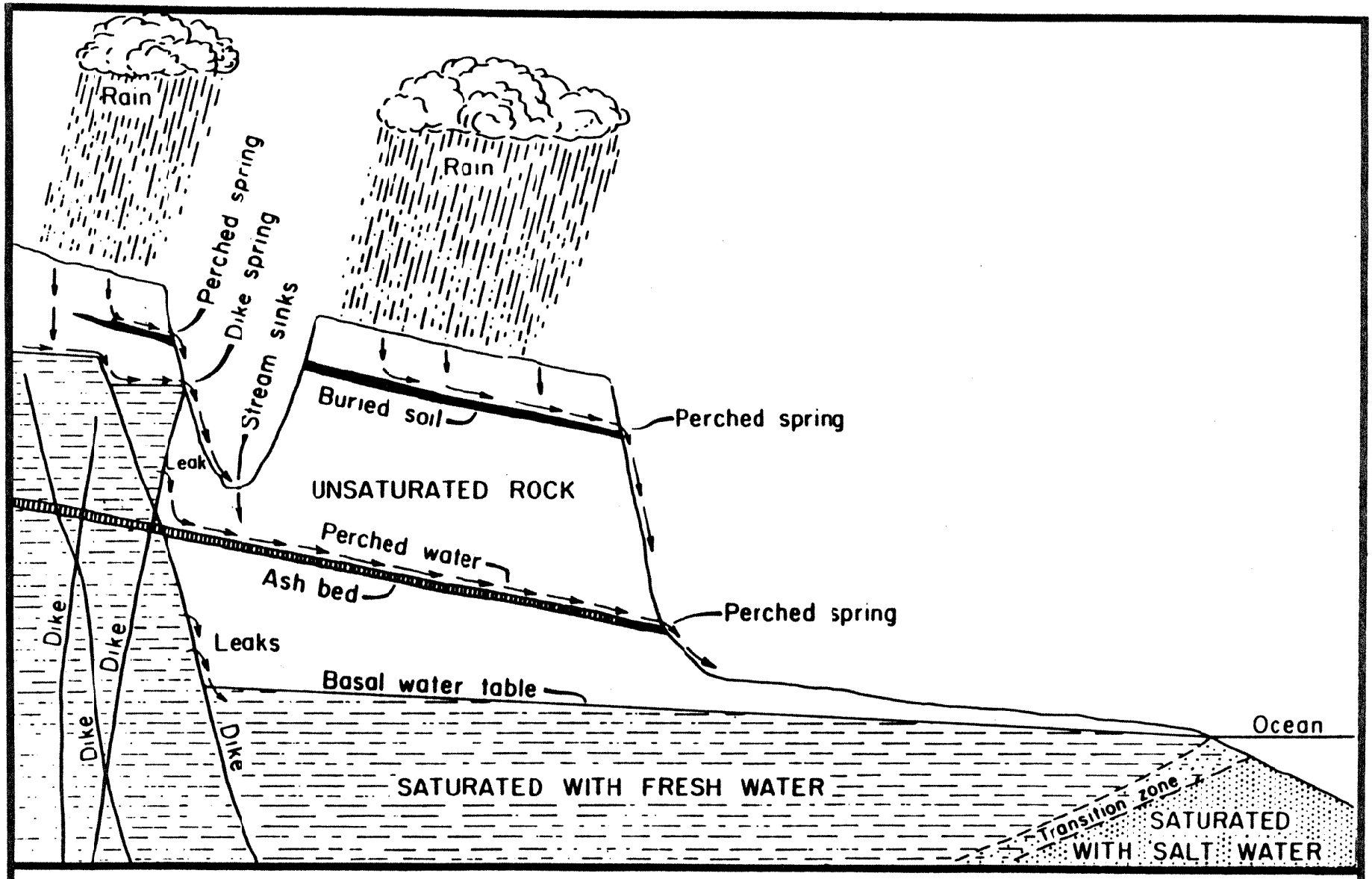
Of lesser importance to Oahu's water resources, but significant to agricultural pursuits especially on the Windward side, is streamflow from Oahu's perennial and intermittent streams. Precipitation and evapotranspiration are also important considerations in



GROUND WATER AREAS ON OAHU

Source: BWS, 1982

Fig. 3



Source: Modified after Stearns and Macdonald, 1946

GROUND WATER SOURCES

Fig. 4

understanding the hydrologic cycle and its influence on Oahu's water supply.

2.4.1 Basal Water

The immense basal water bodies, which are artesian where they underlie the coastal plain, exist because of the difference in density between fresh water and sea water. Fresh water floats on the heavier sea water, both of which permeate the subsurface rock. This relationship is know as the Ghyben-Herzberg principle. The density ratio between fresh water and salt water is such that, theoretically, for each foot that the fresh water lens stands above sea level (i.e. for each foot of "head"), the lens extends 40 feet below sea level to a midpoint where salinity is half sea water. A zone of mixture ("transition zone") grades upward to fresh water and downward to sea water. For example, if the freshwater head was found to be 20 feet above sea level, it can be reasonably estimated that the depth to the midpoint of the transition zone would be approximately 800 feet below sea level. (See Figure 5).

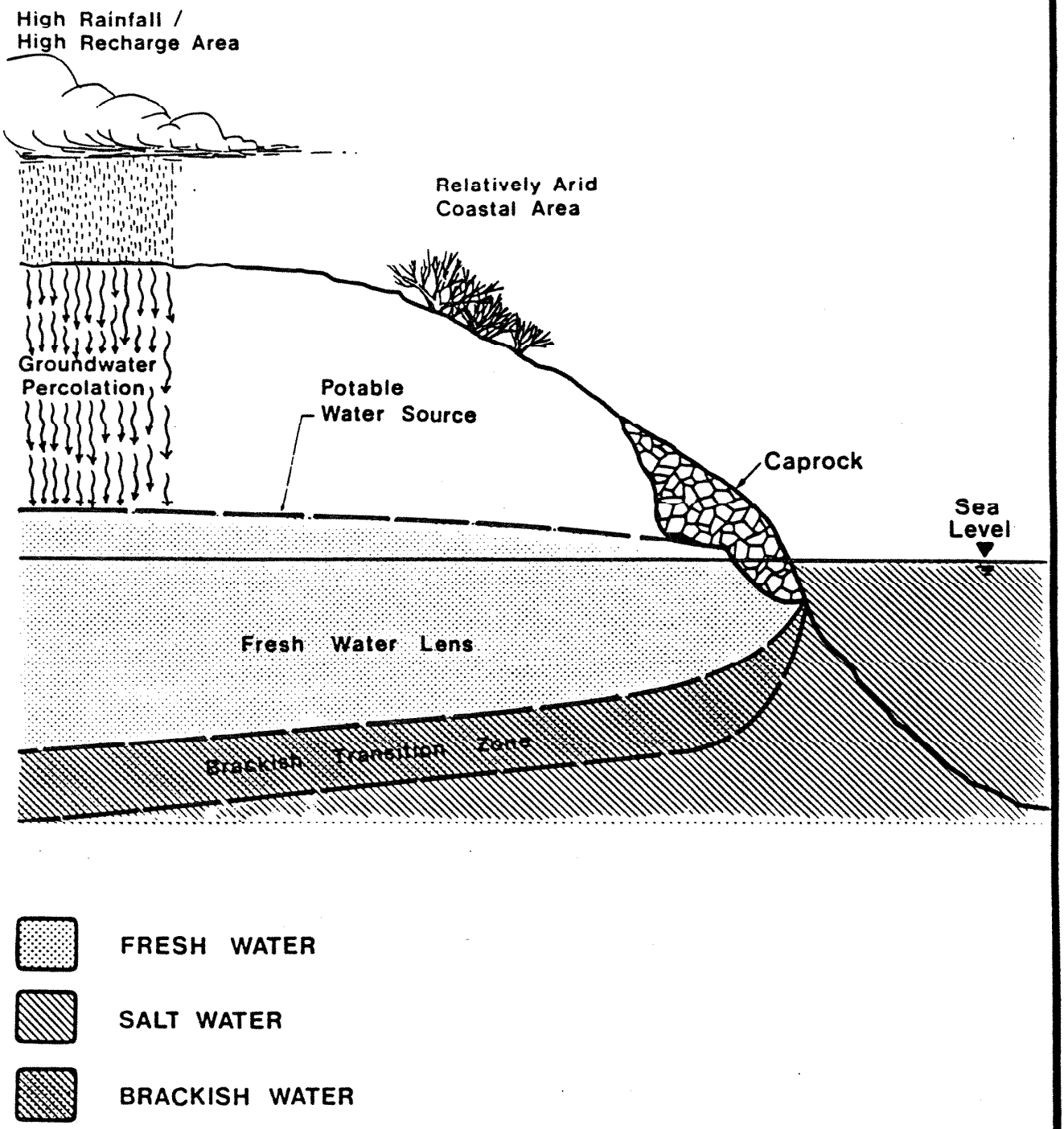
The amount of water in storage in a basal lens is significant. This characteristic permits draft rates in excess of the sustainable yield during periods of high demand and low recharge, so long as there is compensation by reducing draft rates less than the sustainable yield during other periods. Sustainable yield is the upper limit of the average rate of draft from a water resource that can be sustained indefinitely without undue detrimental effects on the resource. Recognizing the temporal pattern of draft, therefore, the sustainable yield of a freshwater lens is defined in terms of an average draft rate that will not cause harm to the lens.

2.4.2 Caprock Water

In some coastal areas there is a relatively impermeable sediment sequence commonly called "caprock." This caprock barrier tends to restrict the seaward flow of freshwater and causes the thickness of the freshwater lens to be greater than it would if the caprock was absent. Depending upon the effectiveness of the caprock, the resulting lens could range from minor local thickening of a few feet to a relatively thick lens of several hundred feet. Caprock water is derived from local rainfall, return irrigation water and leakage of basal water bodies.

2.4.3 Dike Water

Water impounded behind impermeable dikes in the mountains is called "dike water," or "high-level water." Dikes are formed when molten magma intrudes and solidifies in conduits within the volcano's rift zone. These conduits may feed eruptions on the surface or may stay beneath the surface. Typically, they consist of nearly vertical slabs of dense, massive rock, generally a few feet thick, that can extend for considerable distances and cut across existing older lava flows. High level water impounded in permeable lavas occurring between dikes in the interior portions of Oahu is of



Source: BWS, 1988

SCHEMATIC OF BASAL LENS

Fig. 5

excellent quality and is generally hydrologically distinct from the basal water found in dike-free areas. The water is not subject to saline contamination because of the high head of the water trapped between the dikes, distance from the sea, and low permeability of the dikes which inhibit the lateral flow of seawater. However, some water leaking through the dikes or overflowing, supplies the basal lens. The Waiahole Tunnel complex develops much dike water.

In many cases, dike-impounded water discharges at the ground surface where stream erosion has breached dike compartments. Once breached, the percentage of overall contribution to total stream flow depends on the head of the stored water, how deep the stream has cut into the high level reservoir, the permeability of the lavas between dikes, the size of the compartments as well as connections to other compartments, and the amount of infiltration into the compartment that is breached. In the northern portion of the Waianae region and also on the windward side of the Koolau Range, dikes are exposed at or near sea level. Owing to proximity to the ocean, fresh water within the dikes is in balance with underlying salt water and is classified as dike basal water.

2.4.4 Perched Water

Oahu lacks appreciable quantities of perched water, but in a few small areas this type of water has solved minor supply problems. This type of water is "perched" on top of layers of impermeable material such as dense volcanic rock, weathered and solidified ash, or clay-bearing sediments. Discharge of perched water sometimes occurs as springs where the perching member has been breached by erosion. Perched water supplies can be developed by tunnels or by constructing masonry chambers around spring orifices to collect flow and to prevent surface contamination. This type of water is of excellent quality, and like most dike water, is free from sea water encroachment.

2.4.5 Brackish Water

Water occurring in the caprock, the basal water transition zone, and basal springs comprise a large resource that is presently unused for municipal supplies due to excessive mineral content. Chlorides range from just above recommended drinking water limits to that of sea water.

Where fresh and salt water merge, a brackish zone of mixture forms. The movement of this transition zone, both horizontally inland from the seacoast and vertically upward, present a constant potential danger of saline contamination to the fresh water portion of the system.

Utilization of brackish water sources for municipal supplies requires reduction of chlorides by blending and/or demineralization. Water containing more than 250 ppm of chloride ion is considered undesirable for drinking. Although BWS prefers to distribute water containing less than 125 ppm, it will consider a higher level of salinity

where appropriate to enhance opportunities for blending fresh and brackish water.

2.4.6 Streamflow

Perennial streams, as opposed to intermittent streams, flow year around. They occur largely on the windward side of Oahu. These streams are sustained by leakage from high-level dike compartments and from springs and seeps. Kahana, Punaluu, Kaluanui, Waiahole, Kamooalii, and Maunawili Streams have the most potential for development. Presently, only Punaluu and Kahana Streams, both with dependable flow of up to 10.0 mgd are being considered as surface water sources. However, ground water development in the valleys may be more advantageous.

On the leeward side of the island, streams are perennial in their headwaters because of high rainfall but intermittent in their lower reaches due to diversions for sugar cane irrigation and porous ground conditions. Outflow of basal ground water as springs, especially in the Pearl Harbor area, maintains perennial streamflow near the shoreline.

There are extensive plantation surface water diversion systems in the Wahiawa and Waialua areas, utilizing most or all of the streamflow. No future surface water development is foreseen for these areas.

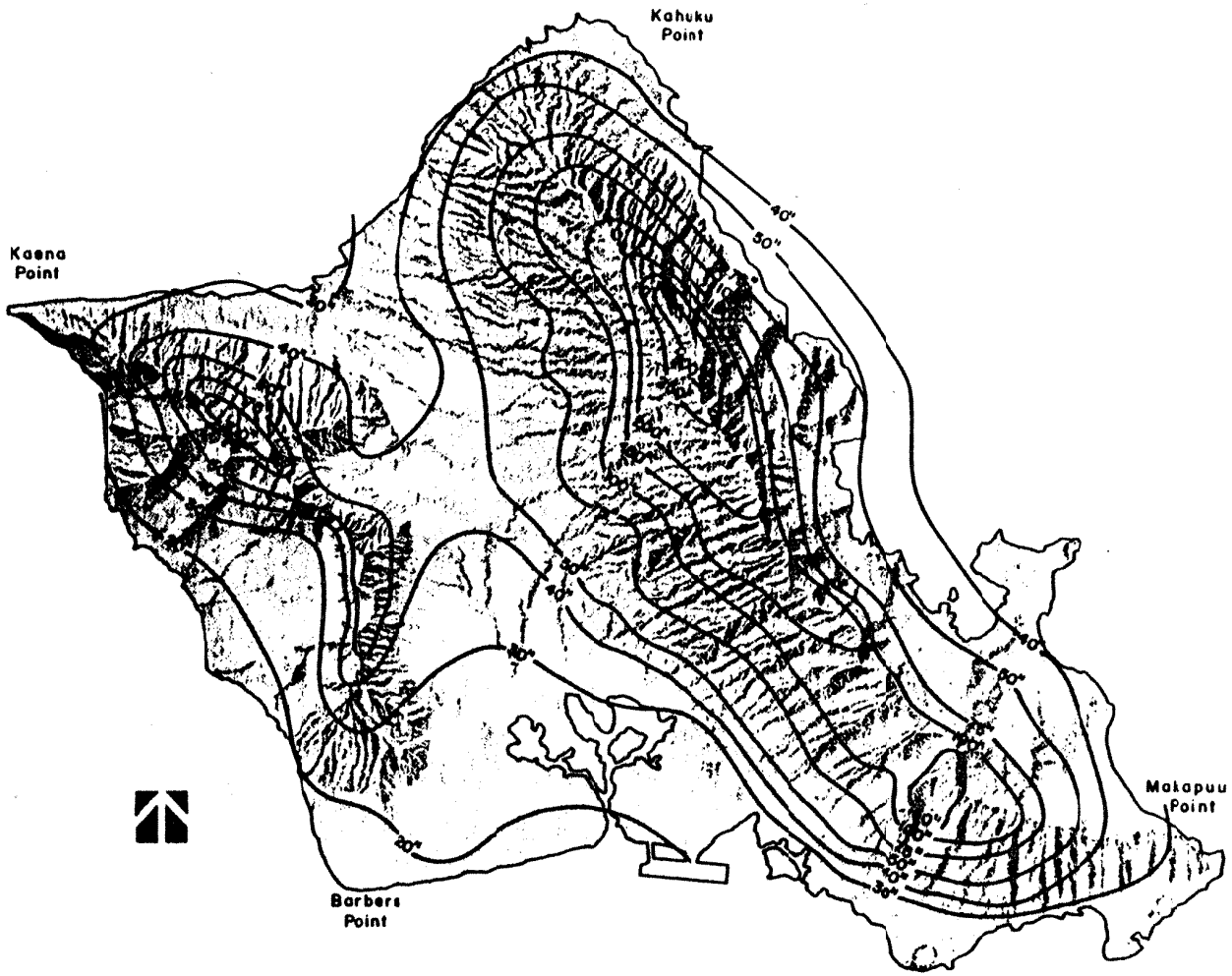
2.4.7 Precipitation

The contrast between the verdure of Oahu's mountains and the aridity of its lowland plains reflects extremely wide rainfall variations. Annual average rainfall on Oahu ranges from less than 20 inches on the leeward coast to almost 300 inches near the central crest of the Koolau Range. (See Figure 6.) Such a marked difference over a distance of less than 15 miles has a significant effect upon water resources.

Were it not for Oahu's mountain ranges, the island would be a barren wasteland. The sea surrounding Oahu receives no more than 30 inches of rain each year, far too little to sustain vigorous plant growth in the subtropics. However, because the rugged, steep Koolau intercepts prevailing trade winds, the moisture carried by these winds is lifted, cooled, and thereby condensed into rain. Rainfall is heaviest high in the mountains and decreases in the leeward direction. The Waianae Range is a less effective rainmaker since it lies to the lee of the Koolau Range.

The trade winds are active throughout the year, but are least continuous from October through April, Hawaii's winter season. During these months, tropical storms occasionally bring heavy rains, which account for practically all of the rainfall on the leeward plains.

Although the island is deeply incised by many stream valleys, the amount of perennial streamflow reaching the sea is comparatively minor. Because of the extraordinary permeability of the volcanic rocks and residual soils that make up the island, most of



Source: BWS, 1982

MEAN ANNUAL RAINFALL, OAHU

Fig. 6

the flow percolates to become ground water. Storm flows may be very heavy, but because of their short duration recharge may be slight.

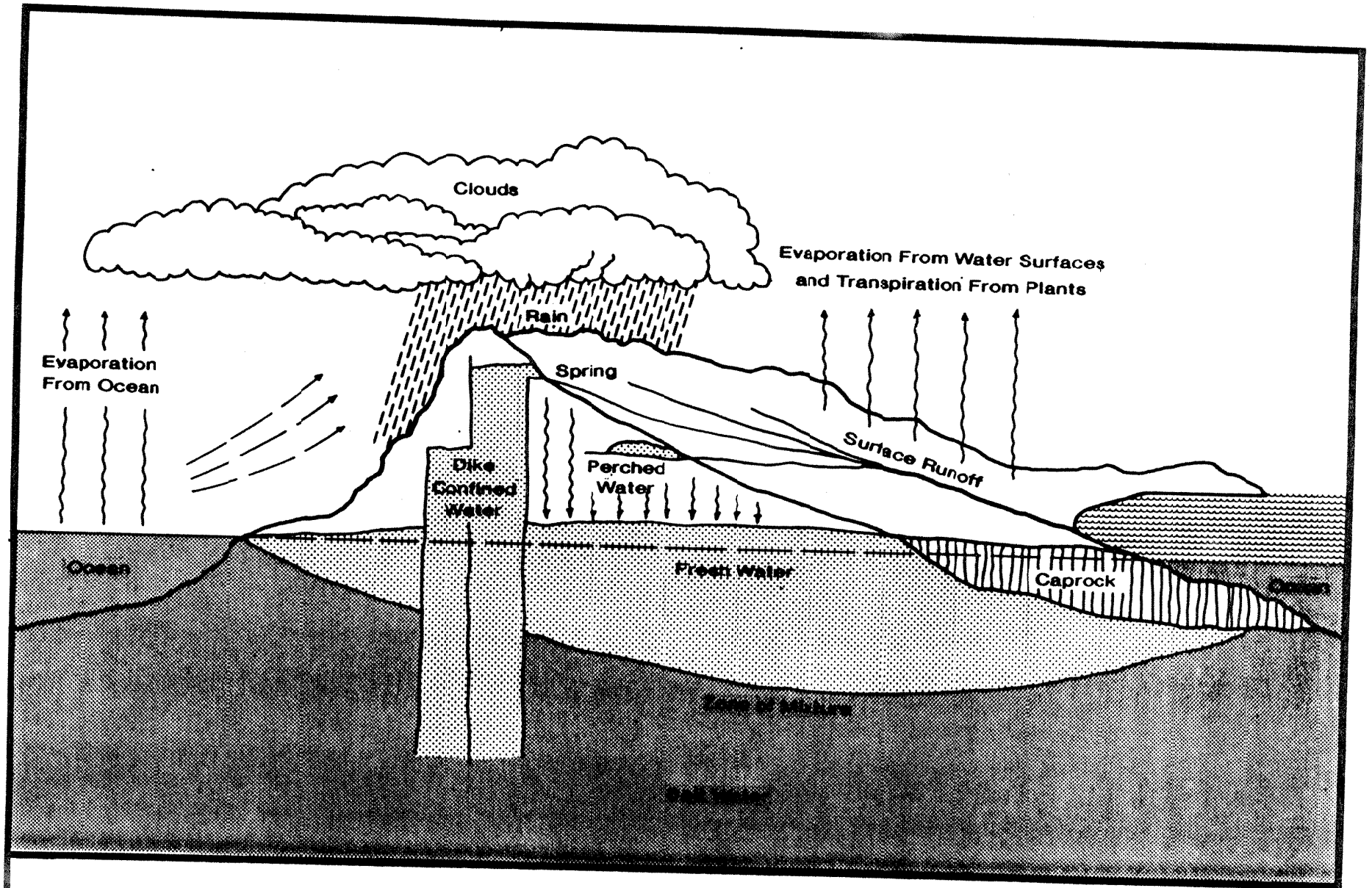
2.4.8 Evapotranspiration

Evapotranspiration is the loss of water from the surface and near-surface zones, both by direct evaporation and by plant usage or transpiration. It represents the portion of the precipitation that is not available for infiltration or surface runoff (See Figure 7). Evapotranspiration is primarily influenced by such factors as temperature, humidity, rainfall, and winds. In Hawaii, evapotranspiration varies widely both in time and space, although annual variations at any one place tend to be small. Maximum evapotranspiration occurs generally in the dry summer months. In areas of heavy rainfall, evapotranspiration losses may be only a small percentage of total precipitation; however, in areas with low rainfall, all or most of the rainfall may be lost to evapotranspiration.

2.5 HYDROLOGIC UNITS AND WATER AVAILABILITY

In response to the need to identify and describe aquifers for the State of Hawaii, a program was initiated to classify and assign codes to the principal aquifers for each island. The product is a single consistent scheme of classification and nomenclature that will serve as a framework for ground water protection strategy. The effort was initiated several years ago by the Department of Health in response to U.S. Environmental Protection Agency directives and is being carried out by the Water Resources Research Center of the University of Hawaii for the Department of Health. The aquifer mapping information for the completed islands (Oahu and Maui) will be included as part of the Water Quality Plan.

The classification scheme reported by Mink and Sumida (1984) is the starting point for developing an Aquifer Code. Classification starts with Island as the largest component in the hierarchy, followed by Aquifer Sectors and Aquifer Systems. Aquifer Types and Aquifer Units will also be identified, but for general planning purposes the Sector and System categories are sufficient. Sectors reflect broad hydrogeological similarities yet maintain traditional hydrographic, topographic and historical boundaries where possible. Aquifer Systems are more specifically defined by ground water hydraulic continuity, in particular hydraulic connections among Aquifer Types and Units. Aquifer Types are differentiated by distinctive features of hydrology and geology. The Aquifer System is the logical category for computing water budgets and deriving sustainable yield.



HYDROLOGIC CYCLE

Source: DLNR, 1979

Fig. 7

In brief the hierarchy is as follows:

a) Island: The global locator

b) Sector: A large region with hydrogeological similarities

c) System: An area within a Sector showing ground water hydraulic continuity

d) Type: Portions of a System having the same hydrological and geological features

Islands are coded by number in conformance with the U.S. Geological Survey (1975) protocol. Island numbers are 1 (Niihau), 2 (Kauai), 3 (Oahu), 4 (Molokai), 5 (Lanai), 6 (Maui), 7 (Kahoolawe), and 8 (Hawaii). Each Aquifer Sector and System is coded with a two-digit number. Sectors and Systems are also assigned geographic names. Hawaiian place names are preferred; but for some Sectors the general locators North, South, East, and West, or a traditional geographic term such as Windward, are required for clarity. All Systems have Hawaiian names. Aquifer Types are coded with a three-digit number which describe fundamental hydrology and geology.

2.5.1 Hydrology

Hydrology is uniquely described by a two-digit code. Aquifer Types are defined as either basal or high level, and as either unconfined or confined. Their numbers with brief descriptions are as follows:

No.	Type	Description
1	Basal	Fresh water in contact with seawater
2	High Level	Fresh water not in contact with seawater
1	Unconfined	Where the water table is the upper surface of the saturated aquifer
2	Confined	Aquifer is bounded by impermeable or poorly permeable formations; top of the saturated aquifer is below the surface of the ground water
3	Confined or Unconfined	Where the actual condition is uncertain

Using the above coding, ground water can be 11 or 12, or 21 or 22. Where confining conditions are unclear, the second digit is designated as 3.

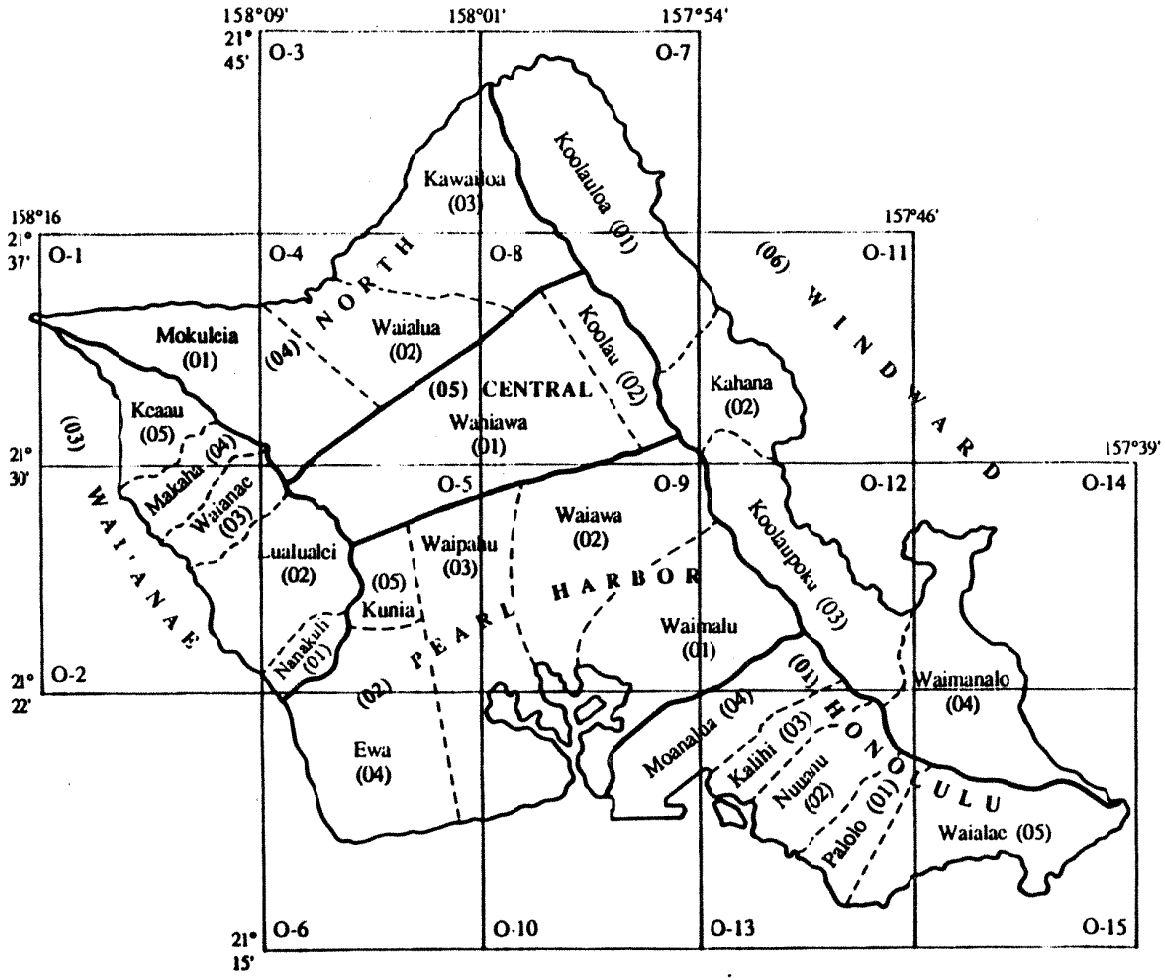
2.5.2 Geology

Geology is uniquely described by a single digit. Aquifers are categorized as occurring in the flank lavas of the volcanic domes, in rift zones characterized by dikes, on poorly permeable perching members, or within the sedimentary sequence. Flank aquifers normally are horizontally extensive and display the lowest heads and usually carry basal water; rift aquifers are segmented into compartments by dikes; perched aquifers lie on impermeable formations but are not ordinarily very extensive; and sedimentary aquifers are comprised of alluvial and marine sediments deposited by erosion and biogenic processes. The geologic codes are as follows:

No.	Type	Description
1	Flank	Horizontally extensive lavas
2	Dike	Aquifers in dike compartments
3	Flank/Dike	Indistinguishable
4	Perched	Aquifer on an impermeable layer
5	Dike/Perched	Indistinguishable
6	Sedimentary	Non-volcanic lithology

One of the above numbers attached to the two hydrology numbers defines the Aquifer Type. Each Aquifer Type has an eight-digit code which is unique. Certain hydrogeological parameters and quantities, such as rainfall, infiltration, sustainable yield and storage, can be appended to the code to expand its utility. For example, items relevant to ground water contamination can be expressed as a separate numerical code and attached to the Aquifer Code.

Following is a table of the Aquifer Codes for the island of Oahu along with Sector and Aquifer System names. Oahu includes six Sectors, 24 Aquifer Systems, and 87 Aquifer Types (See Figure 8).



Source: Mink & Lau, 1987

LAYOUT OF AQUIFER SECTORS AND SYSTEMS FOR OAHU

Fig. 8

AQUIFER CODES

ISLAND: 3 (OAHU)

SECTOR	AQUIFER SYSTEM
01 Honolulu	01 Palolo
	02 Nuuanu
	03 Kalihi
	04 Moanalua
	05 Waialae
02 Pearl Harbor	01 Waimalu
	02 Waiawa
	03 Waipahu
	04 Ewa
	05 Kunia
03 Waianae	01 Nanakuli
	02 Lualualei
	03 Waianae
	04 Makaha
	05 Keaau
04 North	01 Mokuleia
	02 Waialua
	03 Kawailoa
05 Central	01 Wahiawa
	02 Koolau
06 Windward	01 Koolauloa
	02 Kahana
	03 Koolaupoko
	04 Waimanalo

AQUIFER TYPE		HYDROLOGY
1	Basal	Fresh water in contact with seawater
2	High Level	Fresh water not in contact with seawater
3	Unconfined	Where water table is upper surface of the saturated aquifer
4	Confined	Aquifer bounded by impermeable or poorly permeable formations, and top of saturated aquifer is below ground water surface
5	Confined/ Unconfined	Where actual condition is uncertain

		GEOLOGY
1	Flank	Horizontally extensive lavas
2	Dike	Aquifers in dike compartments
3	Flank/Dike	Indistinguishable
4	Perched	Aquifer on an impermeable layer
5	Dike/Perched	Indistinguishable
6	Sedimentary	Non-volcanic lithology

2.6 POPULATION ANALYSIS

The City and County of Honolulu is the center of business and government for the State of Hawaii. Although smallest of the four Counties in geographical size, it has approximately three-fourths of the State's population. Provisional estimates for 1988 indicate a State of Hawaii resident population of 1,098,200 of which 838,500 or approximately 76 percent are in the City and County of Honolulu. This estimate includes members of the armed forces stationed in or homeported in Hawaii and residents temporarily absent, and excludes visitors present.

The 1988 de facto population for the State of Hawaii -- which included 136,000 visitors present on an average day but excluded 20,600 residents temporarily absent -- was 1,213,700. Almost three-fourths of the 1988 de facto total was on Oahu, with a density of 1,500 persons per square mile.

Total resident population for the City and County of Honolulu has increased approximately 26.0 percent from 1960 to 1970; 20.9 percent from 1970 to 1980; and 10.0 percent from 1980 to 1988.

According to the City and County of Honolulu's Department of General Planning, 1988 resident population figures for the Development Plan areas on Oahu were: Primary Urban Center 443,200; Ewa 38,700; Central Oahu 127,700; East Honolulu 48,200; Koolaupoko 119,100; Koolauloa 12,400; North Shore 14,000; and Waianae 35,200.

According to the Hawaii State Department of Health, the 1986 ethnic makeup of the City and County of Honolulu was as follows:

Caucasian	26.9%
Japanese	23.7%
Filipino	9.7%
Hawaiian and part-Hawaiian	15.6%
Chinese	5.6%
Mixed other than part-Hawaiian	11.2%
Other	7.3%

According to the U.S. Bureau of Census, the City and County of Honolulu had a 1985 estimate of 253,400 households with an average persons per household of 3.06. This represents a 10.1 percent increase over the 1980 census figure of 230,214 households with an average persons per household of 3.15.

The civilian labor force for the City and County of Honolulu in 1988 was estimated at 389,350, and civilian employment was 378,550. An estimated 10,750 or 2.8 percent of the labor force was unemployed, the lowest county unemployment rate in the State. Areas with large concentrations of workers in 1980 included downtown Honolulu, 46,000; Waikiki, 30,000; and Pearl Harbor-Hickam, 15,000.

2.7 ECONOMIC ANALYSIS

The major economic forces in the City and County of Honolulu, as well as for the State of Hawaii, are tourism, construction, the military, agriculture, and manufacturing. A brief analysis describing each industry is given below.

2.7.1 Tourism

Tourism is Hawaii's leading economic force based on dollar contribution to the State's economy. Due to a strong showing in the eastbound market, Oahu's visitor industry had another positive year in 1988. Two million eastbound visitors, mostly Japanese, came to Hawaii, a 17 percent increase over 1987. Of the Japanese who came to Hawaii, over 90 percent or approximately 1.4 million, spent their vacations on Oahu. The total eastbound visitor count, through the first quarter of 1989, is up by 14 percent over last year. In spite of some cancellations among older Japanese travellers, a strong surge in younger Japanese travellers continues to boost the overall number of Japanese coming to Hawaii.

In contrast, the Oahu westbound market experienced weakness in 1988 with three million westbound visitors coming to Hawaii, two percent less than in 1987. This marks the second consecutive year of decline in Oahu's major visitor market. Reasons for the reduction included increased competition from other vacation destinations, and a decrease in airplane seats from the West Coast. However, in the first quarter of 1989, due to a colder-than-normal winter in California, westbound visitors increased by eight percent to 773,400 visitors, leading to the strongest first quarter in two years, and a healthy turnaround in the westbound market.

Average daily visitor census in 1988 was 138,910 for the State of Hawaii, of which 80,400 or approximately 58 percent were in the City and County of Honolulu. To accommodate these visitors, Oahu's visitor plant in 1988 consisted of 37,841 hotel and condominium units, or approximately 55 percent of the total number of units in all four Counties. Oahu's occupancy rate during 1988 was 85 percent, by far the highest in the state. Furthermore, because of the increased influx of both east and westbound visitors, the cumulative first-quarter 1989 average came to 93 percent, the highest occupancy rate since the first quarter of 1979. The total preliminary estimated expenditures by visitors to Hawaii in 1987 was 6.6 billion dollars, of which 4.37 billion dollars or approximately 66 percent can be attributed to the City and County of Honolulu.

Both visitors and residents have access to a wide range of recreational and cultural facilities. Waikiki, however, with its shopping opportunities and night life, is still the primary destination for most of Hawaii's millions of tourists.

2.7.2 Construction

Oahu's construction industry, the largest in the state, surpassed the two billion dollar mark for the first time in 1988. Construction-put-in-place for the City and County of Honolulu came to 2.2 billion dollars, a 25 percent increase over 1987. First-quarter figures for 1989 show the industry is still growing at a hectic pace. A total of 593 million dollars in construction occurred through March, a 17 percent increase over 1988. Private permits authorized for residential and nonresidential projects were also up. Through the first quarter, permit value for residential projects stood at 118 million dollars, a 66 percent increase over 1988. Permits for nonresidential projects were up by 26 percent to 106 million dollars. With activity rising in both markets, the industry is headed for another two billion dollar year in 1989.

The rapid increase in private-sector development has been mirrored by increased public-sector construction activity. In 1988, construction contracts awarded by all levels of government in the City and County of Honolulu came to 475 million dollars, a 62 percent increase over 1987. For the first quarter of 1989 public contracts have increased another 92 percent. The county has been the big contractor in 1989 with 75 million dollars contracted out, followed by the state's 63 million dollars, and the federal government's 25 million dollars. In 1980 the City and County of Honolulu employed approximately 21,423, or 6.6 percent of all employed persons 16 years and over, in the construction industry. In 1987 the construction industry generated an estimated 16,500 contract construction jobs (excluding government construction).

2.7.3 Military

The military is the third largest economic sector in the City and County of Honolulu. As of July 1, 1988 there were 64,053 military personnel in the state with 63,824 stationed on Oahu. Together with dependents, the military population on Oahu came to 133,419 people. The Navy has the largest presence with 54,966 military personnel and dependents followed by the Army, Marine Corp., Air Force, and Coast Guard. The military also generates 19,800 civilian jobs, with Pearl Harbor alone employing 6,330 people. As of the third quarter of 1988, direct contributions to the state economy by the military came to 1.5 billion dollars, excluding naval contract purchases from local businesses. A majority of these funds were spent on Oahu, making the military a large contributor to the county's economy.

Major military installations include the Pearl Harbor Naval Shipyard, Kaneohe Bay Marine Corps Air Station, Hickam Air Force Base, Tripler Army Medical Center, and the Army's Fort Shafter and Schofield Barracks. The unified military command for the Pacific (CINCPAC) is located at Camp H.M. Smith in Aiea.

2.7.4 Agriculture

In 1988, Oahu had approximately 125,000 acres of total farm acreage (including land

not in crop and pasture such as farm house lots, roads, woodlots, etc.). Oahu had an estimated 25,700 acres in use for sugarcane, 13,300 acres for pineapple, 1,000 acres for vegetables and melons, 500 acres for other fruits, and 1,600 acres for miscellaneous crops. (See Figure 9.)

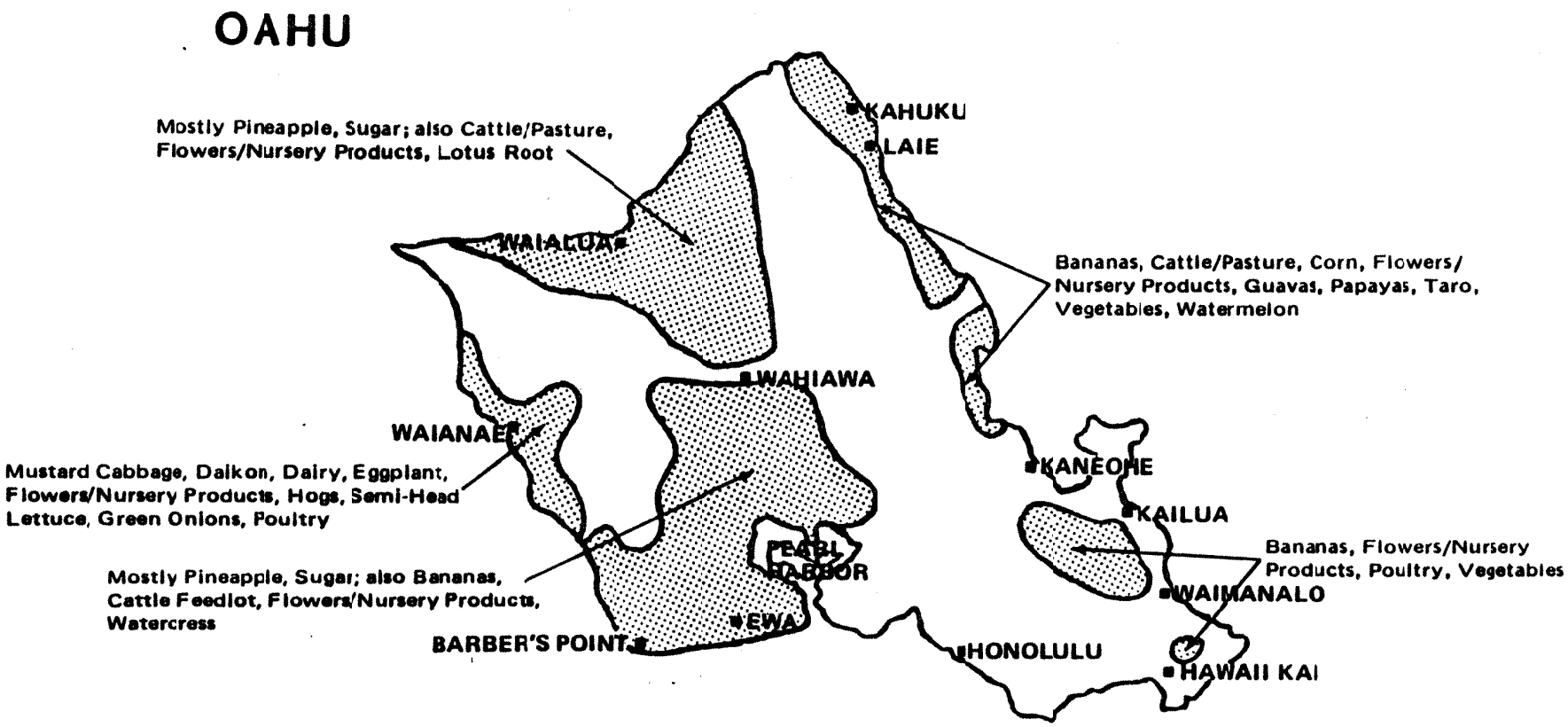
Hawaii's two primary agricultural exports are raw sugar and pineapple (processed and fresh). The physical output of raw sugar has stabilized at about 1 million tons per year, although price changes have resulted in fluctuating values for this commodity. In 1987 Oahu produced approximately 1,300,000 tons of raw sugar for a total value of 35.5 million dollars. Increasing productivity, however, has permitted this output level to be produced by fewer workers which has resulted in a continuously declining level of employment in both the field and processing sectors of the sugar industry.

Pineapple production followed a pattern similar to that of the sugar industry in terms of productivity and, consequently, falling employment levels. In 1987 Oahu produced approximately 248,000 tons of pineapples (fresh equivalent) for a value of 52.9 million dollars. However, the sales of the pineapple industry have generally expanded somewhat in recent years due mainly to the development of the market for fresh pineapple on the Mainland.

Currently there are two pineapple plantations and one pineapple cannery on Oahu; Del Monte Plantation in Kunia, Dole Plantation in Whitmore, and Dole Cannery in Iwilei. Dole Pineapple Company is planting fewer fields this year and has reduced the size of its cannery. Efficiency has been increased by installing state-of-the-art machinery, and cutting the number of processing lines in half. Dole's other pineapple-related developments include a new fresh fruit packing facility and its visitor attractions, the Dole Plantation and the Dole Cannery Square.

In 1987 Oahu's two sugar companies, Oahu Sugar Company, Ltd. and Waialua Sugar Company, Ltd., produced approximately 16 percent in volume of crop marketings of the State's total sugar crop. In addition, the California and Hawaiian (C&H) Sugar Refinery in Aiea processes about 5 percent of the sugar crop for Hawaii consumption. In 1987, the City and County of Honolulu had a total job count of 1,000 in the sugar industry, 750 in the pineapple industry, and 1,500 in other agricultural industries. As sugar profitability declines, the Hawaii Sugar Planters Association and others are exploring supplemental crops such as corn seed, coffee,macadamia nuts, taro, cocoa, alfalfa, and potatoes. Dendrobium orchids and other flowers and potted plants are also an established and expanding crop. Sugarcane fields are also being converted to pineapple cultivation.

In diversified agriculture, gross business receipts for the City and County of Honolulu came to 148 million dollars in 1988, a 17 percent increase over 1987. Floriculture products was the fastest growing segment in 1988. The value of flowers and nursery products was approximately 55.8 million dollars in 1987, a 13.5 percent increase over 1986. In addition, the City and County of Honolulu in 1987 produced 179.8 million pounds of eggs; 115.7 million pounds of milk; 4.9 million pounds of pork; 14.9



Source: DOA, USDA 1988

MAJOR AGRICULTURAL AREAS ON OAHU

Fig. 9

million pounds of vegetables and melons; and 6.4 million pounds of fruits, excluding pineapples.

There are 25 aquaculture industry operators in the City and County of Honolulu, the largest being Marine Culture Enterprises, a successful and expanding fresh shrimp facility at Kahuku.

The State of Hawaii is actively promoting diversified agriculture through the development of agriculture parks. As of 1987 there were also three agricultural parks under construction on Oahu at Kahuku, Waimanalo, and Waianae. These agricultural parks are part of the Department of Agriculture's program to utilize State lands for diversified agriculture and are being developed in cooperation with the Department of Land and Natural Resources.

2.7.5 Manufacturing

In 1982 more than three-fourths of all manufacturing activity in the State of Hawaii was on Oahu. According to the most recent census of manufacturers, the City and County of Honolulu had 780 listed companies. In 1987 the City and County of Honolulu employed approximately 16,350 persons in the manufacturing sector.

Oahu's gross business receipts from manufacturing activity came to 541 million dollars in 1988, in increase of six percent over 1987. The product value added by manufacturing was greatest in food processing mostly sugar and pineapple. Other important manufactures include apparel; stone, clay, and glass products; printing and publishing; and chemicals and allied products.

Heavy manufacturing includes two oil refineries which produce a wide range of petroleum products; one cement plant; two steel mills; and several concrete products plants. In addition, high technology is starting to make a bigger contribution to Oahu's manufacturing sector. As of 1985 there were 21 industrial parks and areas in the City and County of Honolulu with a total of 2,207 developed acres and 492 proposed acres.

2.8 LAND USE

The three major determinants of land use in the City and County of Honolulu are the State Land Use District Classifications, and the City and County of Honolulu Development Plans and Land Use Ordinance (zoning codes). The City and County of Honolulu is divided into eight development plan areas: The Primary Urban Center (from Pearl City to Waialae-Kahala), Ewa, Central Oahu, East Honolulu, Koolaupoko, Koolauloa, North Shore, and Waianae. Figure 10 shows the Development Plan areas for the City and County of Honolulu.

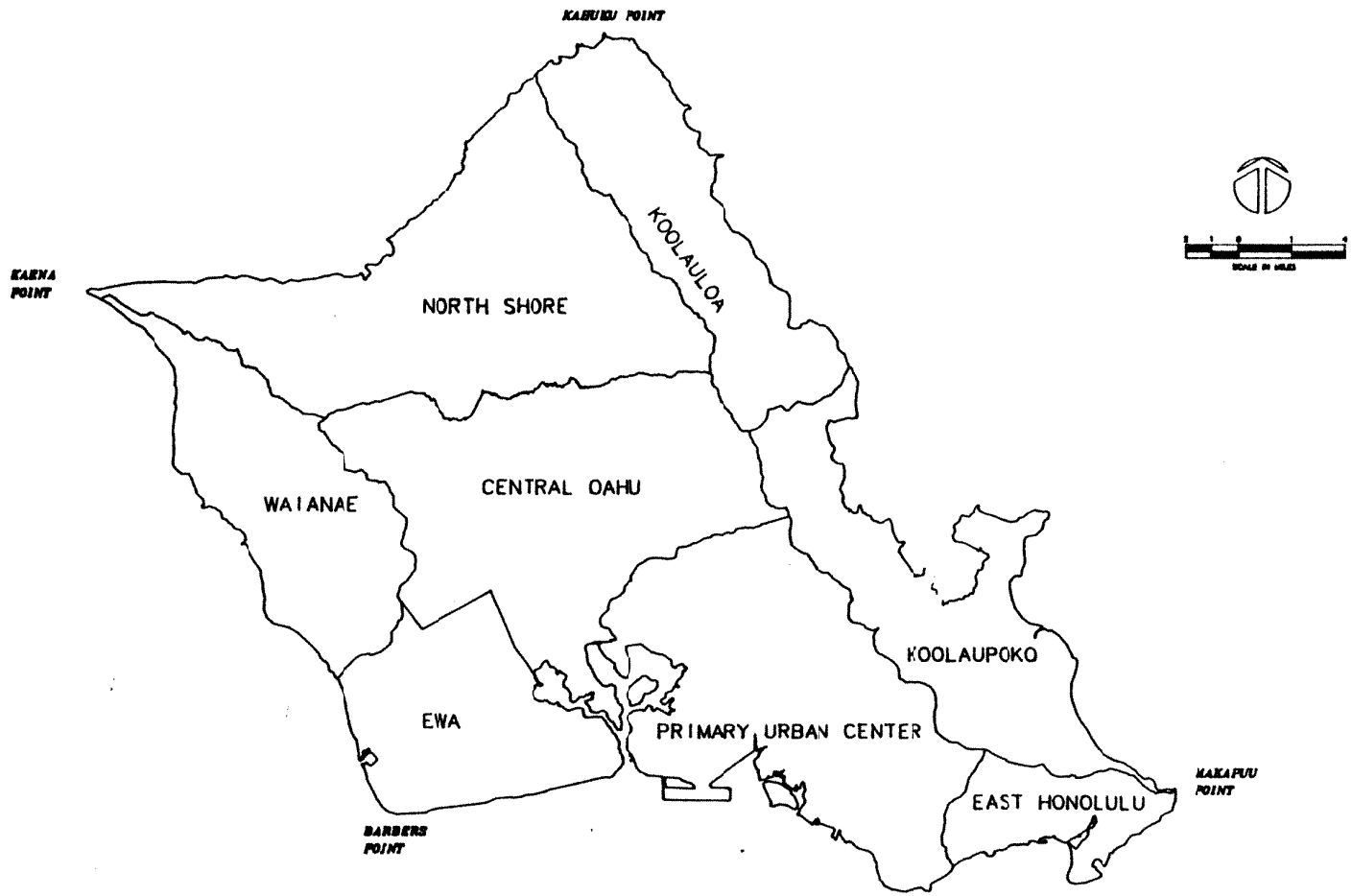


Fig. 10

WILSON OKAMOTO AND ASSOCIATES, INC.
PLANNERS – ENGINEERS – ARCHITECTS

DEVELOPMENT PLAN DISTRICTS

2.8.1 State of Hawaii Land Use District Classification

The State of Hawaii Land Use District includes four classifications: "U" Urban, "A" Agricultural, "C" Conservation and "R" Rural. Urban districts are characterized by "city-like" concentrations of people, structures, streets, urban level of services and other related land uses. Agricultural districts include lands with a high capacity for agricultural production. Conservation districts preserve and protect lands for watersheds and environmental resources, for public safety as with flood zones, for parks and recreation, and for scenic views. Rural districts are characterized by lower density uses than the Urban land use districts. Oahu does not have any Rural designations. (See Figures 11 and 12.)

Islandwide, 82,251 acres or 22 percent of the land are in the Urban District, 133,681 acres or 36 percent of the land is in Agricultural Land Use District, and 159,714 acres or 43 percent of the land is in Conservation Land Use District. Table 1 shows the acreage in Urban, Agriculture, and Conservation Land Use Districts for each of the Development Plan areas, as well as the total acreage of each district for the City and County of Honolulu.

The Primary Urban Center contains much of the Urban designated lands on Oahu (37 percent Urban), followed by Koolaupoko, Ewa, and Central Oahu. Agricultural lands are predominantly in the North Shore and Central Oahu DP areas (together they account for 59 percent of Agricultural). significant amonts of acreage are also found in Ewa, Waianae, and Koolauloa. Conservation district lands encompass mostly watershed areas along the slopes of the Koolau and Waianae ranges.

2.8.2 City and County of Honolulu Development Plan Designations

Table 2 shows the acreage of each designation by Development Plan areas, as well as the total acreage for the City and County of Honolulu. The City's Development Plans provide detailed schemes which implement the objectives and policies of the Oahu's General Plan. The Development Plans for the eight planning districts of the Primary Urban Center, Ewa, Central Oahu, East Honolulu, Koolaupoko, Koolauloa, North Shore, and Waianae guide the desired sequence, patterns and characteristics of future development for the City and County. (See Figures 13A and 13B.) The land use designations are on the Development Plan Land Use Maps which indicate the planned distribution and intensity of land uses. The land use categories established are Residential, Low-Density Apartment, Medium-Density Apartment, High-Density Apartment, Commercial, Industrial, Resort, Agricultural, Public and Quasi-Public, Parks and Recreation, Preservation, Military and Other (Streets, highways, etc.).

Primary Urban Center has approximately 65,430 acres of land. Among the Development Plan areas, the PUC has the largest areas designated for Commercial (1282 acres), Apartment: high, medium, and low densities combined (1,689 acres), Residential (8,908 acres), Public (8908 acres), and Park (2,068 acres). Other significant designations include Resort (104 acres), Industrial (1,359 acres), and

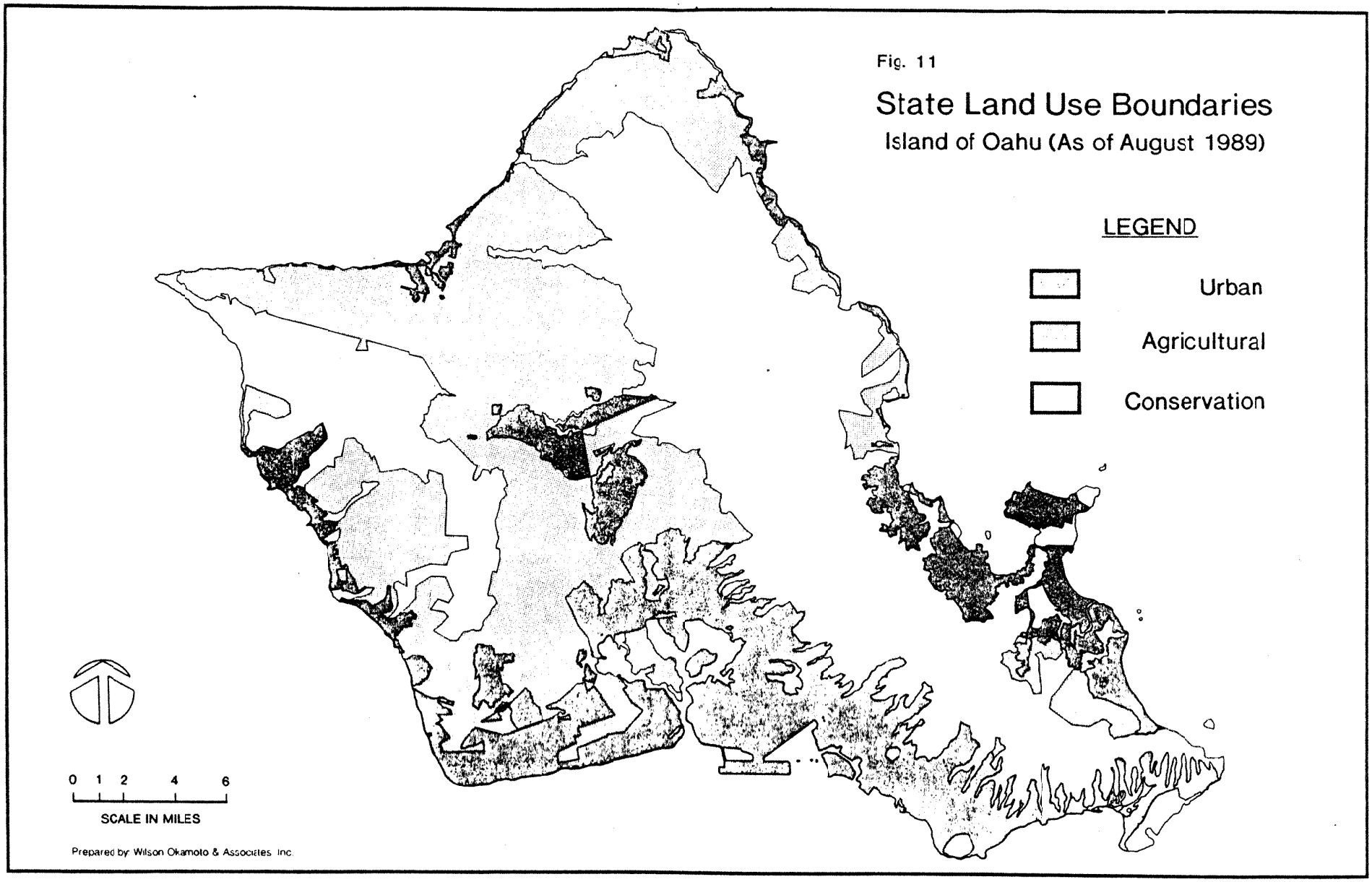
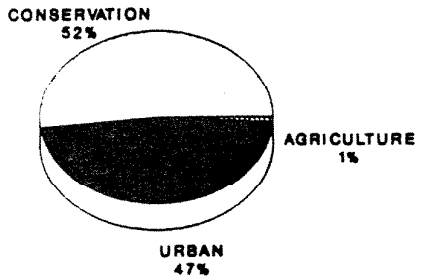


Fig. 11
State Land Use Boundaries
Island of Oahu (As of August 1989)
LEGEND
Urban
Agricultural
Conservation
0 1 2 4 6
SCALE IN MILES
Prepared by Wilson Okamoto & Associates Inc.

CITY AND COUNTY OF HONOLULU
STATE LAND USE DISTRICTS



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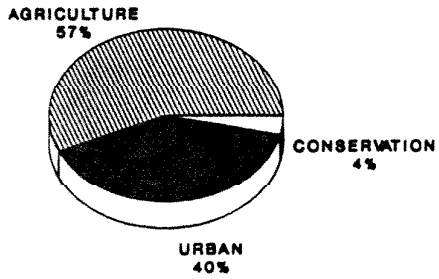
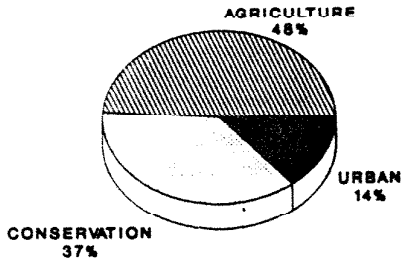
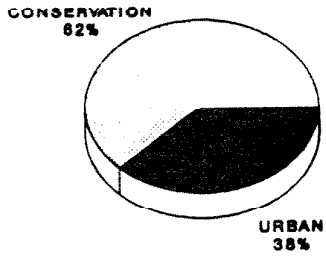


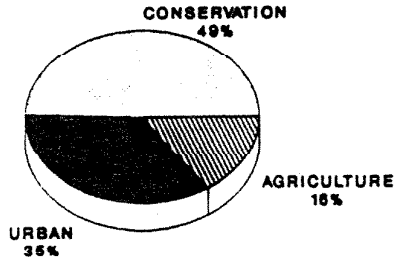
EWA



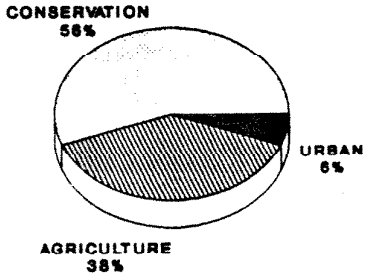
CENTRAL OAHU



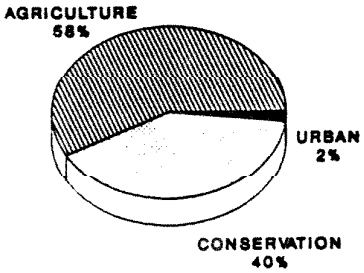
EAST HONOLULU



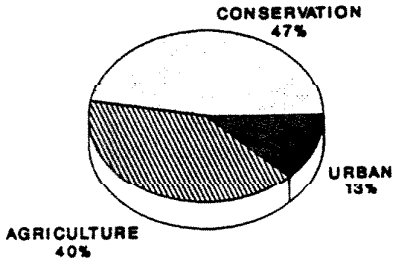
KOOLAUPOKO



KOOLAULOA



NORTH SHORE



WAIANAE

Fig. 12

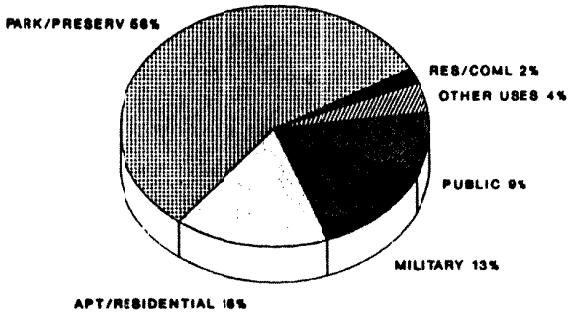
TABLE 1

CITY AND COUNTY OF HONOLULU
STATE LAND USE DISTRICTS
(1988 data, in acres)

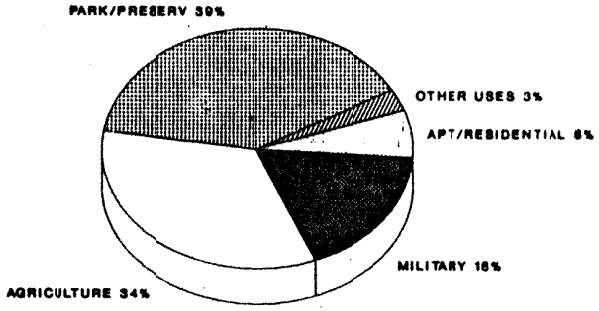
DEVELOPMENT PLAN AREA	URBAN	AGRICULTURE	CONSERVATION	TOTAL
PRIMARY URBAN CENTER	30,867	628	33,913	65,409
EWA	13,177	18,721	1,187	33,086
CENTRAL OAHU	9,890	33,630	25,878	69,398
EAST HONOLULU	5,371	0	8,925	14,296
KOOLAUPOKO	14,459	6,410	20,370	41,240
KOOLAULOA	2,208	14,244	20,582	37,034
NORTH SHORE	1,481	44,650	30,948	77,080
WAIANAE	4,797	15,396	17,910	38,103
TOTALS	82,251	133,681	159,714	375,646

Source: Dept. of General Planning, Planning Information Branch

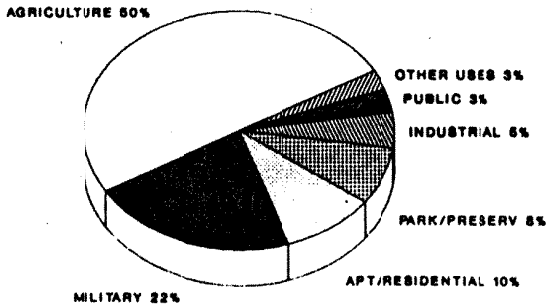
CITY AND COUNTY OF HONOLULU
DEVELOPMENT PLANS: LAND USE DESIGNATIONS



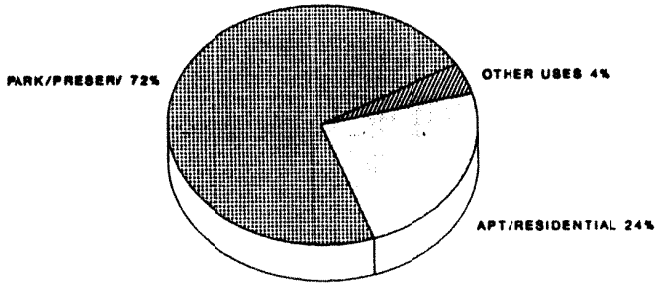
P.U.C.



CENTRAL OAHU



EWA



EAST HONOLULU

Fig. 13A

TABLE 2

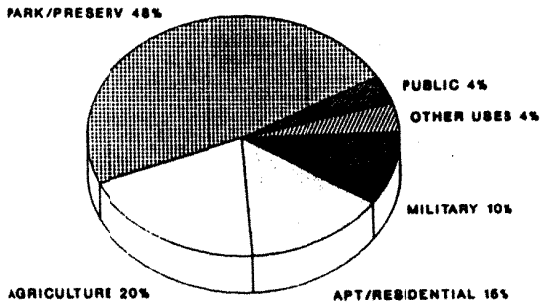
CITY AND COUNTY OF HONOLULU
DEVELOPMENT PLANS: LAND USE DESIGNATIONS

(1988 data, in acres)

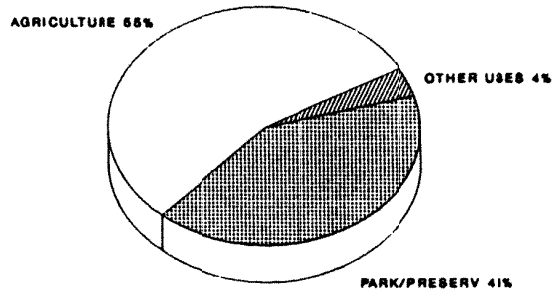
DESIGNATION	PUC	EWA	CENTRAL OAHU	EAST HONOLULU	KOOLAUPOKO	KOOLAULOA	NORTH SHORE	WAIANAE	TOTAL
RESORT	104	81	0	6	0	297	0	57	546
INDUSTRIAL	1,359	1,601	390	17	128	3	32	46	3,575
COMMERCIAL	1,282	715	416	86	218	101	53	86	2,958
APARTMENT	1,689	1,136	823	246	200	39	20	76	4,229
RESIDENTIAL	8,908	2,054	3,628	3,171	5,844	802	710	1,859	26,976
PUBLIC	5,862	1,051	1,012	200	1,559	237	848	498	11,267
PARK	2,068	782	901	389	1,493	969	696	623	7,922
AGRICULTURE	636	16,567	23,274	114	8,107	13,809	42,393	9,659	114,558
PRESERVATION	34,586	1,812	26,220	9,891	18,247	20,757	30,893	17,853	160,259
MILTARY	8,286	7,158	12,333	3	4,156	0	346	6,884	39,167
OTHER	649	88	270	171	1,283	21	1,079	463	4,022
TOTAL	65,430	33,045	69,266	14,294	41,233	37,035	77,070	38,104	375,478

Source: Dept. of General Planning, Planning Information Branch

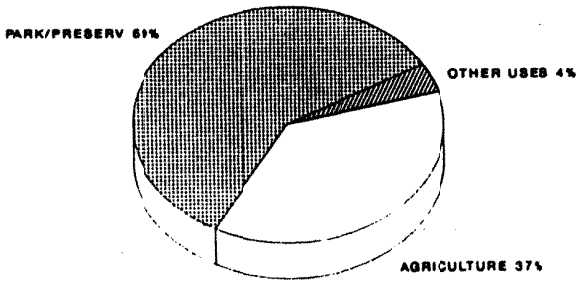
CITY AND COUNTY OF HONOLULU
DEVELOPMENT PLANS: LAND USE DESIGNATIONS



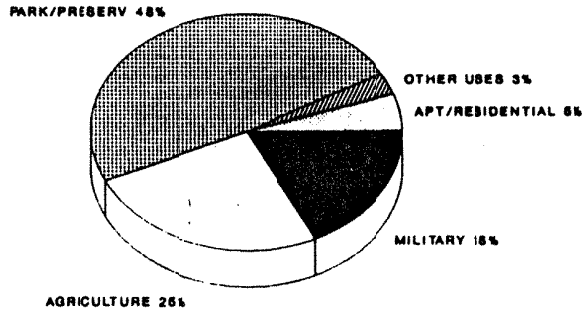
KOOLAUPOKO



NORTH SHORE



KOOLAULOA



WAIANAE

Fig. 13B

Military (8,286 acres).

Ewa encompasses approximately 33,045 acres of land of which about 50 percent is designated Agriculture (16,567 acres). Among the Development Plan areas, Ewa has the largest acreage designated Industrial (1,601 acres). Other significant designations include Commercial (715 acres), Apartment (1,136 acres), Residential (2,054 acres), and Military (7,158 acres).

Central Oahu consists of an estimated 69,267 acres of land, 70 percent of which is designated either Agriculture (23,274 acres) or Preservation (26,220 acres). Among the Development Plan areas, Central Oahu has the largest area designated for Military (12,333 acres). Other significant designations include Industrial (390 acres), Commercial (416 acres), and Residential (3,628 acres).

East Honolulu encompasses 14,294 acres of lands. Mostly in Preservation (9,891 acres), the only other significant designation is Residential (3,171 acres).

Koolaupoko encompasses 41,233 acres of land, of which almost 45 percent is designated Preservation. Other significant designations include Residential (5,844 acres), Park (1,493 acres), Agriculture (8,107 acres), and Military (4,156 acres).

Koolauloa encompasses 37,034 acres of land, over half of which is designated Preservation (20,757 acres). Among the Development Plan areas, Koolauloa has the largest acreage designated Resort (297 acres). Other significant designations include Park (969 acres) and Agriculture (13,809 acres).

North Shore encompasses 77,070 acres on the north end of Oahu. It has the largest acreage of land designated for Agriculture (42,393 acres) as well as significant acreage in Preservation (30,893 acres).

Waianae encompasses 38,103 acres of which over 70 percent is designated for Agriculture (9,659 acres) and Preservation (17,853 acres). Other significant designations include Residential (1859 acres) and Military (6884 acres).

2.8.3 City and County of Honolulu Land Use Ordinance

Table 3 shows the acreage of zoning districts by the Development Plan area, as well as the total acreage for the City and County of Honolulu. The purpose of the City and County of Honolulu Land Use Ordinance (LUO) is to regulate land use to encourage orderly development in accordance with adopted land use polices, including the Oahu General Plan and Development Plans, and to promote and protect the public health, safety and welfare by:

A. Minimizing adverse effects resulting from the inappropriate location, use or design of sites and structures.

TABLE 3

CITY AND COUNTY OF HONOLULU
LAND USE ORDINANCE: ZONING

(1988 data, in acres)

ZONE DESIGNATION	PUC	EWA	CENTRAL OAHU	EAST HONOLULU	KOOLAUPOKO	KOOLAULOA	NORTH SHORE	WAIANAE	TOTAL
SP. DES. DISTRICT	942	0	0	0	0	0	0	0	942
S. FAM. RES.	11413	2182	3905	3378	6022	1012	755	1671	30338
APARTMENT	1732	600	734	200	200	39	19	88	3612
BUSINESS	1055	183	311	86	220	399	40	116	2410
INDUSTRIAL	4259	2221	384	0	81	0	45	86	7076
AGRICULTURE	768	18724	24048	148	9151	13838	44213	10195	121085
PRESERVATION	45260	9137	39884	10481	25559	21747	31998	25947	210013
TOTAL	65429	33047	69266	14293	41233	37035	77070	38103	375476

Source: Dept. of General Planning, Planning Information Branch

B. Conserving the City's natural, historic and scenic resources and encouraging design which enhances the physical form of the City.

C. Assisting the public in identifying and understanding regulations affecting the development and use of land.

The LUO provides development and design standards for the location, height, bulk and size of structures, yard areas, off-street parking facilities, and open spaces, and the use of structures and land for agriculture, industry, business, residences or other purposes.

Figures 14A and 14B summarize the land uses in each of the Development Plan areas. The Primary Urban Center (PUC) has the largest acreage zoned for Single-Family Residences, Apartment, Business, and Industrial in the City and County of Honolulu. The PUC also has 942 acres zoned in the Special Design Districts, specifically Waikiki and Kakaako.

In Ewa, which is planned as the Secondary Urban Center for Oahu, the majority of the total acreage is currently zoned for agriculture (18,724 acres). Ewa has almost one-third of the total industrial zoned district (2,221 acres) for Oahu and less than five percent of the lands zoned for Preservation (9,137 acres). Most of the preservation lands are zoned for military use (F-1).

In Central Oahu, over one-half the area is zoned for preservation (39,884 acres) with much of the land being used by the military (12,554 acres). Other significant land use districts include agriculture (24,048 acres), single-family residential (3,905 acres) and apartment (734 acres).

East Honolulu is the smallest Development Plan area. Almost three-fourths of the land is zoned for preservation (10,481 acres) with the balance in single-family residential (3,378 acres).

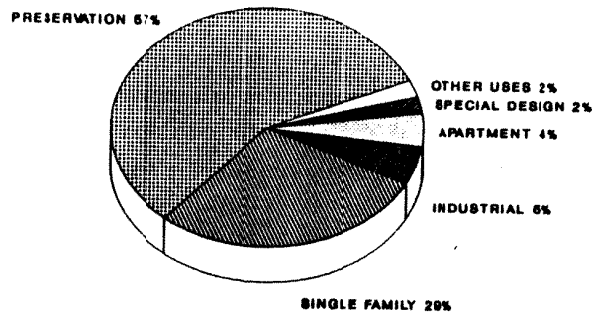
In Koolaupoko, much of the land area is zoned for preservation (25,559 acres). Other important zone districts are single-family residential (6,022 acres) and agriculture (9,151 acres).

Koolauloa largely consists of lands zoned for preservation (21,747 acres) and agriculture (13,838 acres).

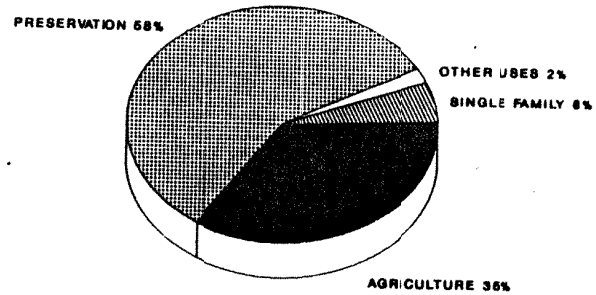
In the North Shore, almost the entire area is zoned for agriculture (44,213 acres) and preservation (31,998 acres).

In Waianae, with over two-thirds of the area zoned Preservation (25,947 acres), the only other significant zone district is agriculture (10,195 acres).

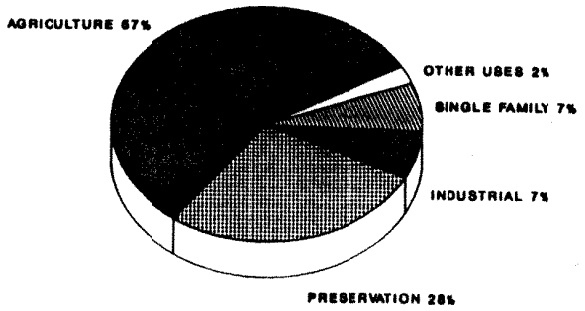
CITY AND COUNTY OF HONOLULU
LAND USE ORDINANCE: ZONING



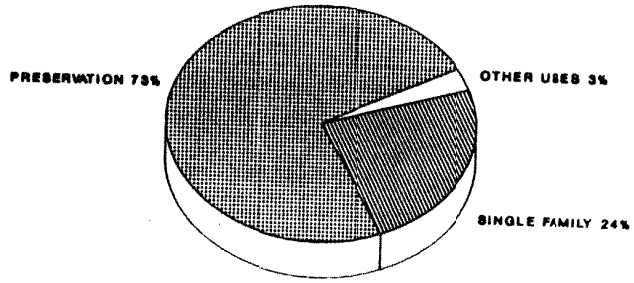
P.U.C.



CENTRAL OAHU



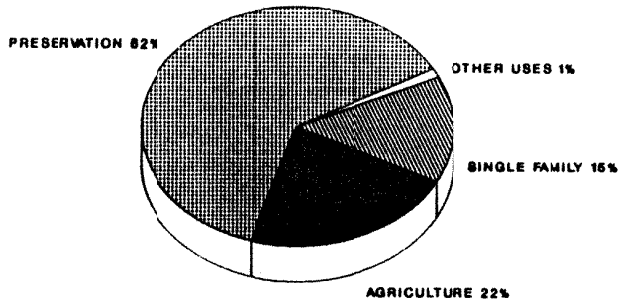
EWA



EAST HONOLULU

Fig. 14A

CITY AND COUNTY OF HONOLULU
LAND USE ORDINANCE: ZONING



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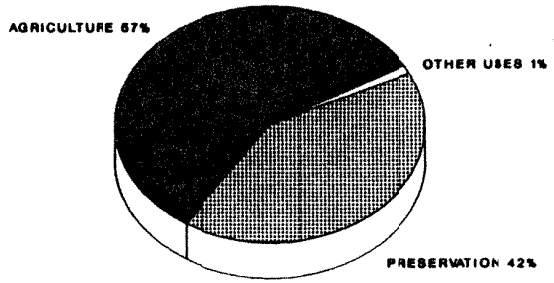
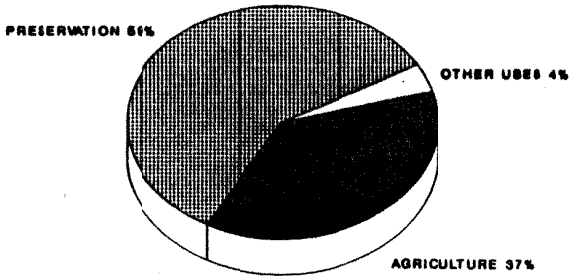
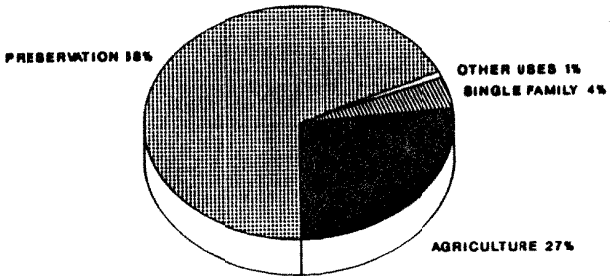


NORTH SHORE



KOOLAULOA



WAIANAE

Fig. 14B

2.9 COUNTY GENERAL PLAN AND LAND USE POLICIES

The City and County of Honolulu General Plan specifies long-range objectives and policies to guide both the quantity and quality of future growth on Oahu. The General Plan is a statement of the long-range social, economic, environmental, and design objectives for the general welfare and prosperity of the people of Oahu. The General Plan also provides broad policies which facilitate the attainment of the objectives of the Plan. The General Plan was first adopted in 1977 and subsequently amended in 1979, 1982, 1985, 1987 and 1989. Relevant objectives and policies of the Oahu General Plan are reviewed in the following subsections.

2.9.1 Population Policies

The population policies of the General Plan establish the basic direction for growth on Oahu. They call for full development of the Primary Urban Center and secondarily encourage development in the Ewa and Central Oahu areas. These policies and the more detailed Development Plan land use and public facilities maps will determine the areas in which water use demands will need to be accommodated. Figure 15 shows the planned urbanized areas to the year 2010.

Objective B:
To plan for future population growth.

Objective B, Policy 2:
Provide adequate support facilities to accommodate future growth in the number of visitors to Oahu.

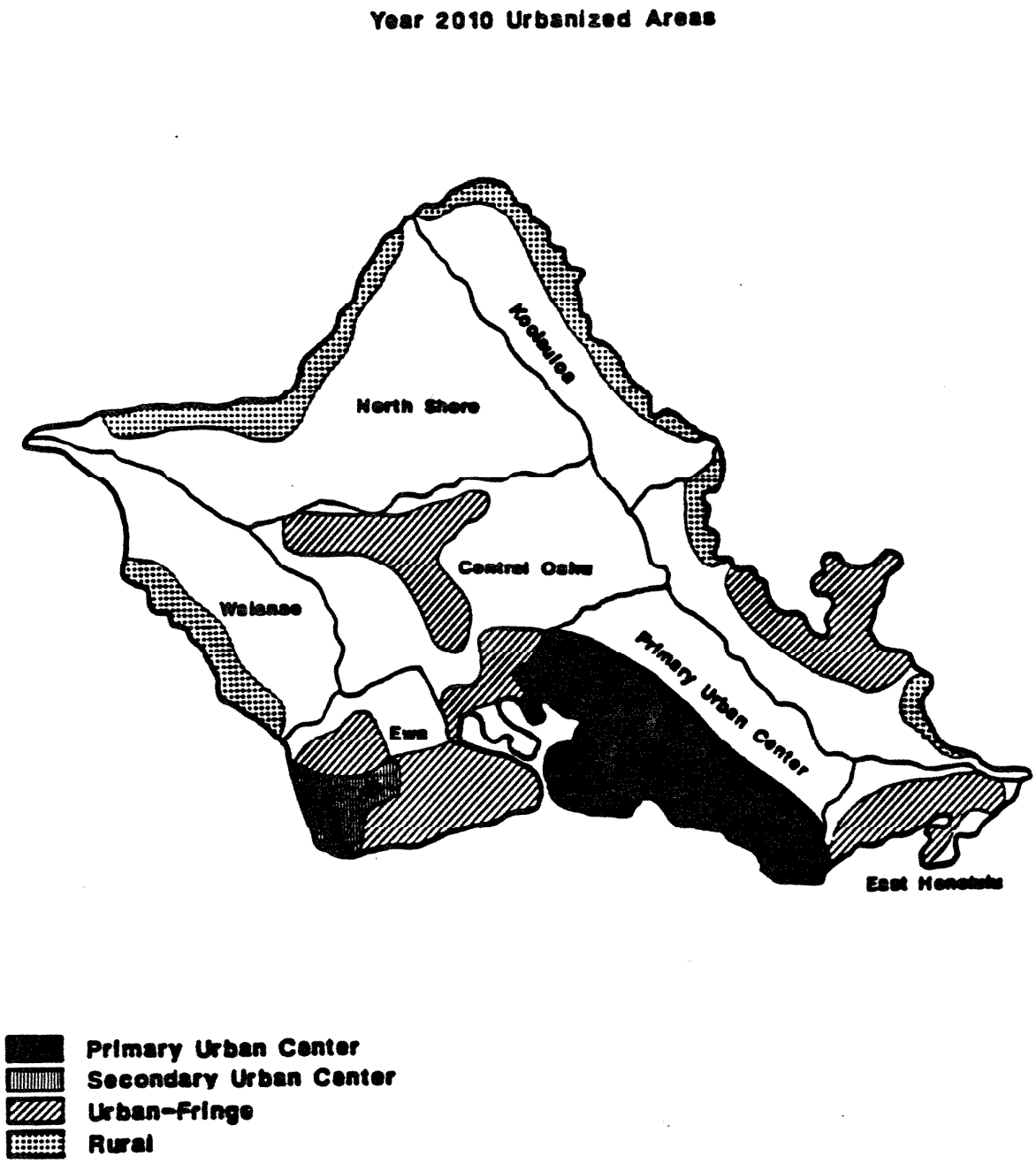
Objective C:
To establish a pattern of population distribution that will allow the people of Oahu to live and work in harmony.

Objective C, Policy 1:
Facilitate the full development of the primary urban center.

Objective C, Policy 2:
Encourage development within the secondary urban center at Kapolei and the Ewa and Central Oahu urban-fringe areas to relieve developmental pressures in the remaining urban-fringe and rural areas and to meet housing needs not readily provided in the primary urban center.

Objective C, Policy 3:
Manage physical growth and development in the urban-fringe and rural areas so that:

a) An undesirable spreading of development is prevented; and



Source: DGP 1989

YEAR 2010 URBANIZED AREAS

Fig. 15

b) Their population densities are consistent with the character of development and environmental qualities desired for such areas.

Objective C, Policy 4:
Seek a year 2010 distribution of Oahu's residential population which would be in accord with Table 4. (See also Figure 16.)

2.9.2 Economic Activity

The economic activities policies of the General Plan establish the basic direction for orderly economic growth on Oahu. They address the major industries of tourism, agriculture, and the military. These policies and the more detailed Development Plan land use and public facilities maps encourage the efficient use of water, and will determine the water use demand of Oahu's major industries.

Objective B, Policy 6:
Permit the development of secondary resort areas in West Beach, Kahuku, Makaha, and Laie.

Objective B, Policy 7:
Manage the development of secondary resort areas in a manner which respects existing lifestyles and the natural environment, and avoids substantial increases in the cost of providing public services in the area.

Objective C:
To maintain the viability of agriculture on Oahu.

Objective C, Policy 1:
Assist the agricultural industry to ensure the continuation of agriculture as an important source of income and employment.

Objective C, Policy 4:
Provide sufficient agricultural land in Ewa, Central Oahu, and the North Shore to encourage the continuation of sugar and pineapple as viable industries.

Objective C, Policy 5:
Maintain agricultural land along the Windward, North Shore, and Waianae coasts for truck farming, flower growing, aquaculture, livestock production, and other types of diversified agriculture.

Objective C, Policy 6:
Encourage the more intensive use of productive agricultural land.

TABLE 4

CITY AND COUNTY OF HONOLULU
POPULATION DISTRIBUTION
1980 AND 2010

DEVELOPMENT PLAN AREA	(1) 1980 COUNT	1980 PERCENT OF TOTAL	(2) 2010 PROJECTION	(3) 2010 PERCENT OF TOTAL
PRIMARY URBAN CENTER	417,240	54.7	450,800 - 497,800	45.1 - 49.8
EWA	35,523	4.7	119,900 - 132,900	12.0 - 13.3
CENTRAL OAHU	101,685	13.3	148,900 - 164,900	14.9 - 16.5
EAST HONOLULU	43,213	5.7	53,000 - 58,000	5.3 - 5.8
KOOLAUPOKO	109,373	14.3	109,900 - 121,900	11.0 - 12.2
KOOLAULOA	10,983	1.4	13,000 - 14,000	1.3 - 1.4
NORTH SHORE	13,061	1.7	16,000 - 18,000	1.6 - 1.8
WAIANAE	31,487	4.1	38,000 - 42,000	3.8 - 4.2
OAHU TOTAL	762,565	100.0	949,500 - 1,049,500	95.0 - 105.0

1) 1980 U.S. Census Data.

2) Population ranges based on the percentages presented in the following column and DBED's Series M-K population projection for the year 2010 of 999,500 for Oahu.

3) From Population Objective C, Policy 4.

CITY AND COUNTY OF HONOLULU
POPULATION DISTRIBUTION

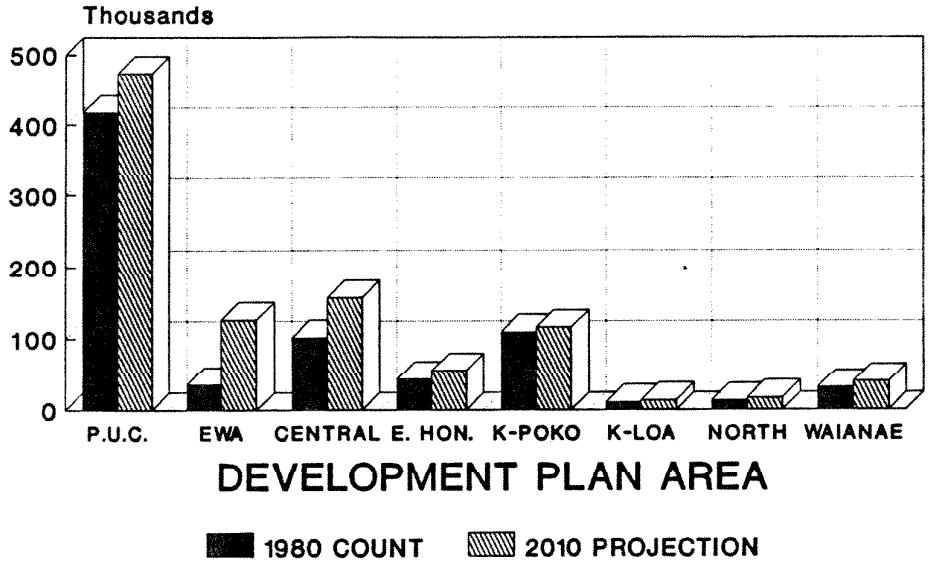


Fig. 16

Objective C, Policy 7:
Encourage the use of more efficient production practices by agriculture, including the efficient use of water.

Objective C, Policy 8:
Encourage the more efficient use of nonpotable water for agricultural uses.

Objective G:
To bring about orderly economic growth on Oahu.

Objective G, Policy 1:
Direct major economic activity and government services to the primary and secondary urban centers.

Objective G, Policy 2:
Permit the moderate growth of business centers in the urban-fringe areas.

Objective G, Policy 3:
Maintain sufficient land in appropriately located commercial and industrial areas to help ensure a favorable business climate on Oahu.

Objective G, Policy 4:
Encourage the continuation of a high level of military-related employment in the Hickam-Pearl Harbor, Wahiawa, Kailua-Kaneohe, and Ewa areas.

2.9.3 Natural Environment

The natural environment policies of the General Plan seek to protect and enhance Oahu's natural attributes by increasing public awareness and appreciation of them and by mitigating against their degradation. These policies and the more detailed Development Plan land use and public facilities maps encourage the preservation and quality of Oahu's water resources.

Objective A:
To protect and preserve the natural environment.

Objective A, Policy 3:
Retain the Island's streams as scenic, aquatic, and recreation resources.

Objective A, Policy 4:
Require development projects to give due consideration to natural features such as slope, flood and erosion hazards, water-recharge areas, distinctive land forms, and existing vegetation.

Objective A, Policy 6:

Design surface drainage and flood-control systems in a manner which will help preserve their natural settings.

Objective A, Policy 7:
Protect the natural environment from damaging levels of air, water, and noise pollution.

Objective A, Policy 10:
Increase public awareness and appreciation of Oahu's land, air, and water resources.

Objective B:
To preserve and enhance the natural monuments and scenic view of Oahu for the benefit of both residents and visitors.

Objective B, Policy 1:
Protect Island's well-known resources: its mountains and craters; forests and watershed areas; marshes, rivers, and streams; shoreline, fishponds, and bays; and reefs and offshore islands.

2.9.4 Housing

The housing policies of the General Plan establish the basic direction for residential development on Oahu. They encourage a choice of ideal living environments, and the full utilization of public utilities and community facilities. These policies and the more detailed Development Plan land use and public facilities maps will determine the residential areas in which water use demands will need to be accommodated.

Objective C:
To provide the people of Oahu with a choice of living environments which are reasonably close to employment, recreation, and commercial centers and which are adequately served by public utilities.

Objective C, Policy 4:
Encourage residential development in areas where existing roads, utilities, and other community facilities are not being used to capacity.

Objective C, Policy 5:
Discourage residential development where roads, utilities, and community facilities cannot be provided at a reasonable cost.

2.9.5 Transportation and Utilities

The transportation and utilities policies of the General Plan address the increasing

demand of residents and visitors for water, sewerage, and solid waste disposal services. They also consider Oahu's agricultural and industrial need for a high level of service for all utilities. These policies and the more detailed development plan land use and public facilities maps will determine the development and maintenance of an adequate supply of water to accommodate Oahu's growing water use demand.

Objective B:
To meet the needs of the people of Oahu for an adequate supply of water and for environmentally sound systems of waste disposal.

Objective B, Policy 1:
Develop and maintain an adequate supply of water for both residents and visitors.

Objective B, Policy 2:
Develop and maintain an adequate supply of water for agricultural and industrial needs.

Objective B, Policy 3:
Encourage the development of new technology which will reduce the cost of providing water and the cost of waste disposal.

Objective B, Policy 4:
Encourage a lowering of the per-capita consumption of water and the per-capita production of waste.

Objective B, Policy 5:
Provide safe, efficient, and environmentally sensitive waste-collection and waste-disposal services.

Objective B, Policy 6:
Support programs to recover resources from solid-waste and recycle wastewater.

Objective C:
To maintain a high level of service for all utilities.

Objective C, Policy 1:
Maintain existing utility systems in order to avoid major breakdowns.

Objective C, Policy 2:
Provide improvements to utilities in existing neighborhoods to reduce substandard conditions.

Objective C, Policy 3:
Plan for timely and orderly expansion of utility systems.

Objective C, Policy 4:
Increase the efficiency of public utilities by encouraging a mixture of uses with peak periods of demand occurring at different times of the day.

2.9.6 Physical Development and Urban Design

The physical development and urban design policies of the General Plan establish the basic direction for both new developments and older communities in conjunction with their supporting public facilities and utilities. The policies focus first on the Primary Urban Center, second on Ewa, and third on the urban-fringe and rural areas. These policies and the more detailed Development Land use and public facilities maps determine the utilities needed to provide adequate water supply to both existing and planned developments.

Objective A:
To coordinate changes in the physical environment of Oahu to ensure that all new developments are timely, well-designed, and appropriate for the areas in which they will be located.

Objective A, Policy 1:
Plan for the construction of new public facilities and utilities in the various parts of the Island according to the following order of priority: first, in the primary urban center; second, in Ewa; and third, in the urban-fringe and rural areas.

Objective A, Policy 2:
Coordinate the location and timing of new development with the availability of adequate water supply, sewage treatment, drainage, transportation, and public safety facilities.

Objective A, Policy 3:
Phase the construction of new developments so that they do not require more regional supporting services than are available.

Objective A, Policy 4:
Require new developments to provide or pay the cost of all essential community services, including roads, utilities, schools, parks, and emergency facilities that are intended to directly serve the development.

Objective A, Policy 6:
Encourage the clustering of developments to reduce the cost of providing utilities and other public services.

Objective B:
To develop Honolulu (Waialae-Kahala to Halawa), Aiea, and Pearl City as the Island's primary urban center.

Objective C:
To develop a secondary urban center in Ewa with its nucleus in the Kapolei area.

Objective E, Policy 3:
Provide and maintain roads, public facilities, and utilities without damaging the character of older communities.

2.10 CITY AND COUNTY OF HONOLULU DEVELOPMENT PLAN

Development Plans prepared for the eight planning districts on Oahu provide detailed schemes for implementing the objectives and policies of the General Plan. The Development Plans guide the desired sequence, patterns and characteristics of future development. Development Plans consist of three elements: Common Provisions, Special Provisions (for each of the eight planning areas), and Development Plan Land Use Maps and Public Facility Maps. These plans also provide maps that indicate: 1) the planned distribution and intensity of land uses and public facilities; 2) statements of standards and principles with respect to land uses: 3) statements of urban design principles and controls; and 4) statements indicating the sequence in which future development is to occur. The Development Plan Land Use Map (1987) is presented in Figure 17. Relevant provisions which guide development in each of the eight Development Plan areas are described in the following sections.

2.10.1 Primary Urban Center

The Primary Urban Center (PUC) is the area that includes the communities from Waialae-Kahala to Pearl City. It consists of 12 Special Areas: Downtown, Waikiki, McCully-Moilili, Alapai-Sheridan, Makiki/Punchbowl, Kakaako, Nimitz/Ala Moana Corridor, Ala Moana, Airport, Kalihi-Palama, Capital District, and Diamond Head. It is the most populated part of the State of Hawaii and is Oahu's largest employment center.

The following outlines the desired land use pattern for the PUC:

1) The overall pattern of urban development within the PUC shall continue to be linear, running parallel with the shoreline and bounded by mountainous conservation lands and the sea.

2) Medium and higher density residential uses are to occur along the coastal plain, near the major travel corridors, with maximum heights primarily within the central urban core. Medium- and high-rise residential buildings shall be sufficiently spaced for recreational and visual purposes. Suburban low-density, low-rise residential development to remain along the lower mountain ridges and inner valley floors, and in the coastal areas of Kahala

and Diamond Head.

3) Commercial uses are to be located along the major roadways, with the exception that small neighborhood oriented commercial uses may be located within low-density residential and apartment areas. Apartments in mixed use with commercial are permitted, subject to appropriate zoning regulations and where public facilities and services are adequate to serve mixed uses, and the area is accessible by major transportation corridors.

4) Major industrial centers and complexes are to be located near major transportation facilities such as Honolulu Harbor, the Airport, and the H-1 Freeway. Areas designated Industrial are to be isolated or buffered from other uses to avoid the negative impact of industrial uses.

5) Waikiki is maintained as Hawaii's primary visitor destination area, with emphasis on improving the quality of the environment and discouraging further high density development in the area. New hotel development may be permitted outside of Waikiki in areas where it will not significantly disrupt existing lifestyles, alter the natural environment, or raise the cost of providing public services in the area. Such areas include the Downtown, Ala Moana, and Airport special areas. Additional sites may be designated in accordance with adopted amendment procedures. Sufficient hotel sites may be provided outside of Waikiki to accommodate about 5,000 visitor units.

6) To promote a pleasing and attractive urban setting and to maintain a strong sense of the nearness of open space and nature, a strong mauka-makai orientation is promoted through the establishment and preservation of mauka-makai view corridors and open space belts along streams. Panoramic views and views of major landmarks are also to be protected.

7) Adequate amounts of recreational facilities and public parks are to be provided for active and passive recreation, particularly in areas where redevelopment or other activities create opportunities for new urban open spaces.

8) The visual impact of taller structures along major roadways and pedestrian corridors are to be minimized through the use of appropriate building setbacks, plantings adjacent to walkways, and open space areas.

The planning, funding, and construction of public projects in the Primary Urban Center supports the following uses in the priority shown:

1) Rapid transit system and stations, including infrastructure improvements along the transit line to support expanded activity at and around transit stations.
2) Affordable housing projects.

3) Upgrade existing infrastructure in Downtown.
4) Industrial areas in Kalihi/Palama/Kalihi Kai.
5) Infrastructure improvements in Waikiki.
6) Public facilities to support a Convention Center.
7) Honolulu Waterfront development.

2.10.2 Ewa

The Ewa Development Plan area encompasses the coral plain which stretches from the Central Oahu district boundary at Waipahu and Pearl Harbor, around the southwestern corner of the island, to Nanakuli. The coral plain meets the moderately steep slopes of the southerly end of the Waianae mountain range, which form Ewa's mauka sector, and contains some of the finest agricultural lands in the State. The Ewa Development Plan area consists of three Special Areas: West Beach, Ewa Villages, and Ewa Marina.

A new secondary urban center is to be gradually developed in the West Beach-Makakilo area in order to accommodate most of the expected influx of population into the area to the year 2000 and beyond.

On the makai part of the Barbers Point coral plain, the present industrial area may expand mauka. Compatible commercial uses may be developed along with the industrial uses.

In addition, sufficient prime and other important agricultural lands are to be provided in Ewa in accordance with the general plan policy "to encourage the continuation of sugar and pineapple as viable industries." This recognizes the important contribution of agricultural lands to the sugar and pineapple industries in Central Oahu, North Shore, and Ewa.

The distinct identities of the existing communities of Makakilo, the Ewa Plantation Villages and Ewa Beach shall also be protected and enhanced. Additional development consistent with these identities shall be permitted in Makakilo as part of the gradual development of the secondary urban center, in the Ewa Plantation Villages area to provide additional affordable housing and permit the improvement of existing infrastructure, and westerly of Ewa Beach to provide additional housing, commercial, and recreational facilities.

The West Beach Special Area is to be an integral part of the central core of the West Beach-Makakilo Secondary Urban Center. The area, containing approximately 640 acres of land, lies on the shoreline between Kahe Point Beach Park and the site of the Barbers Point Deep Draft Harbor. It includes a water-oriented residential and resort community containing a mixture of Low Density Apartment, Medium Density Apartment, Resort, Commercial (comprised of a major shopping complex and a smaller neighborhood shopping area), Public Facility, Park, and Preservation uses, as indicated on the Land Use Map. A marina in the area adjoining the deep draft harbor shall also

be established. The secondary resort destination area will contain up to 4,000 units within the areas designated for Resort use. The West Beach Special Area may also be gradually enlarged subject to demonstrated availability of a market, noise and safety conditions, the adequacy of public facilities, and compatibility with agricultural land requirements.

The Ewa Villages Special Area consists of an area containing approximately 478 acres generally bounded by Fort Weaver Road, Mango Tree Road, Kaloi Gulch, and Geiger Road, is planned to contain a mixture of Residential, Low-Density Apartment, Commercial, Park, and Public Facility (elementary school, transportation center, and civic center) uses.

The Ewa Marina Special Area consists of approximately 707 acres located between the Ewa Beach community and the Barbers Point Naval Air Station is planned for a mixture of Residential, Low Density Apartment, Medium Density Apartment, Commercial, Public Facility (including a marina), Park, and Preservation (waterway and flood control areas) uses.

Public plans, projects, and programs in Ewa shall provide for the implementation of development in the following priority:

1) Public facilities improvements, i.e., wastewater management, transportation, and potable water, to support development of the Secondary Urban Center.
2) Affordable housing.
3) Public structures to provide human services, including child care centers, and public safety services.
4) Development of secondary employment centers.

2.10.3 East Honolulu

East Honolulu includes the area from Aina Koa Ridge to Makapuu Point and is identified as part of Oahu's urban-fringe by the General Plan. The area consists essentially of a string of residential communities clustered along East Honolulu's single transportation corridor (Kalanianaole Highway). The East Honolulu Development Plan area consists of one Special Area, the Hawaii Kai Town Center. The suburban character of the area is firmly established.

The overall pattern of development within East Honolulu is to continue to be linear, running parallel with the shoreline and bounded by the mountainous conservation lands and the sea. Suburban residential development is to remain on the lower ridges, inner valley floors, and along Kalanianaole Highway. Some low- and medium-density apartment uses will be permitted in Hawaii Kai, as designated on the land use map.

The Hawaii Kai Town Center Special Area combines a transportation center, commercial development, neighborhood park, and a mixture of low and medium density apartments. The intent of this Town Center is to provide a mixture of housing

types adjacent to commercial facilities, recreational facilities, and a transportation center designed to promote pedestrian use and the ridership on public transportation facilities and/or carpooling.

In planning, funding, and construction of public projects in East Honolulu, controls shall be established to regulate the implementation of the land use plan until the capacity of Kalanianaole Highway is improved to handle existing traffic requirements and those of additional planned developments. These controls shall not preclude rezoning properties to lower density land uses in order to bring them into conformance with the land use plan. Public plans, projects, and programs shall support uses in East Honolulu in the following priority: expediting the necessary improvements to Kalanianaole Highway; expansion of regional and local park opportunities and preservation of natural open spaces; affordable housing within the Medium- and Low-Density Apartment uses in Hawaii Kai; and Preservation of beach access.

2.10.4 Central Oahu

Central Oahu consists of the wide fertile plateau between the Waianae and the Koolau mountain ranges. The area includes the towns of Waipahu and Wahiawa, and the residential communities of Crestview, Waipio, Mililani, Waipio Acres, and Melemanu Woodlands. Adjacent to Wahiawa are the Schofield Barracks and Wheeler Air Force Base military reservations. Surrounding these suburban communities are some of the State's finest prime agricultural lands. The Central Oahu Development Plan area consists of two Special Areas, Waikele Planned Community and Mililani Technological Park.

The dominant land use in Central Oahu is agriculture, followed by military activities at Wheeler Air Force Base, Schofield Barracks, and the Naval Reservation on Waipio Peninsula. Although increased development of lands for residential use is projected for the area, especially in Waipahu, Waipio, and Mililani, the major contribution Central Oahu makes toward sustaining the State's agricultural industry dictates that the present level of agricultural activity in the district be substantially maintained. This is supported by the General Plan policy that identifies Ewa, the North Shore, and Central Oahu as areas for the provision of sufficient agricultural lands "to encourage the continuation of sugar and pineapple as viable industries."

Waipahu is a growing, low-density, suburban community with some medium-density apartments. Most new residential growth will occur in areas mauka of the H-1 Freeway while the area makai of the freeway can be characterized as a basically stable community with residential development occurring mauka of the Waipahu Sugar Mill.

The Waikele Planned Community Special Area shall be developed as an integral part of the larger Waipahu community. The area planned for development contains approximately 586 acres of land abutting the H-1 Highway and situated directly north of the Waipahu community, between the Waikele Gulch to the west and the

Kamehameha Highway to the east. Waikele is a master planned residential community containing a mixture of residential uses; low-density apartment uses; commercial uses, including a village commercial center and office centers; public and quasi-public facilities; and park areas and facilities. A total of about 3,000 residential units shall be permitted to be developed within the area.

The Mililani Technology Park Special Area, situated east of the H-2 Freeway between the Leilehua Golf Course and Waikakalaua Gulch, is to be developed as a low-rise, campus-style technology industrial park characterized by extensive open space and landscaping.

Public plans, projects, and programs in Central Oahu provide for development in the following priority:

1) Public facility improvements, i.e. wastewater management, transportation, and potable water.
2) Provision of affordable housing which conforms to the General Plan population distribution.
3) Improvement of infrastructure to encourage redevelopment of Waipahu and Wahiawa.

2.10.5 Koolaupoko

Koolaupoko spans the windward coastal and valley areas of Oahu from Makapuu Point to Kaoio Point at the northern end of Kaneohe Bay, and is bounded by the Koolau mountain range and the sea. It includes the agricultural communities of Kahaluu, Waiahole-Waikane, Kualoa, and Waimanalo and the more suburban communities of Kaneohe and Kailua. Suburban single-family development is to be the predominant residential use surrounded by substantial amounts of open space and agricultural land. Limited apartment uses will be permitted close to regional commercial and industrial centers, but future apartments will be low-rise in keeping with the overall open space setting of Koolaupoko.

It is intended that communities of Kailua and Kaneohe will remain stable, predominantly single-family suburban "bedroom communities" and that Waimanalo will remain a rural community having extensive acreage devoted to diversified agricultural pursuits surrounding a small low density residential area. The communities of Kahaluu, Waiahole-Waikane and Kualoa are to remain relatively lightly settled, rural areas with the exception of limited areas in Heeia Kea and Ahuimanu Valley, where residential development of a low-density suburban character already exists.

Public plans, projects, and programs in Koolaupoko shall support the following priorities: the improvement of water resources to support development of agricultural and aquacultural uses in appropriate areas which include Waimanalo and Kahaluu-Kualoa; the improvement of the State highway transportation system; and the

improvement of the quality of wastewater management services provided to existing development.

2.10.6 Koolauloa

The Koolauloa Development Plan area comprises the northern half of Oahu's windward coast and is bounded on the north by the ridgeline of the northerly end of the Koolau mountain range and on the south by the ridgeline extending makai between Kualoa Point and Kaaawa Stream. Kamehameha Highway is the only arterial roadway linking this area with the adjacent communities on the North Shore and in Koolaupoko. Residential communities bordering Kamehameha Highway include Kaaawa, Punaluu, Hauula, Laie, and Kahuku. The Koolauloa Development Plan area consists of two Special Areas, the Kahuku Point-Kawela Bay Resort Area and the Laie Resort Area.

The land use pattern shown on the land use map provides for the preservation of the predominantly rural character of Koolauloa by allowing only limited single-family residential development and confining further tourist oriented development to the Kahuku Point-Kawela Bay area.

Further development within the Koolauloa area, particularly in the Kahuku Point-Kawela Bay area, is to be sensitive to the delicate coexistence between the natural scenic, recreational, and agricultural resources of the area. This is to be accomplished by minimizing adverse impacts on and preserving important agricultural lands and public views, maintaining public access to recreational areas, and providing building designs which reflect the rural character of the area. Residents are to continue to be offered the opportunity to develop social patterns and life styles within a rural setting as expressed by neighborhoods or small housing clusters which are defined by open space boundaries and which blend into the surrounding landscape with as little disruption as possible to the scenic quality of the area.

The existing balance between the single-family residential character of Laie-Kahuku Town and the tourist-oriented activities of the Polynesian Cultural Center and the Kahuku Sugar Mill, is to be maintained so that those resort and commercial activities do not dominate.

The Kahuku Point-Kawela Bay Resort Area is designated for Resort, Commercial, Low-Density Apartment and Park (Golf Course) uses between Kahuku Point and Kawela Bay. Resort development in this area is to continue and be expanded. The resort facilities shall be limited to 4,000 visitor units within the area designated for resort use. In addition, a total of four park sites, as indicated on the Koolauloa Development Plan Map, shall be provided and shall be open to the general public.

In the Laie Resort Area, resort facilities are to be limited to 300 visitor units within the area designated for Resort use. Public plans, projects, and programs in Koolauloa shall support the following priorities: improvement of drainage facilities; establishment of rural preservation and development standards; improvement of water resources to

support development of agricultural, aquacultural, and needed urban uses; and expansion of public beach parks and beach access.

2.10.7 North Shore

The slopes of the northerly ends of the Koolau and Waianae mountain ranges form a natural backdrop for the rural communities of the North Shore. This area extends from Waialee Gulch near Kawela Bay to Kaena Point and consists of one Special Area, Haleiwa Town.

The North Shore is a well-defined drainage basin through which major streams flow into the Kaiaka, Waialua, and Waimea Bays. The primary land use is agriculture. Small coastal residential strips occurring at Mokuleia, Waimea, Pupukea, Sunset Beach, and Kawailoa Camp are surrounded by agricultural uses and open space. The large communities of Haleiwa and Waialua are based on a long-established rural life-style which is still predominant today.

With the exception of some increases in residential development in the Haleiwa-Waialua area, the agricultural, open space character of this district is to be retained. Residents are to continue to be offered the opportunity to develop social patterns and life styles within neighborhoods or small housing clusters that are defined by open space boundaries and that blend into the surrounding open space and agricultural setting with as little disruption as possible to the scenic quality of the area.

Haleiwa Town, a Special Area, is situated along Kamehameha Highway, generally bounded by the shoreline, Haleiwa Beach Park and Weed Circle. The intent is to retain the rural character of Haleiwa Town while accommodating its needs as the major activity center for residents and visitors of the North Shore.

Public plans, projects, and programs in the North Shore are to support the following priorities: improvement of wastewater management services; improvement of the highway system, particularly the Haleiwa bypass road; expansion of beach parks and beach accesses; improvement of water resources to support agricultural, aquacultural and needed urban uses; and the development of employment opportunities for North Shore residents.

2.10.8 Waianae

The Waianae Development Plan area covers the arid coastal fringe from the Ewa-Waianae boundary, north of the Kahe Power Plant, to Kaena Point, and is enclosed by the Leeward slopes of the Waianae mountain range. It is the driest of all Oahu regions, with good beaches and other ocean-oriented recreational resources. Small farms and scattered residences surround the four principal communities: Nanakuli, Maili, Waianae, and Makaha. These rural communities are linked by Waianae's main arterial, Farrington Highway, from which dramatic views of the Leeward Coast and

rugged Waianae mountain range may seen. The Waianae Development Plan area consists of one Special Area, the Makaha Valley.

It is the intent of the Waianae Development Plan that the pattern of the urban development in Waianae generally remain linear along Farrington Highway, with relatively low building heights. The overall agricultural and open space setting is to be retained. The area between Keeau Beach Park and Kaena Point are to be left undeveloped. With the exception of minor infillings, no further urban development is to be allowed on the makai side of Farrington Highway other than parks and single-family residential dwellings.

The Makaha Valley area is designated for Residential, Resort and Park (Golf Course) use in the south-central portion of Makaha Valley. It is to continue as a visitor destination area with some modest expansion. Hotels and apartments are be limited to 1,000 units within the areas designated for Resort use.

Public plans, projects, and programs in Waianae are to support the following priorities: improvement of water resources to support development of agricultural, residential, and resort uses; encouraging the development of agricultural uses; improvement of sewer facilities; improvement of public beach parks and acquisition and preservation of beach access; and improvement of transportation facilities to provide alternative routing and greater mobility during times of regional disasters.

2.11 FUTURE PROJECTIONS

2.11.1 Population Projections

The State Department of Business and Economic Development (DBED) in November 1988 issued its newly revised economic and population projections for Hawaii designated series "M-K." This series covers the period from 1985 to 2010 and constitutes the official population and economic projections for the State of Hawaii.

The M-K projections anticipate that the resident population of the City and County of Honolulu will rise 23 percent from 811,100 in 1985 to 999,500 in 2010. Oahu will account for 70 percent of the total State resident population of 1,435,500 in 2010, down from 77 percent of the 1985 State total of 1,051,500.

The de facto population of the City and County of Honolulu which includes visitors, is expected to increase 27 percent from 861,600 in 1985 to approximately 1,094,700 in 2010. Oahu will contribute only 65 percent of the State's total de facto population in 2010, a decrease from 75 percent in 1985. The Neighbor Islands are expected to receive a proportionately greater share of population increase and visitors relative to Oahu.

As part of its General Plan review, the City and County of Honolulu's Department of General Planning has revised its projections based on the Series M-K Population

Projections by the DBED. The General Plan divides the City and County of Honolulu into eight Development Plan areas and establishes population percentage ranges which guide the distribution of population growth for each of these areas. The eight Development Plan areas are Primary Urban Center, Ewa, Central Oahu, East Honolulu, Koolaupoko, Koolauloa, North Shore, and Waianae. Table 4 summarizes these Development Plan areas and their projected resident population distributions according to the objectives established by the City and County of Honolulu's revised General Plan.

2.11.2 Economic Projections

The three major economic forces in the City and County of Honolulu, as well as in the State of Hawaii, will continue to be tourism, the military, and agriculture, primarily sugar and pineapple exports. A brief analysis of projections for each industry is given below.

Tourism. Tourism, as in the past, will continue to be a leading economic force in Hawaii. In 1985, the average daily visitor count was 65,300 for the island of Oahu. This figure is expected to increase by almost 75 percent to a total of 113,400 daily visitors in 2010.

Between 1985 and 2010, however, it is projected that Oahu's share of occupied visitor rooms will decline from 62 to 45 percent of the State's total. In addition, it is anticipated that Oahu will have a declining share of total visitor rooms from 59 percent in 1985 to about 42 percent of the State total in 2010.

Hotel service jobs in the City and County of Honolulu are anticipated to show a moderate increase from 16,100 jobs in 1985 to 19,000 jobs in 2000. Between 2000 and 2010, hotel employment is expected to remain constant.

The primary resort area on Oahu will continue to be Waikiki. However, as the West Beach and the Kahuku - Kawela Bay areas become developed they are anticipated to increase in importance as major tourist destinations. The Laie-Kahuku area will continue to accommodate tourist related activities, but will remain primarily a residential community. According to the Development Plan, hotel sites may be provided outside of Waikiki to accommodate approximately 5,000 visitor units. The West Beach area is the focus of the West Beach-Makakilo Secondary Urban Center and will become Oahu's secondary resort destination. The Ko Olina Resort will be a water-oriented residential and resort community with approximately 4,000 hotel units. It will also include a major shopping center and a marina.

The Kahuku - Kawela Bay area will also have increased resort development. Resort facilities will be limited to 4,000 visitor units within the area designated for Resort use. Resort facilities at Laie-Kahuku will be limited to 300 visitor units within the area designated for Resort use.

Makaha Valley in Waianae will also continue as a visitor destination area with some modest expansion. The south-central portion of the valley is designated for Residential, Resort and Park (Golf Course) use. Hotel and apartment units will be limited to 1,000 in the areas designated for Resort use.

Military. Being determined by national security needs rather than domestic economic conditions, defense spending historically has provided a partial buffer between Hawaii's economy and outside economic conditions. Despite persistent challenge to maintaining Hawaii's share of national defense dollars, prospects for defense expenditures in the Islands remain promising.

Defense expenditures in Hawaii consist of military personnel pay, civilian worker pay, and the local purchase of goods and services including construction. Examination of past trends suggest that the overall military presence will remain relatively constant in terms of employment, but that real increases in construction and local purchases (i.e., beyond increases needed to keep up with inflation) will grow more slowly, if at all. Consequently, the overall real growth rate for defense spending in Hawaii over the projection period of the M-K series is somewhat lower, 1.5 percent annual rate between 1990 and 2010, while recent experience suggests no real growth between 1985 and 1990.

At mid-1988, there were 34,417 military families on Oahu which comprised a total of 133,419 military personnel and dependents. (Data Book, Table 322). The population of military personnel and their dependents in Hawaii is a function of Federal Government policies regarding deployment of armed forces personnel. In the future, the military's impact could further increase as a result of the 1988 Federal Government report recommending the expansion of the Pearl Harbor Naval Base, and homeporting the U.S.S. Missouri battleship and two cruisers in Hawaii. The expansion of Pearl Harbor would add 2,300 workers to its payroll, while the three ships would bring 2,200 military personnel and an estimated 46 million dollars a year into the state.

Major military installations on Oahu will continue to be the Pearl Harbor Naval Shipyard, Kaneohe Bay Marine Corps Air Station, Barbers Point Naval Air Station, Hickam Air Force Base, Camp Smith, Lualualei, Tripler Army Medical Center, and the Army's Fort Shafter and Schofield Barracks.

Agriculture. According to the DBED's Series M-K, raw sugar, one of Hawaii's primary agricultural crops, is anticipated to decrease in export value from a statewide total of 330 million dollars in 1985 to approximately 230 million dollars in 2010. This amounts to a slight but consistent annual decline averaging about 1.5 percent through 2010. Productivity gains will also likely continue in sugar, resulting in employment declines averaging 2.5 percent per year from 1990 to 2010.

The market for Hawaii sugar is currently assured by the price support provisions of the 1985 Food Security Act through December 1989, assuming that Hawaii sugar production is competitive in the marketplace and that high fructose corn syrup does

not displace sucrose by an additional 1,000,000 tons, which is approximately the current amount imported. Beyond that point there will either be need for a quota system for domestic sucrose producers or part of the sales potentials will be lost to the highest cost domestic producers, possibly including Hawaii. If the 1985 support program is not renewed, most domestic producers, including Hawaii, will not be able to compete in the marketplace against surplus sugar that is dumped on the world market at prices far below costs of production.

Pineapple (processed and fresh), Hawaii's second major agricultural export, is projected to show a slight increase in value from a statewide total of 175 million dollars in 1985 to 200 million dollars in 2010. This results in a 0.5 percent annual increase in real sales over the projected period. Productivity increases in the industry will result in an average 1.5 percent annual decline in employment through 2010.

In assessing the future of Oahu's agriculture, the State of Hawaii Land Evaluation and Site Assessment Commission has recognized the importance of correlating the acreage of agriculturally suited lands to that required to meet the projected agricultural production goals for the future. This correlation would establish quantitative and qualitative bases so that a sufficient amount of the most productive and best suited agricultural lands in the State would be classified as "important agricultural lands." In attempt to achieve this correlation, the Commission has projected the agricultural production goals and acreage requirements for 1990 and 1995.

Acreage requirements have been based upon commodity production goals for 1990 and 1995. Production goals were projected on the basis of current levels of production, projected population increases, and economic feasibility. Commodities which were considered were categorized into two groupings - export and local consumption. The acreage used for the different commodities evolved as a consequence of many factors, such as local and overseas market conditions, land ownership and tenure, availability of human resources, labor organizations, corporate and management policies and opportunities, and public land policies.

Table 5 and Figures 18A and 18B summarize the agricultural production acreage for each commodity and the total acreage requirement for the island of Oahu for 1983 and 1995. It is projected that in 1995 Oahu will have an agricultural production acreage requirement of approximately 57,600. Agriculture jobs for the City and County of Honolulu are projected to increase slightly by approximately 100 jobs every ten years, from 2,700 in 1985 to 2,900 in 2010.

TABLE 5

AGRICULTURAL PRODUCTION ACREAGE
1983 AND 1995
EXPORT/LOCAL COMMODITES FOR OAHU

COMMODITY	1983 (ACTUAL)	1995 (GOAL)
EXPORT:		
AQUACULTURE	300	2,400
FLOWERS/NURSERY	495	850
GUAVA		242
PAPAYA	70	170
PINEAPPLE	11,829	11,800
SEED CORN		180
SUGARCANE	27,200	25,300
TOTAL	39,894	40,942
LOCAL CONSUMPTION:		
BANANAS	540	836
BEEF/CATTLE	18,200	10,090
DAIRY	340	402
EGGS/POULTRY	250	390
FEED/FORAGE	1,741	2,912
FRUITS	90	200
SWINE	144	200
TARO		38
VEGETABLES/MELONS	1,340	1,642
TOTAL	22,645	16,710
GRAND TOTAL	62,539	57,652

Source: Land Evaluation and Site Assessment Commission, 1986.

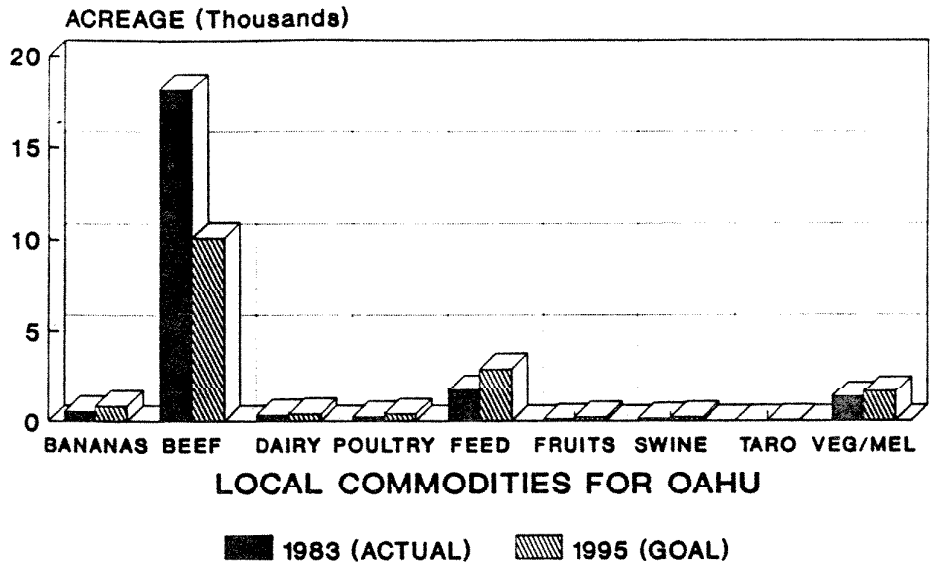


Fig. 18A

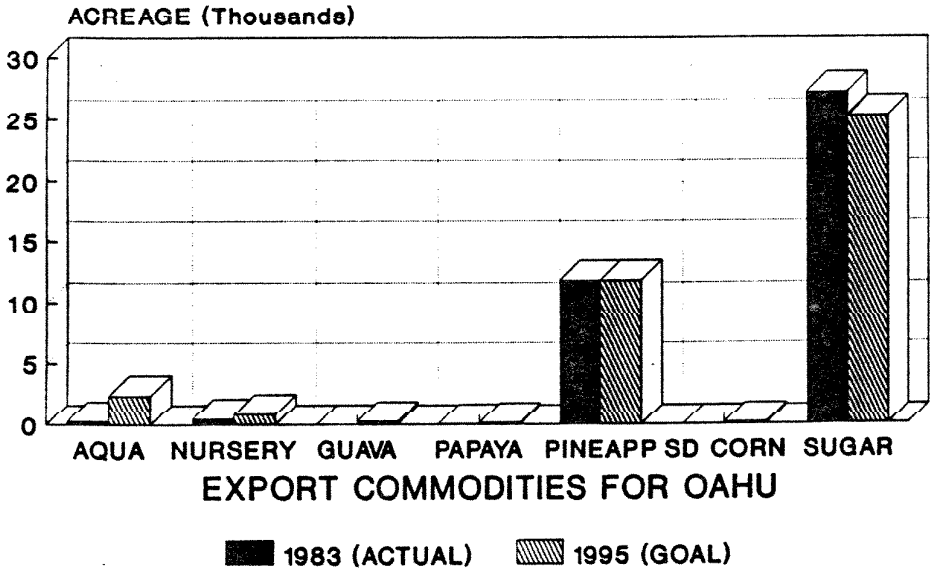


Fig. 18B

3. EXISTING WATER USE AND DEVELOPMENT

3.1 OVERVIEW OF WATER USE ON OAHU

On Oahu, most of the water used for urban and agricultural activities is derived from ground water sources. Surface water has not been extensively used because of the ready availability of an excellent supply of ground water. According to one estimate of water use compiled by the U.S. Geological Survey, there was approximately 402 million gallons per day (mgd) of water used on Oahu in 1985. Of this total, ground water sources accounted for 358 mgd, or 89 percent of the total withdrawals of water use. Surface water sources, primarily agricultural diversions, used 43 mgd, or approximately 10 percent of the total. Recycled water for agriculture used one mgd, less than one percent of the total water use on Oahu.

The users of Oahu water include the sugar plantations, the Honolulu Board of Water Supply (BWS), the military, private industry, diversified agriculture, and other private users who develop water for their own consumption. The BWS is the principal supplier of potable water for nearly all residential and urbanized uses on Oahu. An inventory of water use has been compiled as part of the initial phase in the preparation of the Oahu Water Management Plan. The primary sources of information for the inventory were records maintained by the State Division of Water and Land Development (DOWALD) and the Board of Water Supply. Table 6 and Figure 19 show the estimated amount of water used on Oahu in 1988.

Of the total estimated withdrawals of 408 mgd in 1988 from mostly ground water sources, the sugarcane plantations used the most water, 181 mgd, or 44 percent of all water withdrawn on Oahu. The BWS withdrew 150 mgd or 37 percent. Military use amounted to 6 percent in 1988, and miscellaneous private wells for agricultural, industrial and domestic use consumed 13 percent of the water.

3.2 AVAILABLE WATER SUPPLY

Oahu's abundant ground water supply is an important natural resource that has contributed significantly to the economic growth of the island. The ground water level in the Honolulu area, which once stood as high as 43 feet above sea level, steadily declined to about 25 feet above sea level (Takasaki, 1978). This has given rise to the concept of sustainable yield which has prompted the designation of water management areas on Oahu. "Sustainable yield" refers to the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the State Commission on Water Resource Management.

Rainfall is the sole source of freshwater and its quantity and spatial distribution govern the volume and quality of the ground water. Mean annual rainfall in Hawaii is about 73 inches and ranges from less than 20 inches to 300 inches near the crest of the

TABLE 6

WATER USE ON OAHU
1988

	QUANTITY (mgd)	PERCENT
BOARD OF WATER SUPPLY 1/	150	37%
SUGARCANE PLANTATIONS 2/	181	44%
MILITARY 3/	26	6%
PRIVATE USE & INDUSTRIAL 4/	51	13%
	408	100%

1/ BWS records.

2/ DOWALD and sugar companies; includes Waialua Sugar surface sources and Oahu Sugar Ewa caprock sources.

3/ DOWALD and military water use records.

4/ DOWALD and misc. sources. Includes unverified data from State water registration forms.

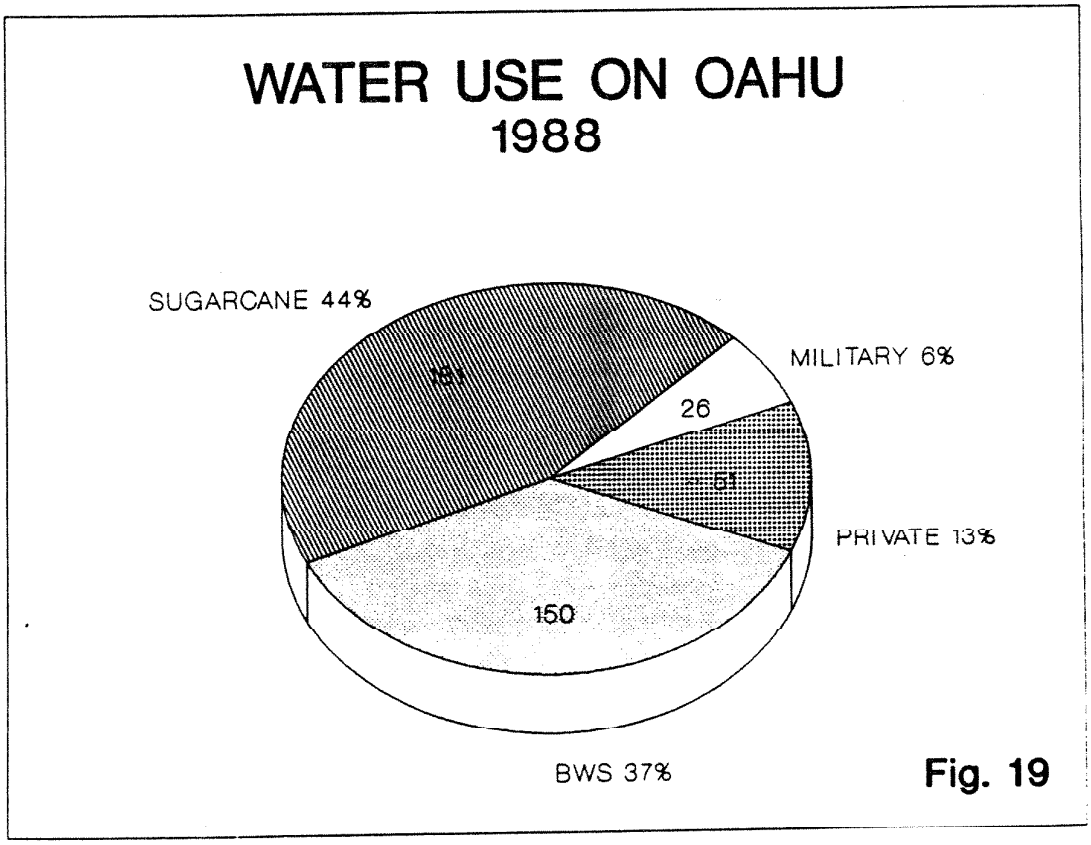


Fig. 19

Koolau Range. Ground water recharge is a function of rainfall as well as return irrigation water (Takasaki, 1978).

As part of the Hawaii Water Plan, a study was commissioned to determine the sustainable yields of surface and ground water sources Statewide. George Yuen and Associates, Inc. (1990) have completed estimating the sustainable yield for all aquifers on Oahu. The yields represent the rate of total pumpage which could be continuously withdrawn from an aquifer without affecting either the quality or quantity of the output. Sustainable yields are derived from water balances and ground water behavior over a period of time.

The sustainable yields determined thus far are estimations of the quantity of water within each aquifer system without regard to potability, developability, or accessibility. The numbers are subject to refinement to account for such factors as agricultural recharge and are meant to be used as a guide for planning. Only in southern Oahu where there has been years of investigation can the sustainable yield be employed with confidence.

For all aquifer systems on Oahu (See Figure 20), the sustainable yield for ground water sources is estimated at 495 mgd. The Pearl Harbor aquifers have the greatest supply at 158 mgd (32 percent), followed by the Central Sector at 104 mgd, Windward aquifers at 100 mgd, Honolulu aquifers at 50 mgd, North Sector at 46 mgd, and Waianae at 14 mgd. Table 7 presents the ground water use by sector and aquifer system to enable a comparison of existing uses and sustainable yield. Appendix A presents a detailed listing of water use by aquifer system. Appendix B presents the same listing by Development Plan area.

Of the total of 495 mgd sustainable yield islandwide, an estimated 339 mgd was withdrawn in 1988. This leaves a potential remainder of 156 mgd of available ground water supply to accommodate future demands. A summary of the sustainable yields by aquifer sector is presented below in relationship to existing ground water withdrawals. (See Figure 21.) Sustainable yield estimates and findings were extracted from the Draft Water Resources Protection Plan (George Yuen and Associates, Inc. 1990). More detailed discussion of the methodology involved in deriving the sustainable yields are contained in the Resource Protection Plan.

<u>Honolulu Sector.</u> The estimated sustainable yield in each aquifer system of the Honolulu Sector is for a large basal aquifer in Koolau volcanics. High level dike and perched ground waters drain into the basal lenses from small aquifers in the mountainous regions. A wide coastal plain is the surface of a thick, effective sedimentary caprock which forced the original ground water head to rise to 42 feet above sea level before balance was attained between inflow and outflow. Estimated sustainable yields are derived from water balances in conjunction with pumping data from the long history of operation.

The aquifer systems in the Honolulu Sector have been efficiently exploited for nearly a century. The total estimated sustainable yield within the Honolulu Sector is 50.0

Fig. 20

WILSON OKAMOTO AND ASSOCIATES, INC.
PLANNERS — ENGINEERS — ARCHITECTS

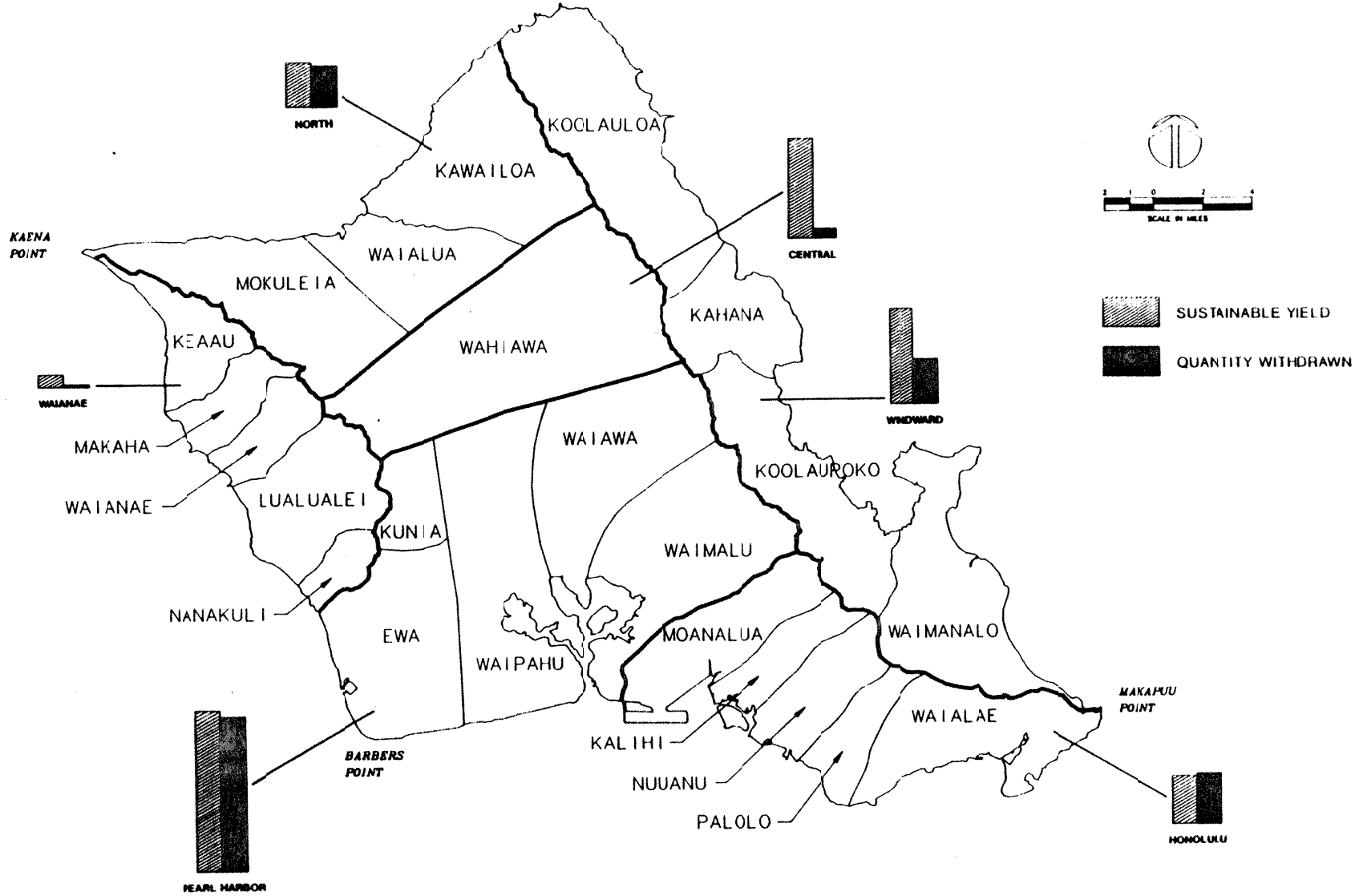
AQUIFER SYSTEMS

TABLE 7

GROUND WATER USE
BY AQUIFER SYSTEM AND SUSTAINABLE YIELD
1988 (MGD)

	SUSTAINABLE YIELD	WMA AUTHORIZED USE	1988 GROUND WATER WITHDRAWN	SURPLUS (+) OR DEFICIT (-)
HONOLULU				
PALOLO	5.0	6.4	10.4	-5.4
NUUANU	15.0	14.7	18.9	-3.9
KALIHI	9.0	12.2	12.0	-3.0
MOANALUA	18.0	14.1	13.5	4.5
WAIALAE	3.0	2.0	0.7	2.3
SUBTOTAL	50.0	49.4	55.5	-5.5
PEARL HARBOR				
WAIMALU	45.0	58.5	52.6	-7.6
WAIAWA	52.0	25.2	18.4	33.6
WAIPAHU	67.0	110.4	84.5	-17.5
EWA-KUNIA	17.0	13.5	11.4	5.6
SUBTOTAL	181.0	207.6	166.9	14.1
CENTRAL				
WAHIAWA	104.0	20.3	10.7	93.3
WAIANAE				
NANAKULI	1.0	----	----	1.0
LUALUALEI	4.0	----	----	4.0
WAIANAE	2.0	----	2.8	-0.8
MAKAHA	3.0	----	0.7	2.3
KEAAU	4.0	----	0.2	3.8
SUBTOTAL	14.0	----	3.7	10.3
NORTH				
MOKULEIA	9.0	5.2	3.4	5.6
WAIALUA	5.0	45.2	32.1	-27.1
KAWAILOA	32.0	6.0	4.3	27.7
SUBTOTAL	46.0	56.3	39.8	6.2
WINDWARD				
KOOLAULOA	42.0	----	18.5	23.5
KAHANA	15.0	----	4.4	10.6
KOOLAUPOKO	30.0	----	38.2	-8.2
WAIMANALO	13.0	----	1.3	11.7
SUBTOTAL	100.0	----	62.4	37.6
GRAND TOTAL	495.0		339.0	156.0

Source: George Yuen and Associates, 1990 and Dept. of Land and Natural Resources



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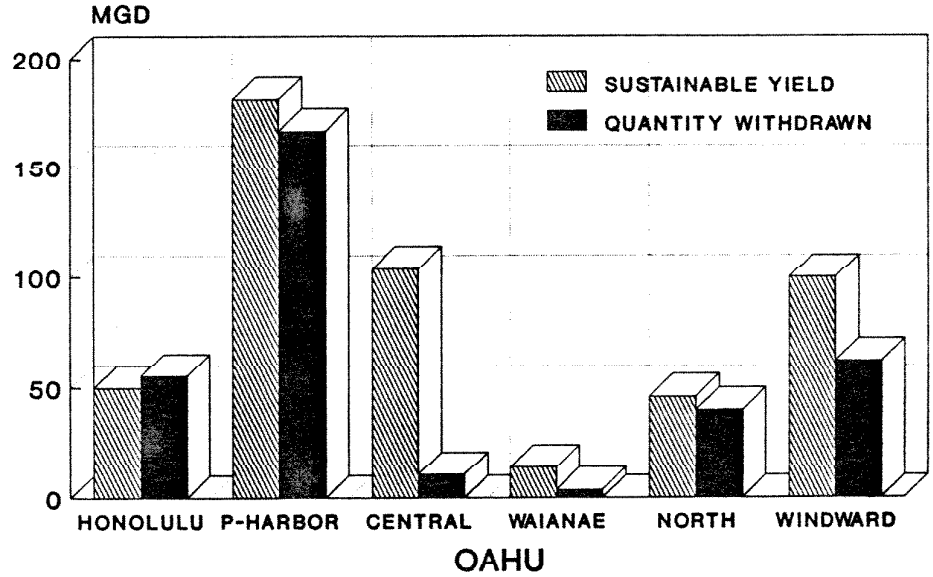
WATER USE AND SUSTAINABLE YIELD

Fig. 21

FIG. 22: GROUNDWATER USE AND SUSTAINABLE YIELD, 1988



BY AQUIFER SECTOR

mgd. Although current withdrawals are tabulated at 55.5 mgd, these withdrawals also include BWS tunnels and high level wells which extract water from dike sources, as well as some springs. Adjusting for these quantities, there is essentially an equilibrium which now exists between natural recharge and current removals of ground water.

Pearl Harbor Sector. The Pearl Harbor aquifer sector consists of five aquifer systems, of which the Waimalu, Waiawa, and Waipahu can be considered one system because the great basal lens of central and southern Oahu extends in unbroken continuity beneath them. The Ewa and Kunia systems can also be considered jointly, but they are separated geologically from the other systems. Estimated sustainable yields are among the most accurately calculated in the State and are highly reliable.

The current sustainable yield of 181 mgd for the Pearl Harbor Sector includes the recycling of irrigation water in the Waipahu, Ewa, and Kunia systems. The sustainable yield also takes into account spillover from the Wahiawa Aquifer System.

Among the six aquifer sectors on Oahu, the Pearl Harbor Sector is the largest supplier of ground water, with 166.9 mgd withdrawn in 1988. This quantity withdrawn excludes water use from the brackish Pearl Harbor springs and the unregulated Ewa caprock aquifer. Although there are some significant variations in surplus and deficit within the individual aquifer systems, the continuity among systems provides overall equilibrium. There is an indicated surplus of approximately 14 mgd in the sector, but proposed developments in the Ewa region have water demands in excess of this amount. The present arrangement of pumpage for domestic and irrigation demands, and the method and extent of irrigation, are in a quasi-steady state as a consequence of the allocation of the water resource by the State.

Central Sector. Only high level ground water occurs in the Central Sector. The resource is continuous from the wet Koolau to the drier Waianae mountains. Leakage from the high level aquifer helps sustain the large basal lenses in the Pearl Harbor Sector and the smaller ones in the North Sector. The sustainable yield estimate of 104 mgd assumes that all of it would be withdrawn from within the Sector. Doing so, however, would reduce the sustainable yields of the Pearl Harbor and North Sectors. The estimated sustainable yield of the Pearl Harbor Sector requires a total spillage from Wahiawa of 76 mgd. As a result, there is very limited development potential for the indicated surplus of 93 mgd in this sector.

Waianae Sector. The Waianae basalt is intruded by dikes all the way to the coast. For some distance inland a brackish to fresh basal lens exists in the dike compartments. Caprock, although thick and extensive, does not play an important role in supporting a fresh water lens. The sustainable yields in each of the systems refer to high level and basal ground water in dike aquifers. An indicated surplus in the developable sustainable yield from these sources is approximately 10 mgd.

North Sector. A deep wedge of sedimentary caprock causes thick basal lenses to exist in the Mokuleia and Waialua Systems. The Kawailoa System lacks an effective caprock. Estimates of sustainable yields are based on water balances computed within

System boundaries. A large deficit of withdrawals over sustainable yield is shown for the Waialua System. The sustainable yield estimate for the Waialua System is understated because spillage from the Wahiawa High Level System is not included. A total of 37 mgd could be added to the sustainable yield as a result of spillover from Wahiawa. This substantially adds to the total developable resource in the North Sector.

Windward Sector. The Windward sector includes a system (Koolauloa) having a thick basal lens, one dominated by a large stream which is the sink for ground water (Kahana), another (Koolaupoko) in which high level dike water reaches the coast, and a fourth (Waimanalo) which is dominated by the caldera complex of the original Koolau volcano.

In the Koolauloa System, high level dike water in the interior leaks to the basal lens which is protected at the coast by a deep wedge of sedimentary caprock. The sustainable yield estimate of 42 mgd refers to potable water in the basal lens. However, a more conservative estimate of 35 mgd is being used in planning to maintain a higher equilibrium head.

In the Koolaupoko Aquifer System, the estimated sustainable yield of 30 mgd computed by the water balance method refers to high level water exclusive of that removed by the Waiahole Tunnel for diversion to southern Oahu. Because all ground water becomes surface or wetland water before escaping to the sea, removal of water for domestic and other uses could decrease surface flows. The sustainable yield estimate does not consider the environmental consequences of its development. Current withdrawals in the Koolaupoko System show a higher level of withdrawals than the estimated sustainable yield. This is because the withdrawals figure includes 25 mgd for Waiahole Tunnel, an amount which is excluded in the sustainable yield estimate. When the Waiahole quantities are added to sustainable yield, there is actually a substantial surplus of 16.8 mgd.

The estimated sustainable yield of 15 mgd for the Kahana System includes ground water which drains to streams. Withdrawal of the sustainable yield would eventually decrease flow in Kahana Stream. Ground water in the volcanics of the Waimanalo Stream is also inseparable from the base flow of streams. Development of the estimated sustainable yield of 13 mgd would also reduce stream flow. It would also be difficult to develop because of the unfavorable hydrogeological conditions in the System.

3.3 WATER MANAGEMENT AREAS ON OAHU

Under the State Water Code, water management areas may be designated by the State Commission on Water Resource Management when it can be reasonably determined that the water resources in an area may be threatened by existing or proposed withdrawals or diversions of water. Such designations are based on a determination that an aquifer, or contiguous groups of aquifers, is being exploited to and beyond the limits of sustainable yield. To date, three water management areas have been designated on Oahu: Pearl Harbor, Honolulu, and Waialua, as shown in Figure 23.

Pearl Harbor. The Pearl Harbor Water Management Area was established in 1979 as the first ground water control area. The Honolulu-Pearl Harbor lenses are exceptionally productive basal aquifers. A sedimentary caprock formed by erosion of the uplands has created a coastal barrier that confines the ground water and causes artesian heads ranging from about 15 to 30 feet. Most of the shoreline elsewhere in Hawaii has little or no caprock to produce artesian conditions.

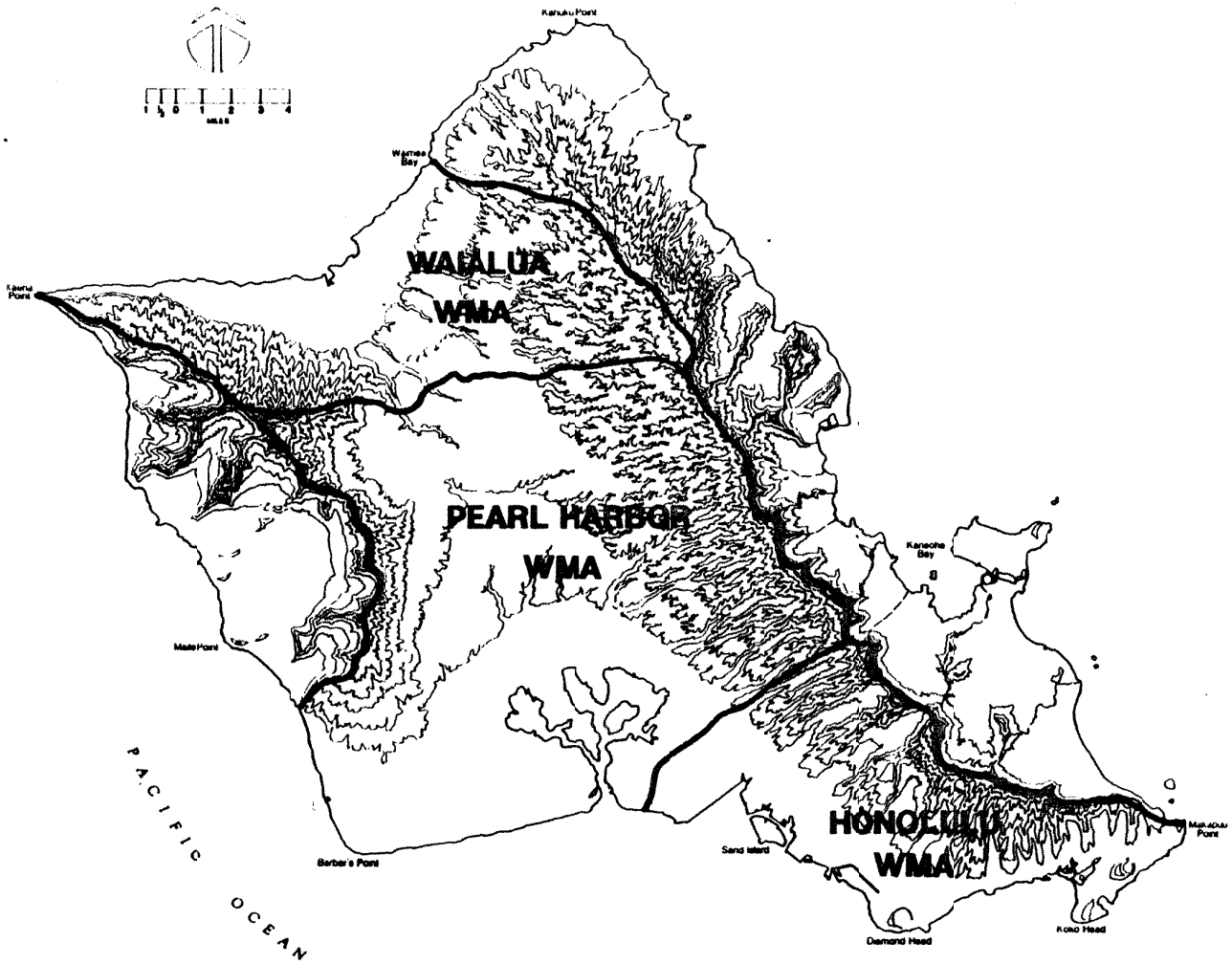
There are five distinct ground water bodies within the boundaries of the Pearl Harbor Water Management Area: the Koolau basal aquifer, the Waianae basal aquifer, the southern portion of the Schofield high-level water body, the caprock area, and the high level area between the Koolau Crest and rift zone. These areas are shown diagrammatically in Figure 24.

Sustainable yield for the Pearl Harbor WMA was initially established at 225 mgd. This amount is the mean maximum water supply that may normally be pumped from the WMA without unduly impairing source utility. In March 1989, following a reevaluation of ground water resources in the area, the sustainable yield was reduced to 195 mgd. Existing pumpages are below this level, but are expected to reach the sustainable limit much earlier than the projected year 2005 with the larger limit.

Honolulu Area. The aquifers within the Honolulu Water Management Area are developed principally by the Board of Water Supply. Because of concerns for diminishing reserves of developable ground water and threats to water quality at developed sources, protection as a water management area was instituted in 1981. The sustainable yield for the Honolulu Water Management Area is established at 60 mgd. Existing withdrawals in 1988 totalled 52.5 mgd.

Waialua Area. The basal aquifer in the Waialua Water Management Area is easily affected by heavy draft. Salinity has been increasing recently due to pumping of the Schofield high level aquifer for sugar plantation irrigation. This has prompted its designation as a water management area. The sustainable yield for the Waialua Water Management Area is 90 mgd. Pumpages in 1988 amounted to 41.6 mgd.

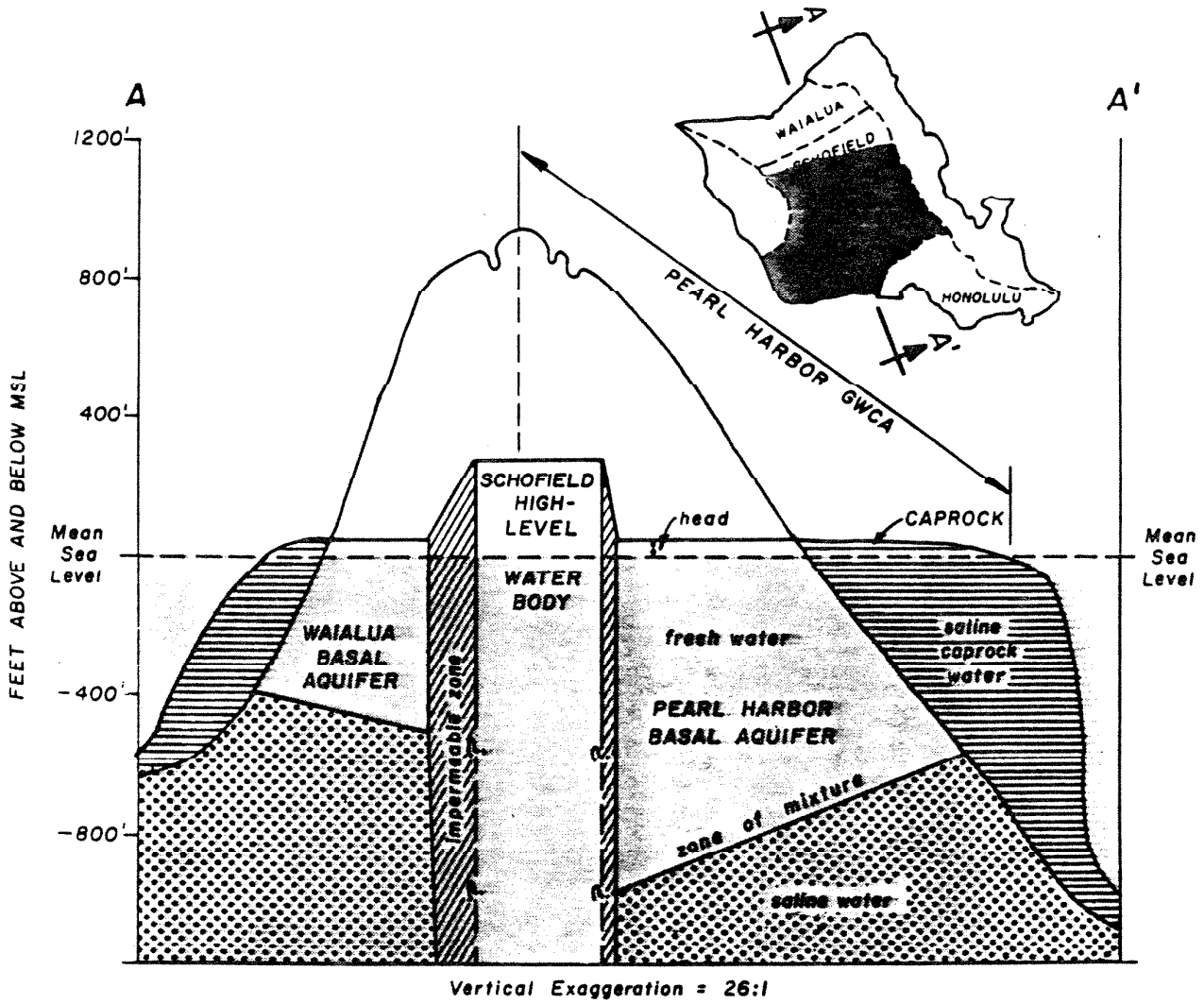
Recently, a petition was filed by the Sierra Club Legal Defense Fund requesting the designation of the Windward area as a water management area. Public hearings for the proposed designation were held in July, 1989.



WATER MANAGEMENT AREAS ON OAHU

Source: Windward Oahu Regional Water System Improvements (EIS)

Fig. 23



Source: DLNR, 1980

GROUND WATER RESOURCES OF THE PEARL HARBOR WMA

Fig. 24

3.4 MUNICIPAL SYSTEMS - BOARD OF WATER SUPPLY

The Board of Water Supply (BWS) of the City and County of Honolulu is a semi-autonomous agency responsible for the management, control, and operation of Oahu's municipal water system. The BWS is entirely self-supporting from water sales revenues.

The BWS is mandated to provide for growing consumer demand on Oahu to the extent of available water resources. The Board has no authority to control growth by restraining water system development. The Board's water use planning objectives include the following:

- Manage its ground water sources to insure preservation of the aquifers for the benefit of future generations, in perpetuity.

- Achieve optimum utilization of the existing water supply in order to minimize the need for development of additional potable ground water sources and alternative sources.

- Investigate, prepare for, and timely develop additional potable ground water sources and alternative sources requiring treatment, to provide for anticipated consumer demands.

- Attempt to insure that growth in consumer demand will be compatible with available water supply. (BWS, 1982)

3.4.1 BWS Water Sources and System

To facilitate its planning and administration, the BWS has divided Oahu into seven water use districts: Honolulu, Windward, Waialua-Kahuku, Wahiawa, Pearl Harbor, Ewa, and Waianae. These districts correspond somewhat with the DP areas, but with significant deviations in key areas. See Figure 25. The BWS Honolulu District includes the East Honolulu DP area, but extends west only to Halawa, whereas the Primary Urban Center DP area extends to Pearl City. The BWS Pearl Harbor District is split between the PUC and the Central Oahu DP areas. The BWS Ewa District includes some Central Oahu DP lands as well, while the BWS Waialua-Kahuku District encompasses the Kahuku area which is within the Koolauloa DP area.

The BWS presently maintains 57 well stations with 145 individual wells, 5 major shafts (Halawa, Pearl City, Makaha, Waialae, and Kalihi), 22 tunnels, 3 springs (Alewa, Booth, Makiki), and 1 stream (Lulumahu near Nuuanu Reservoir No. 4). Figure 16 shows the location of BWS wells, tunnels, and shafts, in addition to major agricultural, private, and military wells. Figures 26 to 32 depict the existing BWS system in greater detail by Development Plan area, indicating transmission lines and

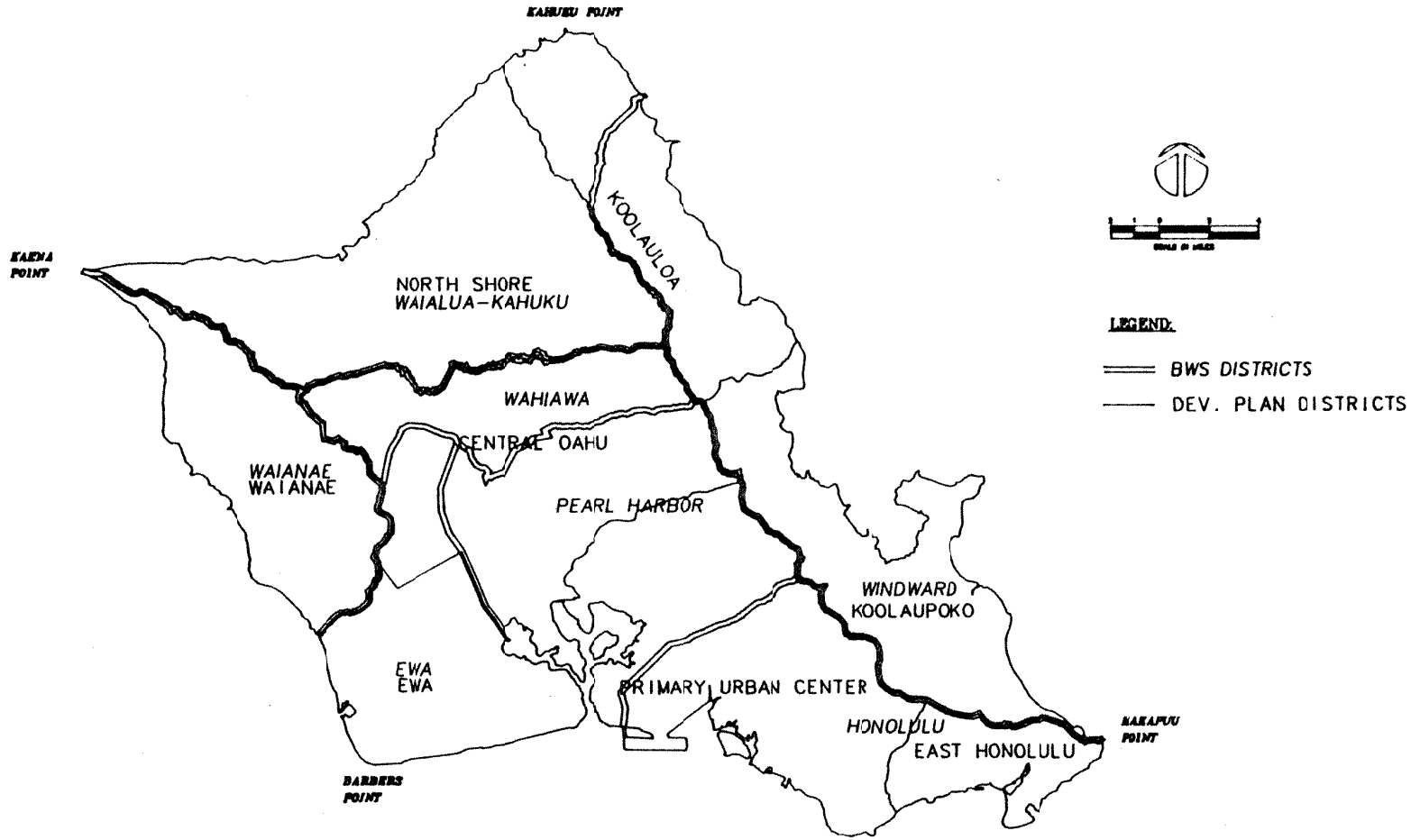


Fig. 25

BOARD OF WATER SUPPLY AND DEVELOPMENT PLAN DISTRICTS

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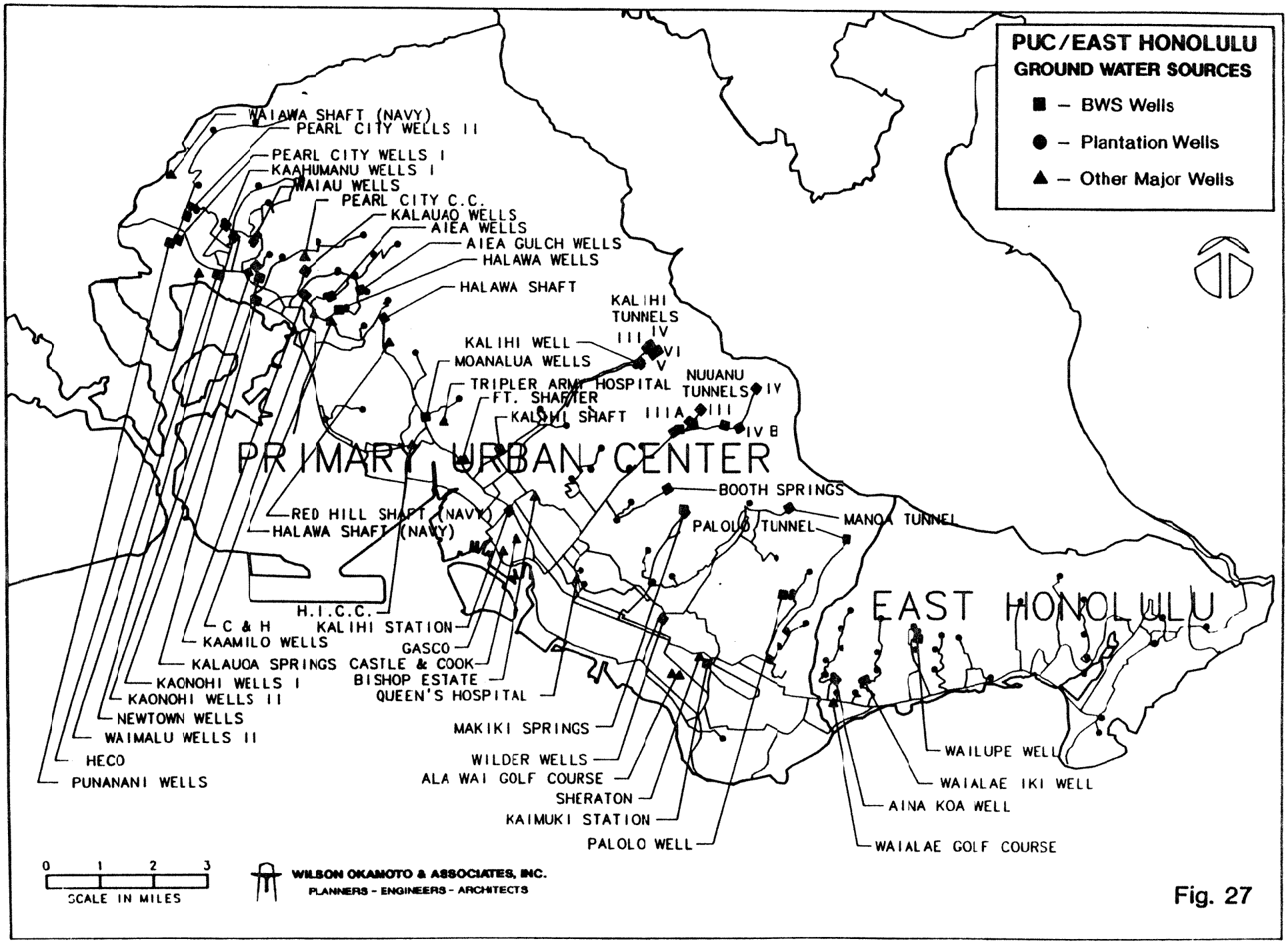
Fig. 26

EXISTING GROUNDWATER SOURCES


PUC/EAST HONOLULU
GROUND WATER SOURCES
■ – BWS Wells
● – Plantation Wells
▲ – Other Major Wells
WAIAWA SHAFT (NAVY)
PEARL CITY WELLS II
PEARL CITY WELLS I
KAAHUMANU WELLS I
WAIAU WELLS
PEARL CITY C.C.
KALAUAO WELLS
AIEA WELLS
AIEA GULCH WELLS
HALAWA WELLS
HALAWA SHAFT
KALIHI TUNNELS
III IV
VI
V
KALIHI WELL
MOANALUA WELLS
TRIPLER ARMY HOSPITAL
FT. SHAFTER
KALIHI SHAFT
NUUANU TUNNELS
IV
III
IIIA
IV B
PRIMARY URBAN CENTER
BOOTH SPRINGS
PALOLO TUNNEL
MANOA TUNNEL
RED HILL SHAFT (NAVY)
HALAWA SHAFT (NAVY)
EAST HONOLULU
H.I.C.C.
KALIHI STATION
C & H
KAAMILO WELLS
GASCO
KALAUOA SPRINGS
CASTLE & COOK
BISHOP ESTATE
KAONOHI WELLS I
KAONOHI WELLS II
QUEEN'S HOSPITAL
NEWTOWN WELLS
WAIMALU WELLS II
MAKIKI SPRINGS
HECO
PUNANANI WELLS
WILDER WELLS
ALA WAI GOLF COURSE
SHERATON
KAIMUKI STATION
PALOLO WELL
WAILUPE WELL
WAIALAE IKI WELL
AINA KOA WELL
WAIALAE GOLF COURSE
0 1 2 3
SCALE IN MILES
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PLANNERS - ENGINEERS - ARCHITECTS

Fig. 27

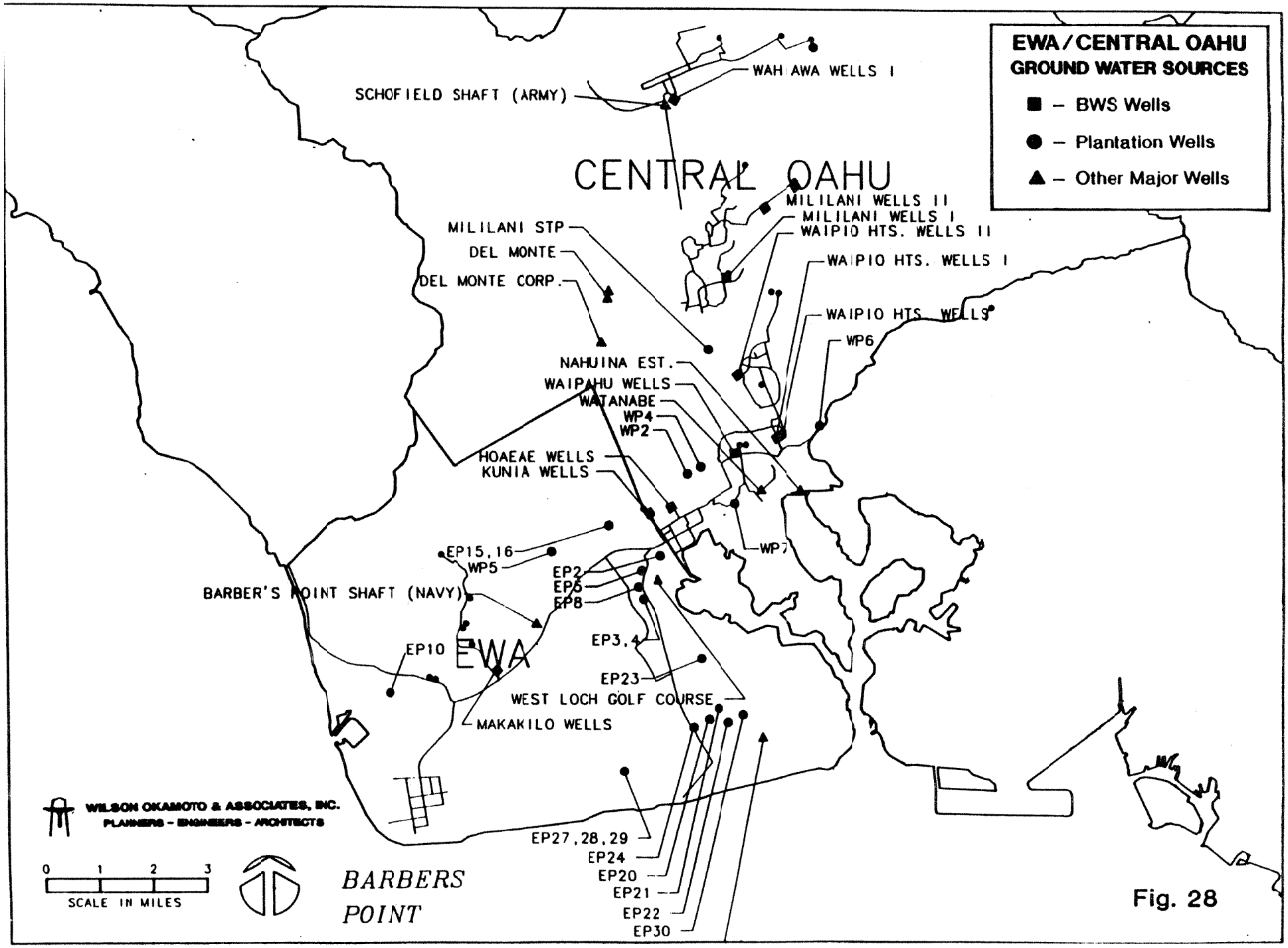
EWA / CENTRAL OAHU
GROUND WATER SOURCES
■ – BWS Wells
● – Plantation Wells
▲ – Other Major Wells
CENTRAL OAHU
EWA
BARBERS POINT
WAH AWA WELLS I
SCHOFIELD SHAFT (ARMY)
MILILANI WELLS II
MILILANI WELLS I
WAIPIO HTS. WELLS II
WAIPIO HTS. WELLS I
WAIPIO HTS. WELLS
WP6
MILILANI STP
DEL MONTE
DEL MONTE CORP.
NAHUINA EST.
WAIPAHU WELLS
WATANABE
WP4
WP2
HOAEAE WELLS
KUNIA WELLS
WP7
EP15,16
WP5
EP2
EP5
EP8
BARBER'S POINT SHAFT (NAVY)
EP10
EP3,4
EP23
WEST LOCH GOLF COURSE
MAKAKILO WELLS
EP27,28,29
EP24
EP20
EP21
EP22
EP30
WILSON OKAMOTO & ASSOCIATES, INC.
PLANNERS - ENGINEERS - ARCHITECTS
0 1 2 3
SCALE IN MILES

Fig. 28

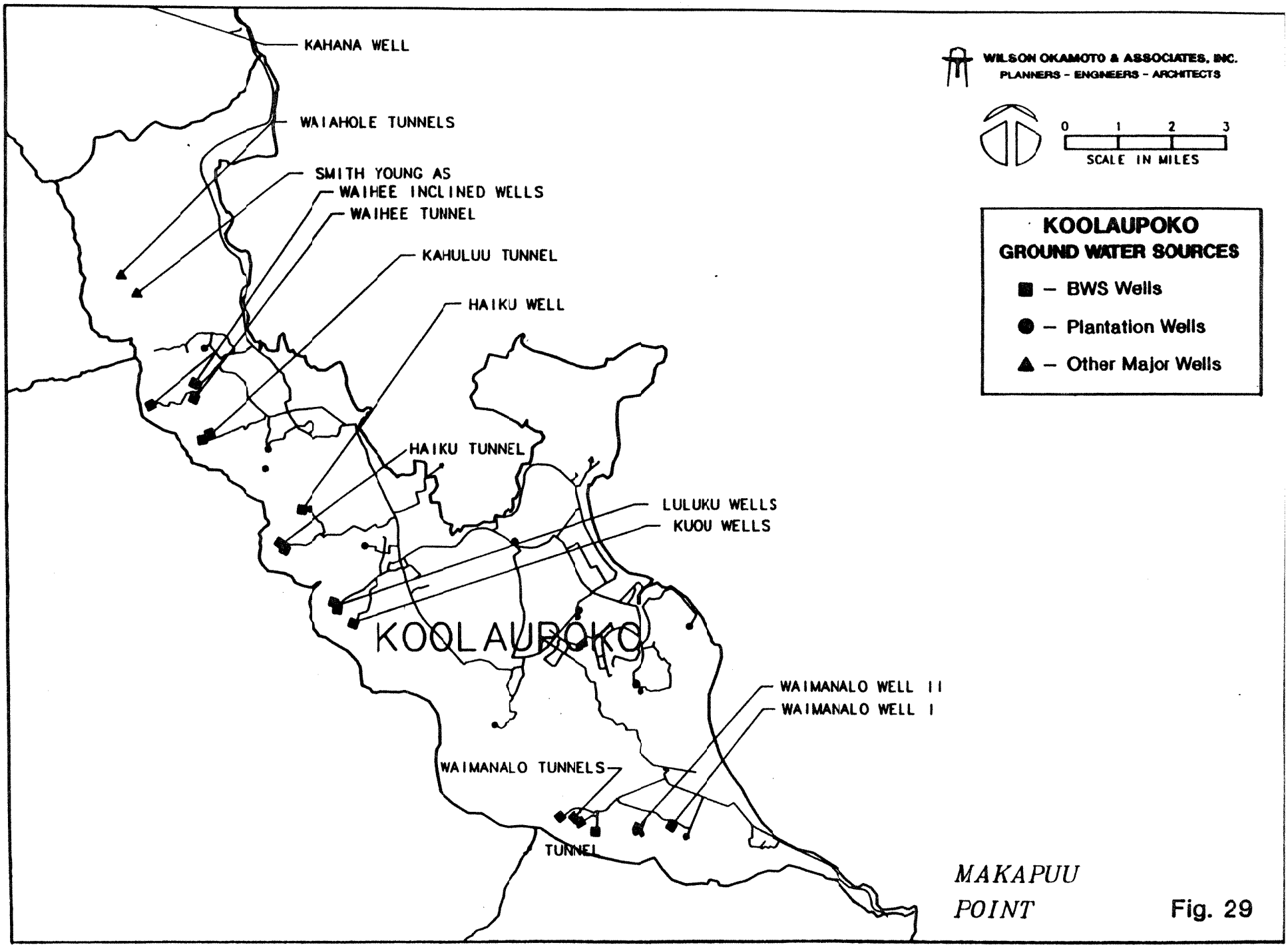
KAHANA WELL
WAIAHOLE TUNNELS
SMITH YOUNG AS
WAIHEE INCLINED WELLS
WAIHEE TUNNEL
KAHULUU TUNNEL
HAIKU WELL
HAIKU TUNNEL
LULUKU WELLS
KUOU WELLS
KOOLAUPOKO
WAIMANALO WELL II
WAIMANALO WELL I
WAIMANALO TUNNELS
TUNNEL
WILSON OKAMOTO & ASSOCIATES, INC.
PLANNERS - ENGINEERS - ARCHITECTS
0 1 2 3
SCALE IN MILES
KOOLAUPOKO
GROUND WATER SOURCES
■ – BWS Wells
● – Plantation Wells
▲ – Other Major Wells
MAKAPUU
POINT

Fig. 29

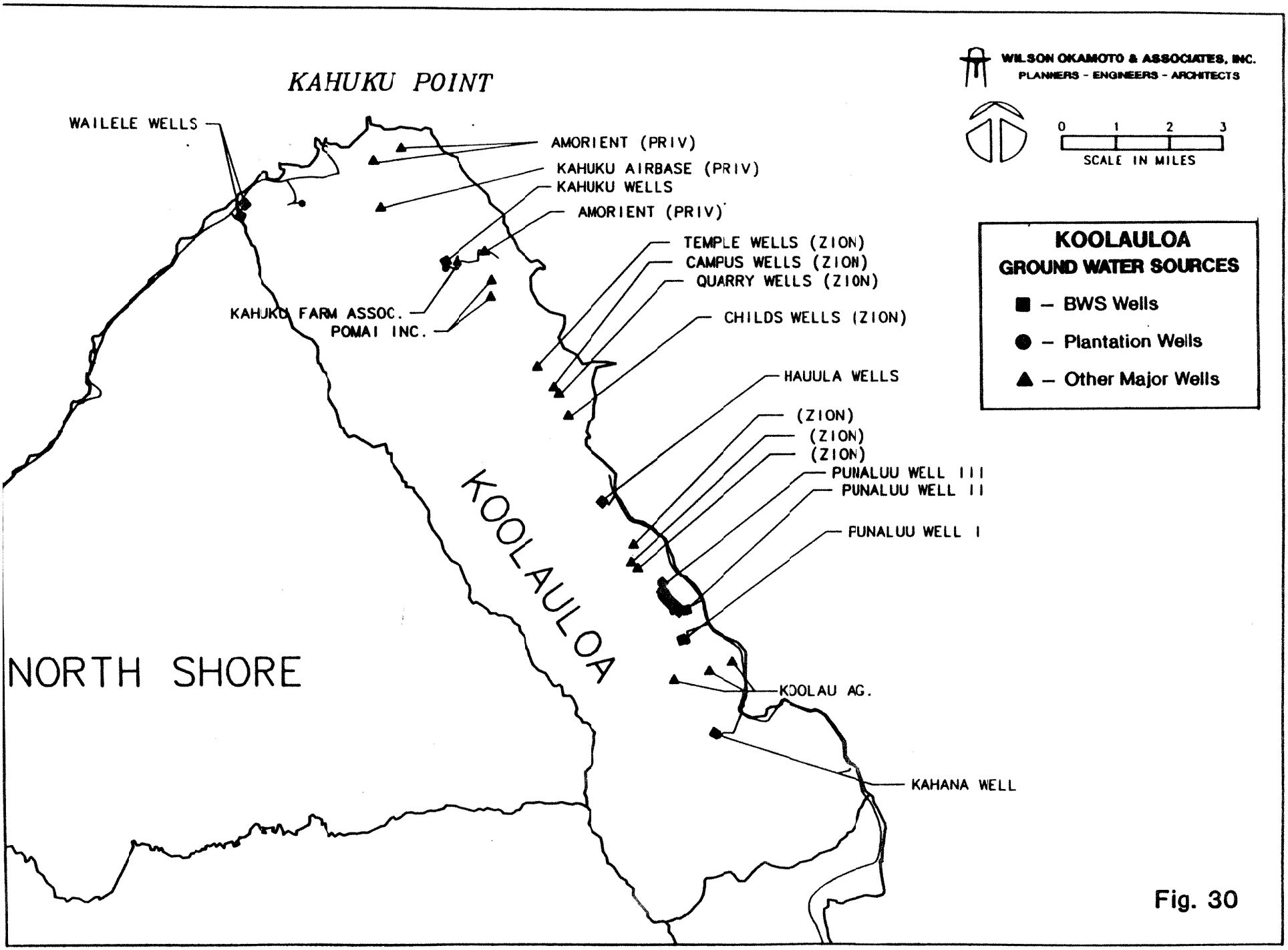
KAHUKU POINT
WILSON OKAMOTO & ASSOCIATES, INC.
PLANNERS - ENGINEERS - ARCHITECTS
0 1 2 3
SCALE IN MILES
KOOLAULOA
GROUND WATER SOURCES
■ – BWS Wells
● – Plantation Wells
▲ – Other Major Wells
WAILELE WELLS
AMORIENT (PRIV)
KAHUKU AIRBASE (PRIV)
KAHUKU WELLS
AMORIENT (PRIV)
TEMPLE WELLS (ZION)
CAMPUS WELLS (ZION)
QUARRY WELLS (ZION)
KAHUKU FARM ASSOC.
POMAI INC.
CHILDS WELLS (ZION)
HAUULA WELLS
(ZION)
(ZION)
(ZION)
PUNALUU WELL III
PUNALUU WELL II
PUNALUU WELL I
KOOLAULOA
NORTH SHORE
KOOLAU AG.
KAHANA WELL

Fig. 30

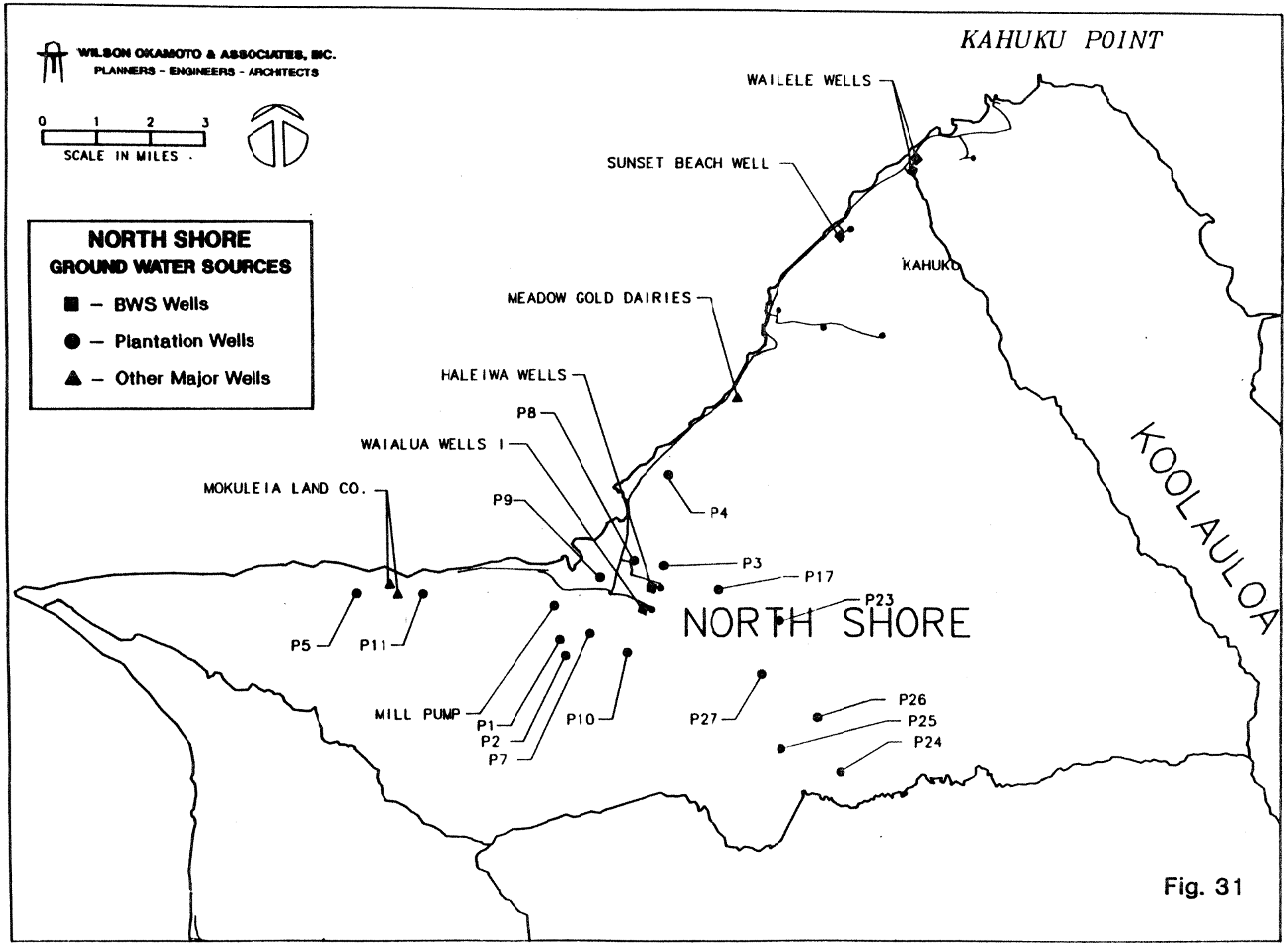
WILSON OKAMOTO & ASSOCIATES, INC.
PLANNERS - ENGINEERS - ARCHITECTS
0 1 2 3
SCALE IN MILES
NORTH SHORE
GROUND WATER SOURCES
BWS Wells
Plantation Wells
Other Major Wells
KAHUKU POINT
WAILELE WELLS
SUNSET BEACH WELL
KAHUKU
MEADOW GOLD DAIRIES
HALEIWA WELLS
P8
WAIALUA WELLS I
MOKULEIA LAND CO.
P9
P4
P3
P17
P23
NORTH SHORE
KOOLAULOA
P5
P11
MILL PUMP
P1
P2
P7
P10
P27
P26
P25
P24

Fig. 31

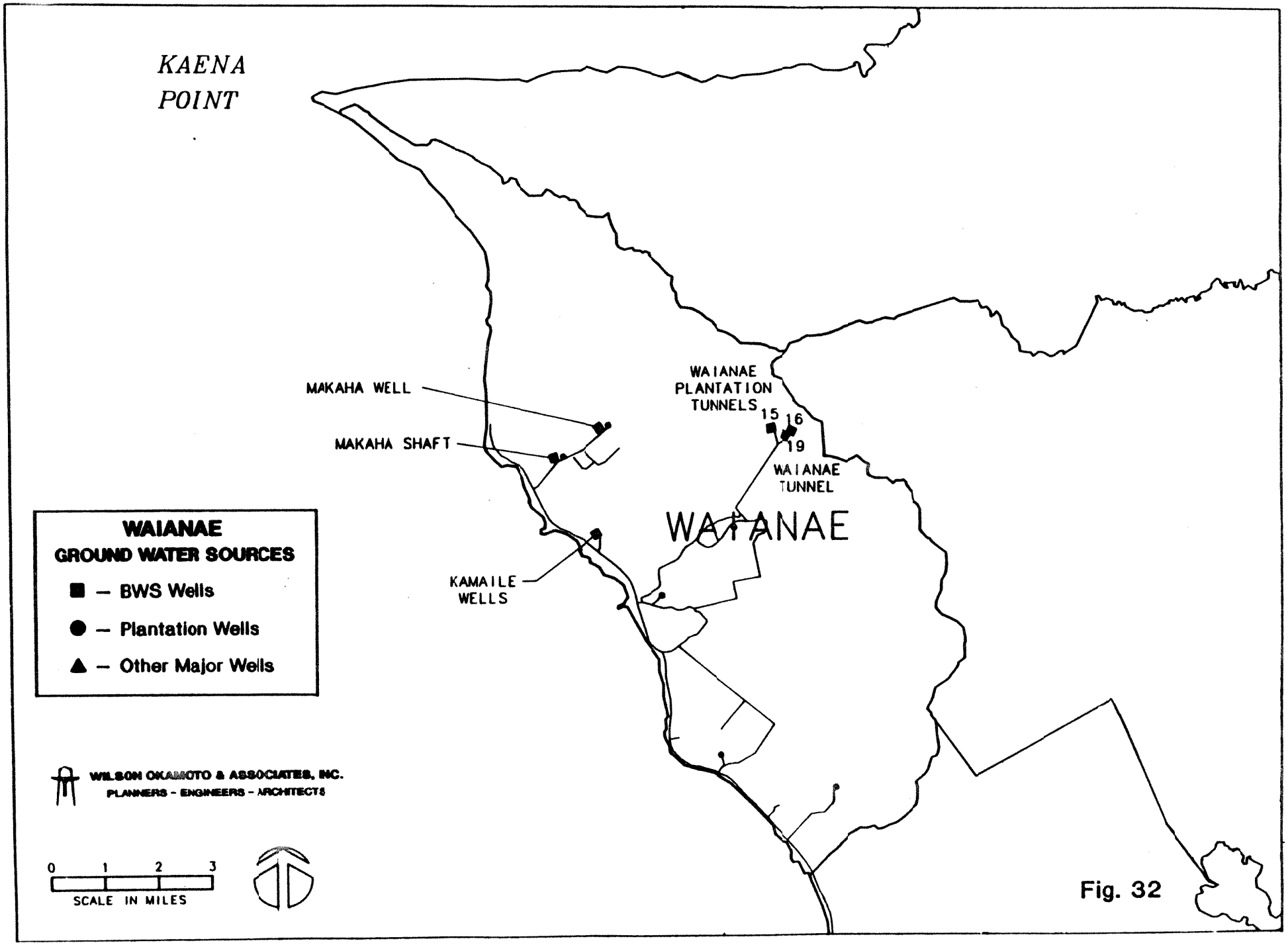
KAENA POINT
MAKAHA WELL
MAKAHA SHAFT
WAIANAE PLANTATION TUNNELS
15
16
19
WAIANAE TUNNEL
WAIANAE
KAMAILE WELLS
WAIANAE
GROUND WATER SOURCES
■ — BWS Wells
● — Plantation Wells
▲ — Other Major Wells
WILSON OKAMOTO & ASSOCIATES, INC.
PLANNERS - ENGINEERS - ARCHITECTS
0 1 2 3
SCALE IN MILES

Fig. 32

reservoirs, as well as the major plantation and private wells. The BWS maintains a total of 1,533 miles of transmission mains and lines, and 137 reservoirs with a total storage capacity of 128.7 mgd.

3.4.2 BWS Quantity and Quality of Water Use

Of the 149.8 mgd withdrawn by the BWS in 1988, 99 percent was from ground water sources. Wells and shafts tapping the basal aquifer provided 90 percent of the total, while high-level tunnels contributed 9 percent. The remaining one percent is divided between stream and spring water.

The largest water producing sources are within the BWS's Pearl Harbor District. These include the Halawa Shaft and the Punanani and Kalauao Wells which export their water to the BWS Honolulu District. In 1988, the Halawa Shaft had an average mean production of 11.13 mgd, the Punanani Wells produced 11.21 mgd and Kalauao Wells produced 10.85 mgd of water.

Table 8 and Figure 9 present BWS sources and quantities of water pumped by Development Plan area. The Primary Urban Center with 47.8 percent of the population produces 61.9 percent of total BWS pumpages. DP areas which are deficient in water sources relative to population include Ewa (11.8 percent population, 0.9 percent pumped), East Honolulu (6.0 percent population, 0.3 percent pumped), Koolaupoko (12.4 percent population, 9.3 percent pumped), and Waianae, 4.2 percent population, (2.5 percent pumped).

The BWS's usage of water is restricted along the entire central corridor of Oahu by the three Water Management Areas designated by the Board of Land and Natural Resources (now by the Commission on Water Resource Management). With these restrictions, the major challenge facing the BWS is to maintain pumpages within the authorized levels while accommodating urban growth authorized through the State and County planning and zoning processes.

In particular, the Pearl Harbor Water Management Area embraces the largest ground water body on Oahu and supplies more than 50 percent of the municipal water demand. In 1989, the total allowable BWS pumpage was recertified at 87.41 mgd (down from 92.01 mgd in 1988). Total authorized pumpages for all users for the Pearl Harbor WMA was 201.1 mgd for 1989, decreasing to 185.49 mgd by 1995.

In the Honolulu Water Management Area, authorized pumpage by BWS is limited to 40.66 mgd. BWS is the predominant water user in this district, accounting for more than 80 percent of the 49.39 mgd authorized use. The BWS is a minor water user in Waialua. In the Waialua-Kahuku Water Management Area, BWS authorized use is certified at 2.73 mgd. Total authorized use in the area is 64.73 mgd.

BWS monitors the quality of domestic water to ensure it is safe to drink in conformance with the State's Safe Drinking Water regulations. Approval from the

TABLE 8

BOARD OF WATER SUPPLY WATER SOURCES
BY DEVELOPMENT PLAN AREA

	POPULATION 1988	POPULATION PERCENTAGE	NUMBER OF WATER SOURCES	1988 QUANTITY PUMPED (MGD)	QUANTITY PERCENTAGE
PRIMARY URBAN CENTER	443,195	52.9	33	92.7	61.9
EWA	38,682	4.6	1	1.3	0.9
CENTRAL OAHU	127,723	15.2	10	27.9	18.6
EAST HONOLULU	48,205	5.7	3	0.4	0.3
KOOLAUPOKO	119,115	14.2	11	14.0	9.3
KOOLAULOA	12,417	1.5	8	7.6	5.1
NORTH SHORE	13,983	1.7	2	2.2	1.5
WAIANAE	35,180	4.2	6	3.7	2.5
TOTAL	838,500	100.0	74	149.8	100.0

Source: Board of Water Supply

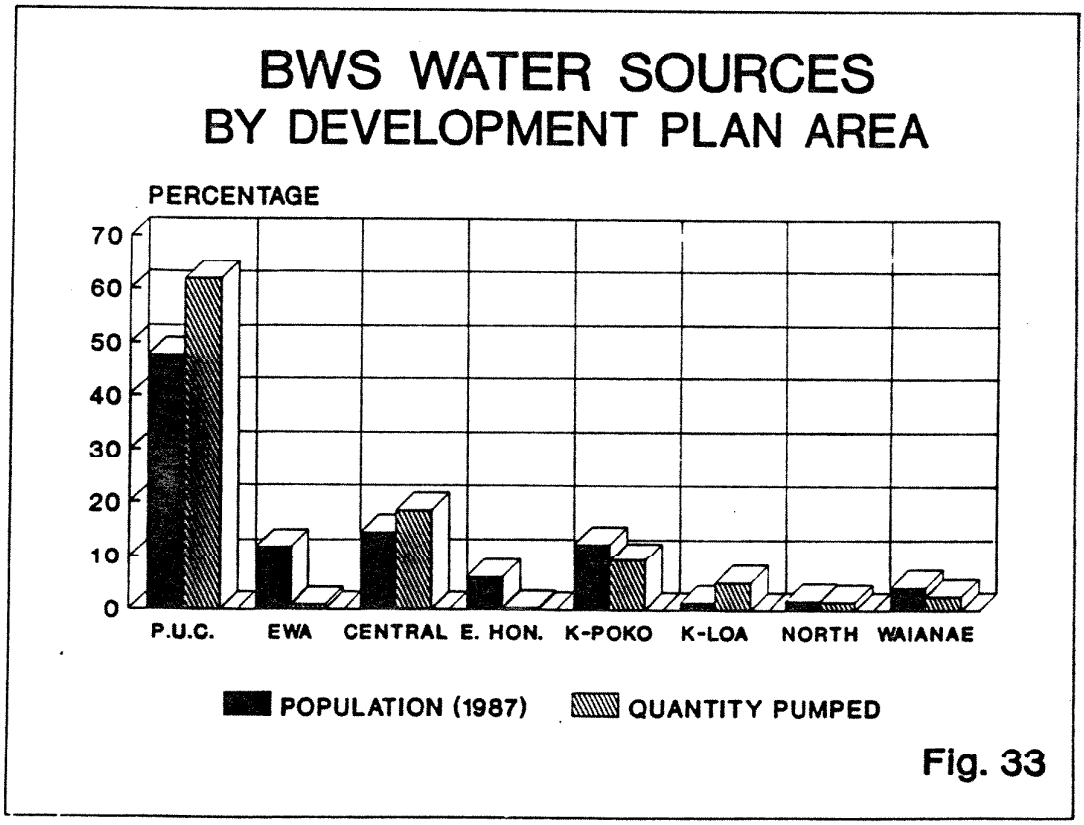

Fig. 33

State Department of Health must be obtained before any new drinking water source is used. All BWS potable water sources meet DOH and Environmental Protection Agency water quality standards.

3.4.3 BWS Integrated Islandwide System

An important goal of the BWS since it absorbed the Suburban Water System in 1959 is the installation and operation of a single, substantially integrated islandwide water system. The BWS has implemented a system of interconnections among its systems which facilitate inter-district water transfer. Water is drawn by pumps from wells and shafts, then brought by connecting laterals into transmission pipelines. The water is then transported long distances by transmission mains to service areas where smaller distribution laterals branch off to deliver water supplies throughout the community. Water is thus exported from areas of available supply to areas of municipal demand. This provides the BWS with an integrated islandwide system and the needed flexibility to accommodate urban growth in accordance with State and County land use plans.

In the Pearl Harbor BWS District, water is presently exported in substantial quantities to the BWS Honolulu District as well as to the Ewa-Waianae Districts. Exports from the Pearl Harbor District to Honolulu averaged about 35 mgd in 1988, while exports to the Ewa-Waianae area were at about 15 mgd. The amount transferred is variable, depending on weather conditions and operational considerations.

With continued growth envisioned within the Ewa and Central Oahu DP areas, greater demands will be placed on supplying in-district demands. Any reduction of water exports to accommodate growth in this area must be coordinated with additional source developments for the impacted Honolulu and Waianae Districts to avoid shortfalls.

The BWS envisions substantial source development in the Windward District to enable a reduction of exports from the Pearl Harbor District. Transmission capacity to the east end of Honolulu can provide for the transfer of up to 5 mgd from the Windward District. Thus, water not used to service Windward Oahu demand could be pumped around Makapuu to Honolulu. Proposed Windward region water sources have a projected maximum potential yield of about 43 mgd based on a BWS study of the area (VTN Pacific, 1988). Should streamflow be affected, however, BWS withdrawals would be reduced in line with the interim streamflow standards for the area.

Ewa Water Plan. In consideration of the high demand for water for proposed developments in Ewa, Oahu's designated Secondary Urban Center, the Ewa Water Master Plan was prepared by the Ewa Plain Water Development Corporation (consisting of major developers on the Ewa Plain) to compile projected water use and plan for the construction of on- and off-site water facilities to serve development projects in Ewa (Belt Collins and Associates, 1987). Among others, these projects include the Campbell Industrial Park, West Beach/Ko Olina Resort, Kapolei Town

Center and Village, Makakilo expansion, Ewa Gentry, West Loch, and Ewa Marina. A dual water system for potable and non-potable uses is promoted in the Plan.

3.5 AGRICULTURAL SYSTEMS

Agricultural users of water on Oahu consist primarily of plantation irrigation of sugarcane and pineapple fields. Other diversified agricultural pursuits also use considerable water, including taro, watercress, and other vegetables, melons, and fruits.

3.5.1 Sugarcane

The largest use of water on Oahu is for the irrigation of sugarcane plantations. Sugarcane requires enormous quantities of water, nearly 1.5 tons of water is required to produce one pound of sugar. Sugar yields are highest where sugarcane is irrigated, and water use has been estimated at between 6,000 and 10,000 gallons per day per acre, depending on method of irrigation. Plantation sugarcane companies used approximately 181 mgd for irrigated sugarcane, including 129 mgd or about a third of ground water withdrawals on Oahu.

Of the 42,500 acres of cropland of Oahu, sugarcane is grown on approximately 25,700 acres (Statistics on Hawaiian Agriculture, 1988). The two major plantations on Oahu are the Oahu Sugar Company which cultivates 13,441 acres of land in Ewa and Central Oahu, and Waialua Sugar Company which cultivates on 12,248 acres in Central Oahu and on the North Shore. Acreages under cultivation have gradually declined over the years due to falling sugar prices, increased use of artificial sweeteners, and increasing urbanization of sugarcane lands. Acreage in sugarcane declined from 34,000 acres in 1978 to 25,700 acres in 1988. About 60 percent of Hawaii's sugarcane lands are irrigated, and these lands produce nearly two-thirds of Hawaii's sugar. Irrigation is primarily by furrow and drip systems. Water use has declined, aided by the conversion to drip irrigation (6,000 gpd per acre) from furrow irrigation (10,000 gpd per acre). With furrow irrigation, the entire field must be wetted to achieve wetting the sugarcane root zone. With drip irrigation, water is applied only to the root zone area of the plant. The fields are watered using subsurface plastic tubes perforated with tiny holes. Drip irrigation is used now on over 80 percent of the irrigated fields to allow more efficient watering and fertilizing, higher yields, use of steeper mauka lands, and less labor.

In 1988, Oahu Sugar Company pumped 70.44 mgd from the Pearl Harbor and Waianae basal lens. In addition, approximately 20 mgd of water was transported from the Windward side via the Waiahole Ditch to irrigate the higher elevation lands at Kunia. Waiahole Ditch is a Koolau Mountain surface water and dike collection and conveyance ditch/tunnel system operated by the Waiahole Irrigation Company. Caprock sources not presently regulated on the Ewa Plain account for an additional estimated 20 mgd.

In 1987, Waialua Sugar Co. withdrew 38.16 mgd from its wells in the Waialua aquifer to irrigate its sugarcane fields. Surface water sources totalled 32.8 mgd, including 25.5 mgd from Wahiawa Dam, 4.7 mgd from Upper Helemano, 2.1 mgd from Opaeula Reservoir, and 0.5 mgd from Kawainui Stream. It should also be noted that about 10 percent of Waialua Sugar's mauka cane lands are unirrigated.

3.5.2 Pineapple

Pineapple is the second most important cultivated crop on Oahu. Approximately 12,400 acres of land are cultivated in pineapple on Oahu in 1987 by Del Monte Corporation and Dole Pineapple Company, a slight increase from 12,000 acres in 1978. Dole's pineapple operations have evolved from a processed (canning) operation to principally a fresh fruit operation. Del Monte deals exclusively in fresh pineapple. The primary consideration for a fresh fruit operation is the ability to harvest a premium quality fresh pineapple year round. This is dependent on soil, sunlight, and proper rainfall or irrigation. Dole's 8,000 acres are in drip irrigation. About half of Del Monte's 5,000 acres are drip irrigated.

Pineapples are cultivated under semi-arid conditions, needing 18 inches of water annually, or 1,000 gpd per acre. Based on BWS data and water use reports filed with the State, pineapple irrigation consumed about 7 mgd in 1987, applied by sprinkler and drip methods, with needs met mostly by rainfall.

3.5.3 Diversified Agriculture

Despite historical dominance by sugar and pineapple, diversified agriculture has become a significant factor in Oahu's agricultural economy. Oahu farms produced a variety of fruits and vegetables, half of the pork, as well as most of the eggs and milk in the State. Flowers and nursery products have also increased production significantly.

Most of the diversified agricultural farms are in Windward Oahu and Waianae. A survey of the farms in selected watershed areas and amount of irrigation water used annually in these areas was conducted in 1981 (Hawaii Agricultural Reporting Service, 1982). In Windward Oahu, 187 farms involving 2,565 acres of farmland were surveyed. Surface waters comprised a substantial proportion of the total water usage, 1.73 mgd, or 70 percent of the 2.49 mgd total water usage. The remaining 0.76 mgd was from BWS and private wells. Major agricultural activities include pasture, bananas, vegetables, flowers and nursery products, papaya and other fruits, taro, and aquaculture.

Windward Oahu is one of the major taro growing areas in Hawaii, with 53 acres under taro cultivation. Surface water applied by taro grown in flooded paddies is

estimated at 25,000 gallons per day per acre, although most of the water is returned to the stream from which the water has been diverted.

Along the Waianae Coast, the survey included 256 farms on 3,030 acres of land from Nanakuli to Makaha. The municipal water supply provided 98 percent of the water used for agricultural activities, 2.19 mgd of the 2.24 mgd total. No surface water use was reported. About three-fourths of the 3,030 acres of Waianae Coast farmland surveyed is for pastureland and livestock and poultry production. Vegetable crops are predominant on 521 acres of land, followed by flowers and nursery products (48 acres) and fruit crops (39 acres).

The Pearl Harbor wetlands are especially suited to the cultivation of watercress and other wetland crops because of the abundant supply of naturally occurring spring water and sunlight. This area is the major watercress producing area in the State having 23 acres out of the State's total 30 acres of watercress in cultivation (Statewide Agricultural Park Action Plan, 1984). There are three producing areas at Kalauao Springs, Waiau Springs and Waiawa Springs. Watercress requires substantial quantities of water, estimated at 50,000 gallons or more per day per acre.

State Agricultural Parks. There is one established agricultural park in Waimanalo and three more planned or under construction in Waianae, Kahuku, and Waiahole. These Agricultural Parks are part of the State's promotion of diversified agriculture on State lands.

The Waimanalo Agriculture Park in Waimanalo is being developed in two phases with a total of 196 acres. Phase I consisting of 126 acres became operational in 1987. Tenants include growers of nurseries and diversified crops on 14 lots of 5 to 10 acres in size. Phase II which is under construction entails the subdivision of about 70 acres into six lots ranging in size from 6 to 12 acres.

The Waianae Agricultural Park is expected to commence operations by early 1990. The Park consists of 150 total acres, and will include 17 lots ranging from 5 to 10 acres in size for diversified crops.

Kahuku Agricultural Park is under construction and is expected to be ready by early 1991. The park consists of 550 acres of land. Twenty-four lots of 5 to 10 acres in size are anticipated, supporting truck crops, nursery, and orchard production.

Water for the Waimanalo Agricultural Park Phase I is supplied by surface water from springs and stream diversions through the Waimanalo Irrigation System. The Waimanalo Irrigation System is maintained by the Department of Land and Natural Resources and serves 116 farm lots and the University of Hawaii Agricultural Research Station. The system includes four reservoirs, 12 miles of open ditches and 52 wooden flumes extending from Maunawili Valley. The total area served was 974 acres. Crops grown in 1987 included banana, truck crops, corn, floral and foliage plants. During the 1986-87 fiscal year, 0.18 mgd of water was used (DLNR, 1988).

Upon full development of the agricultural parks on Oahu, anticipated water usage is approximately 2 mgd (DLNR, 1981).

The BWS furnishes potable water for agricultural use at preferential quantity rates which are slightly lower than general use rates. The agricultural monthly water rate is $.98 per thousand gallons for the first 13,000 gallons, then $.69 per thousand gallons thereafter. (The general use rate is $.98 per thousand gallons for all water drawn.) The agricultural rate includes water drawn for crop production, stock raising or dairy farming on a commercial basis. Principal areas on Oahu which use the municipal system for diversified agriculture include the Waianae Coast, with 1.71 mgd in Fiscal Year 1988 (53 percent of BWS agricultural water use), and Windward Oahu, with 0.85 mgd (26 percent).

3.5.4 Aquaculture

The early promising potential for aquaculture development in Hawaii has begun to materialize. Most of the acreage in aquaculture is on Oahu, 374 acres of the State's 437 acres in total production in 1987 (DBED, 1988). Major species raised include prawns and marine shrimp. An interesting trend over the years has been the slightly decreasing farm acreage, while overall production has increased, indicating intensification of production yields (Hawaii Aquaculture Newsletter, Spring 1989).

Water requirements for aquaculture development are high. It is estimated that water consumption for growing freshwater prawns is 14,000 to 36,000 gallons per day per acre, about two to five times as much as sugarcane cultivation (Plasch, 1981). Some types of aquaculture, however, use seawater or brackish water.

In the long term, aquaculture may have the potential of competing for the land and water now being used to grow sugar. By the year 2000, it has been projected that 28,000 acres in the State could be devoted to aquaculture. Of the lands in the State determined to be well-suited to aquaculture (excluding water availability), 30 percent of the 135,000 acres identified are situated on Oahu in areas now being used mostly for growing sugarcane and pineapple.

3.6 MILITARY SYSTEMS

Military personnel assigned to the Navy, Army, Marine Corps, and Air Force comprise a major portion of the population of Oahu. Most military activities are located within the various military installations located throughout the island. Of the eleven major military installations on Oahu, only one, Marine Corps Air Station (MCAS) Kaneohe Bay, purchases water from the BWS. All of the major installations use their own wells or purchase water from another military source. The various military installations and water sources are shown in Table 9.

TABLE 9

MILITARY INSTALLATIONS AND WATER SUPPLY SOURCE

MAJOR INSTALLATIONS	COMPONENT	WATER SUPPLY SOURCE
Pearl Naval Complex 1/	Navy	Waiawa, Halawa, Red Hill
Camp Smith	Marine Corps/Navy	Navy
NAS Barbers Point	Navy	Barbers Point
Naval Magazine Lualualei 2/	Navy	Lualualei
Hickam AFB	Air Force	Navy
Schofield Barracks 3/	Army	Schofield
Wheeler AFB	Air Force/Army	Schofield
FT Shafter	Army	Shafter
Tripler Medical Center	Army	Tripler
MCAS Kaneohe Bay	Marine Corps	BWS
Naval Communications Station (Wahiawa)	Navy	Schofield
OTHER INSTALLATIONS		
Cannon Club (Fort Ruger)	Army	BWS
Fort Kamehameha	Army	Navy
Kapalama Military Res.	Army	BWS
Fort Derussy	Army	BWS
Kahuku Training Area	Army	BWS
Kaena Point	Army	BWS
Dillingham Airfield	Army	DLNR
Pearl City Annex	Marine Corps/Navy	Navy
Marine Barracks	Marine Corps	Navy

1/ Includes: Naval Station (includes Makalapa and Moanalua); Submarine Base; Supply Center; Shipyard; and Public Works Center.

2/ Includes Lualualei; West Loch and Waikele.

3/ Includes Kunia Field Station.

The military installations provide their own internal storage, transmission, and distribution systems to supply water to buildings, facilities, personnel and family housing units. The responsibility for maintenance of these systems is assigned to the public works functions at each installation or to a centralized activity such as the Navy Public Works Center, which supports all the Navy facilities on Oahu. Funding for construction, operation, and maintenance of the storage, transmission and distribution systems are provided by the military.

Water usage data for military installations is dominated by the large Navy presence on Oahu. Since 1980, total military water usage has ranged from 30.79 mgd in 1983 to 24.35 mgd in 1986. In 1988, water usage at all military installations (excluding Kaneohe Marine Corps Air Station) totalled 25.5 mgd.

Water usage data show that the Pearl Harbor Water Management Area accounts for almost all of this usage. For example, in 1987, the Pearl Harbor Water Management Area accounted for total usage of 24.08 mgd (94.7 percent) compared to the total usage of 25.43 mgd. The Honolulu Water Management Area accounted for 1.14 mgd (4.5 percent) and Lualualei 0.2 mgd (0.8 percent). (See Table 10)

These data include water usage by the various family housing areas located within the installations. On Oahu, family housing for all Department of Defense components is administered by the Army through the Oahu Consolidated Family Housing Office. Notwithstanding this administrative control, each component provides the transmission, storage, and distribution to the family housing units located on its installation.

3.7 PRIVATE DOMESTIC, COMMERCIAL, AND INDUSTRIAL SYSTEMS

Private domestic, commercial, and industrial systems encompass a relatively minor category of self-supplied users of Oahu's water sources. These water users are regulated only in the Water Management Areas of Oahu and include users who are not provided water from the BWS, plantations, or military water systems.

Industrial water supplies are provided by both the municipal BWS system and by private industrial systems. A few major industries, such as sugar and pineapple processing, provide their own water supplies, and the balance, mostly smaller businesses, rely on the municipal system.

Based on data compiled by the U.S. Geological Survey (DBED, 1988), self-supplied water use in 1985 amounted to 10.03 mgd for industrial uses, 34.42 mgd for thermoelectric cooling (brackish and salt water), and 28.54 mgd for commercial uses (out of total of 401.56 mgd for surface and ground water use on Oahu).

It is expected that future needs for major self-supplied industrial water would consist largely of increased requirements for electric power generation. Wash water used by sugar mills are now largely recycled to irrigate adjacent canefields.

TABLE 10

MAJOR MILITARY INSTALLATIONS WATER USAGE
(MGD)

INSTALLATION	GROUND WATER MANAGEMENT AREA	WATER USE IN 1988
Pearl Naval Complex 1/	Pearl Harbor	17.09
NAS Barbers Point	Pearl Harbor	2.40
Naval Magazine Lualualei 2/	Lualualei	0.24
Schofield Barracks 3/	Pearl Harbor	4.13
Fort Shafter	Honolulu	0.84
Tripler Medical Center	Honolulu	0.31

1/ Includes: Naval Station (includes Makalapa and Moanalua); Submarine Base; Supply Center; Shipyard; Public Works Center and Hickam AFB.

2/ Includes Lualualei; West Loch and Waikele.

3/ Includes Kunia Field Station and Wheeler AFB.

A major independent water system has been established in the Laie community by Zions Securities. The Laie Water System serves domestic and commercial water needs for the Laie community including residences, light industry, school and small shopping areas, the Brigham Young University - Hawaii, and the Polynesian Cultural Center. The system also supports agricultural activities in the surrounding community, including water for aquaculture, truck crops, pastureland, and taro. The system is supplied by 13 wells which tap into the artesian aquifer, accompanying reservoirs, including a 2,000,000 gallon reservoir, and distribution system. While precise figures are not available, domestic and commercial water use is approximately two mgd, and agricultural irrigation also uses approximately two mgd.

4. FUTURE WATER NEEDS AND DEVELOPMENT

4.1 FUTURE WATER NEEDS

The future water needs of Oahu are a function of the water demands of the major users. They include municipal (BWS), agriculture, military, and private water systems users.

4.1.1 Municipal Water Demand

Municipal water demand consists of the water supply provided for Oahu customers of the City and County of Honolulu Board of Water Supply. These include the vast majority of residential, commercial, governmental and industrial users, as well as smaller agricultural farmers. A portion of the military water demand is also serviced by the Board of Water Supply.

Forecast Methodology. In forecasting water demand, the most commonly used variables are population and service connections. Among the single-coefficient methods used, the per capita approach is by far the most widely used (Prasifka, 1988). The per capita approach estimates future water use as the product of the projected service area population and the projected value of a per-capita water use coefficient.

The projections are based on the widely accepted population projections developed by the State Department of Business and Economic Development (DBED). Honolulu's General Plan requires use of the DBED's latest official projections. The most recent Series M-K projections indicate a residential population for Oahu of 999,500 in the year 2010. These projections are somewhat higher than the M-F series published by DBED in 1984, primarily because of upward revisions in the anticipated growth in tourism over the recent years. Comparatively, the M-K forecasts falls midway between other statewide projections issued by the National Planning Association and the U.S. Bureau of the Census.

The M-K forecast population for Oahu was distributed among the eight development plan areas using existing and future 2010 population distributions provided by the Department of General Planning.

The City and County of Honolulu uses a population range in guiding land use decisions in its General Plan and Development Plans. The upper limit of the population range is 105 percent of the M-K forecast. Thus, the City allocates land use among the Development Plan areas based on a forecast upper limit of 1,049,500 persons in the year 2010 (105 percent of 999,500). The municipal water demand forecasts were developed based on the midpoint and upper limits of the General Plan population ranges. See Tables 11 and 12.

TABLE 11

OAHU RESIDENT POPULATION
M-K PROJECTIONS
1988 - 2010, BY DP AREA

	ACTUAL						PROJECTED							
DP AREA	1980		1985		1988		1995		2000		2005		2010	
PUC	417,215	54.7%	439,841	54.2%	443,195	52.9%	466,100	51.2%	465,500	49.9%	468,100	48.7%	474,300	47.5%
EWA	35,709	4.7%	36,738	4.5%	38,682	4.6%	64,600	7.1%	84,000	9.0%	103,800	10.8%	126,400	12.6%
C. OAHU	101,494	13.3%	114,611	14.1%	127,723	15.2%	140,200	15.4%	144,600	15.5%	149,900	15.6%	156,900	15.7%
E. HONO	43,242	5.7%	46,029	5.7%	48,205	5.7%	51,900	5.7%	52,200	5.6%	53,800	5.6%	55,500	5.5%
KOOLAUPOKO	109,373	14.3%	113,769	14.0%	119,115	14.2%	122,000	13.4%	119,400	12.8%	117,300	12.2%	115,900	11.6%
KOOLAULOA	11,123	1.5%	11,977	1.5%	12,417	1.5%	12,800	1.4%	13,000	1.4%	13,500	1.4%	13,500	1.4%
NO SHORE	12,921	1.7%	13,227	1.6%	13,983	1.7%	14,500	1.7%	15,900	1.7%	16,300	1.7%	17,000	1.7%
WAIANAE	31,487	4.1%	34,903	4.3%	35,180	4.2%	37,300	4.1%	38,200	4.1%	38,400	4.0%	40,000	4.0%
TOTALS	762,564	100%	811,095	100%	838,500	100%	909,400	100.0%	932,800	100.0%	961,100	100.0%	999,500	100.0%

Source: Dept. of General Planning (1980-88 and 2010 distributions)

TABLE 12

OAHU RESIDENT POPULATION
GENERAL PLAN LIMIT
1988 - 2010, BY DP AREA

DP AREA	ACTUAL 1980		1985		1988		PROJECTED 1995		2000		2005		2010	
PUC	417,215	54.7%	439,841	54.2%	443,195	52.9%	488,500	51.1%	488,700	49.9%	491,500	48.7%	497,800	47.4%
EWA	35,709	4.7%	36,738	4.5%	38,682	4.6%	68,800	7.2%	88,100	9.0%	109,000	10.8%	132,900	12.7%
C. OAHU	101,494	13.3%	114,611	14.1%	127,723	15.2%	147,200	15.4%	151,800	15.5%	157,400	15.6%	164,900	15.7%
E. HONO	43,242	5.7%	46,029	5.7%	48,205	5.7%	54,500	5.7%	54,800	5.6%	56,500	5.6%	58,000	5.5%
KOOLAUPOKO	109,373	14.3%	113,769	14.0%	119,115	14.2%	128,100	13.4%	125,400	12.8%	123,100	12.2%	121,900	11.6%
KOOLAULOA	11,123	1.5%	11,977	1.5%	12,417	1.5%	13,400	1.4%	13,700	1.4%	14,100	1.4%	14,000	1.3%
NO SHORE	12,921	1.7%	13,227	1.6%	13,983	1.7%	16,200	1.7%	16,700	1.7%	17,200	1.7%	18,000	1.7%
WAIANAE	31,487	4.1%	34,903	4.3%	35,180	4.2%	39,200	4.1%	40,200	4.1%	40,400	4.0%	42,000	4.0%
TOTALS	762,564	100%	811,095	100%	838,500	100%	955,900	100.0%	979,400	100.0%	1,009,200	100.0%	1,049,500	99.9%

Source: Department of General Planning (1980-88 and 2010 distributions)

To obtain a per-capita water use coefficient, water consumption data as recorded by the Board of Water Supply was used. Consumption data are available for the seven BWS districts. Differences between the BWS districts and the Development Plan areas necessitated deriving some estimates in the distribution of population and water consumption. The overlap of the BWS Pearl Harbor District with the Primary Urban Center required assigning water consumption in the Aiea to Pearl City areas to the Primary Urban Center. The consumption in East Honolulu, Koolaupoko and Koolauloa DP areas were estimated based on population percentages. Other districts had nearly identical or inclusive boundaries.

The existing per capita consumption by DP area was used in projecting water demand for the planning period. A level demand (no increase or decrease) in per capita consumption has been assumed through the planning period, based on BWS consumption trends in the recent past. Per capita consumption was derived by determining the de facto population (resident population plus visitors present minus residents absent), then subtracting the population served by private and military systems. The resultant BWS-served population is then divided by total water consumption to arrive at a per capita demand. Appendix D contains the tables used in developing the water demand projections.

Forecast Municipal Demand. Table 13 shows the actual and projected municipal water demand from 1980 to 2010 based on the above methodology. Future municipal water demand on Oahu is projected by Development Plan area up to the year 2010 in five-year intervals commencing with 1995. The projection for 1990 has been omitted due to the proximity of this time period. Two projections are given for each five-year interval--the midpoint of the General Plan population range (M-K projection figure) and the upper limit of the General Plan population distribution (105 percent of the M-K forecast).

Municipal water demand for Oahu is anticipated to increase from the current level of 149.9 million gallons per day (mgd) to 198.7 mgd by the year 2010, with a potential for demand of 208.3 mgd if the upper limit of the General Plan population range is attained. This represents a 33 to 39 percent increase over the twenty-year planning period. Residential population during the same period is expected to increase 19.2 percent, and de facto population by 21.3 percent. The higher increase in usage of water relative to population growth is due to the anticipated direction of much of the urban growth to the drier Ewa region of Oahu. The Ewa Development Plan area is expected to house three times as many people by 2010, but there will be nearly a five-fold increase in water demand.

4.1.2 Agricultural Water Demand

The future water demand for agricultural pursuits is dependent on the type of crops cultivated and the number of acres under cultivation. Principal among these on Oahu are sugar, pineapple, and diversified agriculture.

TABLE 13

MUNICIPAL WATER DEMAND PROJECTIONS
1980-2010 (MGD)

	ACTUAL			FORECAST							
	1980	1985	1988	1995		2000		2005		2010	
				M-K	GP-LMT	M-K	GP-LMT	M-K	GP-LMT	M-K	GP-LMT
PRIMARY URBAN CTR	77.1	76.4	83.7	88.9	92.9	89.5	93.6	90.7	94.9	92.7	96.8
EWA	7.8	7.8	9.4	18.2	19.6	25.1	26.5	32.2	33.9	40.3	42.4
CENTRAL OAHU	11.5	11.8	15.1	17.0	18.0	17.7	18.7	18.5	19.6	19.5	20.7
EAST HONOLULU	6.2	8.0	9.0	9.8	10.2	9.8	10.3	10.1	10.6	10.5	10.9
KOOLAUPOKO	16.0	15.4	17.6	18.1	19.0	17.7	18.6	17.5	18.3	17.3	18.1
KOOLAULOA	1.5	1.6	1.8	2.0	2.1	2.1	2.2	2.3	2.4	2.4	2.5
NORTH SHORE	2.3	3.2	3.6	3.8	4.3	4.4	4.6	4.7	5.0	5.1	5.4
WAIANAE	7.7	7.6	9.6	10.3	10.7	10.5	11.0	10.6	11.1	11.0	11.5
TOTALS	130.1	131.8	149.9	168.0	176.8	176.9	185.6	186.6	195.7	198.7	208.3

Source: Board of Water Supply (Consumption data)
Dept. of General Planning (Population distribution)

Note: See Appendix D for detailed calculations of demand.

Sugar. By far, the largest users of water are the sugar plantations. Oahu Sugar Company and Waialua Sugar Company collectively use 181 mgd or 44 percent of the total water use on Oahu. Sugarcane requires large quantities of water, using 6,000 to 10,000 gallons per day per acre depending upon the irrigation system used. The conversion of much of the sugar irrigated acreage from furrow to drip irrigation has saved substantial amounts of water and increased yields through the efficient application of fertilizer.

Sugar is expected to experience a gradual decline in acreage under cultivation due primarily to the costs of production and sugar prices. U.S. sugar support prices are expected to remain unchanged with the 1990 renewal of the U.S. Food Security Act, but the costs of labor, materials, equipments, and new facilities are expected to increase with inflation. Motivated by the uncertain outlook for sugar, sugar companies are actively exploring replacement crops, including macadamia nuts, coffee, tea, cocoa, and citrus. Of these replacement crops, the only land-extensive crop of proven profitability is macadamia nut orchards. Should large acreages be removed from sugar, one result could be the gradual relocation of diversified agriculture from the Neighbor Islands to Oahu, where growers would be closer to the large Honolulu consumer and supply markets, and could also avoid inter-island shipping costs. In addition, sugar is confronted by strong pressures for the urbanization of agricultural lands for residential and other purposes in Ewa and Central Oahu.

Barring a major drop in sugar prices, Oahu Sugar Company is expected to continue operations at least until its major leases with Campbell Estate, Robinson Estate, and the Navy expire in the mid-1990's. The long term outlook beyond this is uncertain. It should be noted that several thousand of Oahu Sugar Company's leased lands are already subject to urbanization pressures from announced development proposals.

Waialua Sugar Company's 12,000 cultivated acres are mostly owned by its parent company, Castle and Cooke, Inc. Approximately 5,000 of these acres are leased from Bishop Estate with an expiration date in the year 2000. With its lands less subject to urbanization, sugar is expected to continue as the principal crop, although the exploration of alternative crops such as macadamia nuts and pineapple will continue.

Reflecting the uncertain future for sugar, the State Department of Business and Economic Development (DBED) anticipates a decrease in export value statewide for raw sugar from $325 million in 1987 to $230 million by 2010. There is expected to be a decline of approximately 26 percent with an average annual decline of 1.5 percent between 1990 and 2010. See Table 14. Such a decline could translate to a reduction in water demand of approximately 48 mgd. Regardless of what activities replace the withdrawn sugar acreage, there should be a reduced demand for water, given the high consumption rate of sugarcane cultivation.

Pineapple. After experiencing declines and consolidation over the past two decades, the outlook for the pineapple industry has improved somewhat in recent years due mainly to the development of the market for fresh pineapple on the mainland. Acreage in pineapple cultivation on Oahu has increased from 11,500 acres in 1983 to

TABLE 14

PROJECTED GROWTH OF SUGAR AND PINEAPPLE
STATE OF HAWAII

YEAR:	1985	1990	1995	2000	2005	2010
SUGAR:						
TOTAL VALUE (1982 $Millions)	330	310	290	270	250	230
AVERAGE ANNUAL PERCENT CHANGE		-1.2	-1.3	-1.4	-1.5	-1.7
PINEAPPLE:						
TOTAL VALUE (1982 $Millions)	175	180	185	190	195	200
PROCESSED VALUE	130	130	130	130	130	130
FRESH FRUIT VALUE	45	50	55	60	65	70
AVERAGE ANNUAL PERCENT CHANGE (Fresh Fruit)		2.1	1.9	1.8	1.6	1.5

Source: State Department of Business and Economic Development
Series M-K Projections

12,400 acres in 1987, with much of this acreage stemming from the replacement of sugarcane with pineapple cultivation. The DBED projects a 0.5 percent annual increase in real sales, spurred mainly by a continued expected growth in the fresh fruit market.

Pineapple is grown under semi-arid conditions, requiring only about 1,000 gallons per day per acre, with needs met mostly by rainfall. Compared with the 6,000 to 10,000 gallons per day per acre for sugarcane, increased cultivation of pineapple will conserve more of Oahu's potable ground water. Assuming the projected 14 percent growth in pineapple production by the year 2010 is achieved through the replacement of sugarcane lands, there would be an estimated savings of 8.7 mgd.

Diversified Agriculture. Diversified agriculture in the State has done well over the past decade, with sustained growth in numerous commodities. Oahu has also experienced consistent increases over the past few years. The floriculture and nursery industry has done particularly well, increasing in acreage on Oahu from 406 acres in 1984 to 508 acres in 1987. Acreage in diversified fruits on Oahu has varied, as banana acreage has increased from 390 acres in 1984 to 475 acres in 1987, but papaya has decreased from 85 to 61 acres during the same period. Acreage in diversified vegetables and melons have in general maintained their acreages, although there have been notable increases in acreage in tomatoes and watermelons on Oahu.

Irrigation figures for a number of diversified crops were included in the Governor's Agriculture Coordinating Committee's Industry Analyses which are published by the University of Hawaii College of Tropical Agriculture and Human Resources. Table 15 shows the commodities and the water requirements which were listed in their respective analyses.

Drip or trickle irrigation is the most efficient in terms of crop production per gallon of water used, followed by sprinkler systems, while furrow irrigation is the least efficient. Several factors affecting the choice of systems are topography, soil type, initial cost of capitalization, and labor costs. Irrigation may not be required in areas receiving rainfall of 80 or more inches per year if evenly distributed throughout the year.

Projections of future water demand for diversified agriculture are difficult to determine except in the aggregate. First of all, existing water usage by farms and by crops in terms of surface and ground water use is not available. For Windward Oahu in particular, many farms use available surface water and private ground water supplies, the quantities of which are not routinely reported. A review of the recently compiled water registration forms submitted to the State Commission on Water Resource Management revealed many with incomplete or missing data on quantities of water usage. Secondly, long range projections for diversified agriculture are not available. The only such projections thus far compiled were in conjunction with the Land Evaluation and Site Assessment (LESA) Study, in which acreage projections to the year

TABLE 15

WATER REQUIREMENTS FOR SELECTED DIVERSIFIED CROPS

CROP	IRRIGATION REQUIREMENT (gallons/acre/day)
DENDROBIUM ORCHID	3,000 to 4,000
FEED AND FORAGE (Alfalfa, Corn)	7,700
GUAVA	4,400
LEAFY VEGETABLES	4,050 to 5,400 (sprinkler)
MACADAMIA NUTS	4,400
FOLIAGE PLANTS	4,000 to 6,000
PASSION FRUIT	10,000
PROTEA	2,000 to 2,500
TARO	5,400 (dry) 4,000 to 8,000

Source: State Department of Agriculture

1995 have been made. These projections, however, are only by crops and by County and do not provide any breakdown by districts (see Section 2.11.2).

The LESA projections show that the acreage in diversified agriculture are expected to increase from 4,280 acres in 1983 to 7,070 acres by 1995, a 65 percent increase over the 12-year period of forecast. These include flowers/nursery, guava, papaya, bananas, feed/forage, fruits, taro, and vegetables/melons. On the basis of the above table on irrigation requirements, the estimated water demand is expected to increase from 25.5 mgd to 43.4 mgd, a 17.9 mgd increase from 1983 to 1995. Should the LESA projections hold true to the year 2010, diversified agriculture could encompass 10,600 acres and require approximately 66 mgd of irrigation water.

4.1.3 Military Water Demand

The military in Hawaii is expected to continue to maintain a strong presence in the foreseeable future. Water demand for the military is affected principally by the number of active duty personnel and their dependents stationed on Oahu, and by the number of planned military housing units built on the various bases. There are currently about 55,000 military personnel and another 50,000 of their dependents in Hawaii.

The State's expectation per the M-K projections is that the total military population will remain relatively constant in terms of military personel and civilian employment. The exception to this stability is the expected decision within the next year to homeport the Missouri battleship group at Pearl Harbor. This would result in a near and long term increase in the number of military personnel and dependents stationed on Oahu. In addition to the increased shoreside support facilities which would be required, additional housing units would be needed for the 1,200 additional dependent families expected to accompany the ships and personnel.

Future military water demand may be seen principally as a function of the increase in housing units planned and under construction on military bases on Oahu. On this basis, military water demand is expected to increase by 12 percent over the next decade. Based on estimates provided by the Oahu Consolidated Family Housing Office, Table 16 below shows the planned housing units and their locations by Development Plan area.

4.1.4 Private Systems Demand

Private systems water demand is expected to remain relatively constant over the planning period. No major expansions or increases are anticipated, except for the Zions system in Laie and private water developments in Ewa.

Zions Securities operates a major private water system in Laie serving domestic, commercial, agricultural, and institutional needs. Residential units are expected to

TABLE 16

PLANNED MILITARY HOUSING UNITS ON OAHU

	LOCATION	NO. UNITS
FY 1988	Catlin Park, Pearl Harbor	56
	Schofield Barracks	100
FY 1989	Schofield Barracks	284
FY 1990	Hickam Air Force Base	70
	MCAS Kaneohe Bay	40
	Helemano	260
	NAS Barbers Point	80
FY 1991	Hickam Air Force Base	20
	Pearl City	50
	Helemano	50
Homeported Missouri Battleship Group	Ford Island	600
	Pearl Harbor Basin	600
	TOTAL:	2,200

Source: Oahu Consolidated Family Housing Office

increase by up to 100 units in the existing community, and 450 units in the new residential area, over the existing 900 units. Non-residential demand (shopping center, resort, community center, industrial park) is expected to increase by 100 percent. Brigham Young University at Hawaii enrollment and facilities at the Polynesian Cultural Center are each expected to expand by 50 percent. 1987 water demand of 1.7 mgd is expected to increase to 2.6 mgd upon completion of the master planned improvements to accommodate these anticipated increases. (Group 70 Architects, 1987)

In Ewa, major developers in the area have formed the Ewa Plains Water Development Corporation (EPWDC) to plan, develop and secure the necessary water to support their developments. The EPWDC consists of the Estate of James Campbell, West Beach Estates, Gentry Development Corp., and HASEKO (Hawaii), Inc. The Ewa Water Master Plan prepared by the Corporation and approved by the Board of Water Supply promotes the use of dual water systems and identifies the necessary source, transmission, and storage systems. These include a potable system for human consumptive uses and brackish systems for irrigation and other non-potable uses. The potable water system will be connected among all Ewa projects as an integral part of the BWS system. The brackish systems will generally be separate and small scale.

Total water use for Ewa Plain developments is projected to be 31.4 mgd upon full development of the proposed projects within the next 10 to 20 years. Of this amount, 24.1 mgd is expected to be supplied by potable and non-potable systems owned and operated by the BWS. The remaining 7.3 mgd would be provided by private, non-potable irrigation systems (Belt Collins and Associates, 1987). Most of the water system facilities would be privately developed and subsequently dedicated to the BWS.

Potable water will be supplied by deep wells into the basalt aquifer at inland locations. Shallow on-site wells into the limestone aquifer will supply most of the brackish non-potable water for irrigation and other uses. Single-family residential areas will be supplied exclusively by the potable water system, reflecting State Department of Health as well as marketing and liability concerns of the developers.

4.2 PROPOSED WATER DEVELOPMENTS

This section describes proposed water developments to be undertaken by government agencies and the private sector. In the City and County of Honolulu, the coordination of public facilities with land use has been implemented through the Development Plan process. Planned and proposed public facilities, including those for the development, transmission, and storage of water, are indicated on the Development Plan Public Facilities Maps which are maintained by ordinance. Government-sponsored projects indicate the anticipated timing of development as being within or beyond a six-year timeframe.

4.2.1 Municipal Water Development Plans

BWS water development plans are reflected on the DP Public Facilities Map and also in the six-year BWS Capital Improvements Program budget. Table 17 lists by DP area the BWS projects planned and included on the DP Public Facilities Map as of mid-1989.

Proposed BWS capital improvements over the 1990 to 1995 time period are presented in Appendix C. If the proposed source development projects of 16 wells and springs proceed as scheduled and the estimated sustainable yields are achieved, these sources would add 19.05 mgd capacity to the BWS system. Also planned are 7 reservoirs and 19 interconnecting and supplemental transmission mains. Emphasis on Windward area water developments include 13 well projects with a projected yield of 10.2 mgd. An additional 23 well sites are indicated in the Windward Regional EIS, but many of these projects may not materialize because of instream and other environmental problems.

Total proposed projects over the six-year timeframe will involve the expenditure of $201,105,000 in capital improvements for source production, storage, transmission and support facilities. As required by City Charter, the BWS annually consults with the Chief Planning Officer of the Department of General Planning prior to adopting their capital improvements program and budget.

4.2.2 Agricultural, Private, and Military Plans

Agricultural Plans. The two sugar plantations have adequate water supply for their irrigation requirements and have no plans or need for additional water development projects. Ongoing conversion from furrow to drip irrigation is expected to continue to improve sugar yields and free water for use on other fields. The State's Agricultural Park program supporting diversified agriculture is well underway in Waimanalo with Phase II under construction (200 total acres), and additional agricultural parks planned or under construction in Waianae (150 acres), Kahuku (550 acres), and Waiahole.

Private Sector Plans. Private water development plans are shown in a section on privately funded projects on Table 17-DP Public Facilities. Most of the indicated source, transmission and storage facilities are in the Ewa and Central Oahu DP areas in support of planned and approved residential and commercial developments. Upon development, most of these water facilities will be dedicated to the BWS for ongoing maintenance. In Ewa, new potable wells have been identified for development at the 440-foot elevation of upper Honouliuli, mauka of the H-1 Freeway and west of Kunia Road.

Military Plans. No new water sources are expected to be developed by any of the military installations. If additional supply is required, adequate capacity exists to increase pumpages from the existing wells. The military has been cooperative with

TABLE 17

DEVELOPMENT PLAN PUBLIC FACILITIES
(as of August 1989)

BOARD OF WATER SUPPLY

Map No.	Primary Urban Center / Project Titles	Timing Code	Site Code	Project Implementation Status
	Primary Urban Center			
107	Dillingham Boulevard 42" Water Main, Ph II (Waiakamilo/N King St)	W	D	P & E Funds Budgeted
016	HECO Water Line	W	D	P & E Funds Budgeted
177	Kahuawai (Rose Apple) Springs Well	W	D	No Action
066	Kalihi Corporation Yard Modification, Phase II	W	D	P & E Funds Budgeted
465	Kalihi Valley 614 Reservoir and 16 Inch Main	W	D	Land Acq./Constr. Funds Budgeted
235	Manoa Well I (0.5 mgd)	W	D	No Action
200	Manoa Well II (0.7 mgd)	W	D	On-Line
202	Manoa Well III	B	D	No Action
022	Moanalua Road 36" Line (Punanani Channel to Aiea)	W	D	Land Acq./Constr. Funds Budgeted
422	Salt Lake Boulevard 36" Main	W	D	Land Acq./Constr. Funds Budgeted
237	Waahila 180' Reservoir	W	D	Land Acq./Construction Underway
238	Waahila 405' Reservoir	W	D	P & E Funds Budgeted
015	Waiau HECO Wells (5.0 mgd)	W	D	Construction Funds Budgeted
	Ewa			
176	Barbers Point "215" Reservoir No. 5	W	D	No Action
177	Barbers Point "215" Reservoir No. 6	W	D	No Action

Timing Code- W= within 6 years
B= beyond 6 years
P= private funding

Site Code- D= Determined
U= Undetermined

BOARD OF WATER SUPPLY

Map No.	Central Oahu	Timing Code	Site Code	Project Implementation Status
086	Cane Haul Rd 16" Main Phase III, Kam Hwy Waipahu St to Lumiauau St	W	D	Land Acq./Constr. Funds Budgeted
033	Kamehameha Highway - 24" Main (from Waikalani Dr to Kipapa Dr)	W	D	P & E Funds Budgeted
035	Mililani Wells IV	W	D	No Action
036	Mililani Wells IV - 20" Water Transmission Line	W	D	No Action
012	Wahiawa 1361' No. 2	W	D	Land Acq./Construction Underway
015	Wahiawa Well II (1.0 mgd)	W	D	Land Acq./Construction Underway
136	Waipahu 228 Reservoir No. 3	B	D	No Action
148	Waipio Heights Well III	W	D	Land Acq./Constr. Funds Budgeted
	East Honolulu			
008	Kuliouou Well (0.2 mgd)	W	D	No Action
001	Waialae Nui Well (0.7 mgd)	W	U	No Action
005	Wailupe Well II (1.0 mgd)	B	D	P & E Funds Budgeted

BOARD OF WATER SUPPLY

Map No.	Koolaupoko	Timing Code	Site Code	Project Implementation Status
001	Hakipuu Well (0.5 mgd)	W	U	No Action
029	Heeia Kai 272' Reservoir	W	U	No Action
013	Kahaluu Well II (0.2 mgd)	B	U	No Action
026	Kahekili/Likelike 42" Main-Phase III - 30" Main	W	D	P & E Funds Budgeted
047	Kahekili/Likelike Highway 42" Main (Kaneohe to Kahaluu Util Tunnel)	W	D	P & E Funds Budgeted
116	Kalanianaole Highway 36" Main	W	D	P & E Funds Budgeted
176	Kalanianaole Highway 36" Main Realignment	W	D	P & E Funds Budgeted
127	Kamehameha Highway 30" Main (Waihee Line Booster To Waikane)	W	D	P & E Funds Budgeted
128	Kamehameha Highway 30" Main (Waikane to Kaawa - portion)	W	D	No Action
020	Kamehameha/Likelike 42' Line (Kahaluu Util Tunnel to Waihee Booster)	W	D	Land Acq./Constr. Funds Budgeted
066	Kamooalii Well I (0.5 mgd)	W	U	No Action
087	Kamooalii Well No. II (0.5 mgd)	W	D	No Action
065	Kuou Well II (0.5 mgd)	W	D	Land Acq./Constr. Funds Budgeted
045	Luluku 500' Reservoir (Kaneohe 500' Reservoir)	W	U	Land Acq./Construction Underway

BOARD OF WATER SUPPLY

Map No.	Koolauloa	Timing Code	Site Code	Project Implementation Status
018	Hauula 180′ Reservoir	W	U	No Action
035	Kaaawa Well I (0.5 mgd)	W	U	No Action
036	Kaaawa Well II (0.5 mgd)	W	U	No Action
031	Kahana 315′ Reservoir	W	D	Land Acq./Construction Underway
032	Kahana Well II (0.5 mgd)	W	U	No Action
030	Kahana Well III (2.0 mgd)	W	U	No Action
019	Kaipapau Well (1.0 mgd)	W	U	No Action
023	Kaluanui Well (2.0 mgd)	W	D	Land Acq./Construction Underway
042	Kamehameha Highway 12" Main (Kaipapau to Laie)	W	D	P & E Funds Budgeted
041	Kamehameha Highway 16" Main (Hauula to Kaipapau)	W	D	P & E Funds Budgeted
040	Kamehameha Highway 20" Main (Punaluu to Hauula)	W	D	Land Acq./Constr. Funds Budgeted
038	Kamehameha Highway 30" Main (Waikane to Kaawa - portion)	W	D	No Action
039	Kamehameha Highway 30" Main (Kaaawa to Punaluu)	W	D	No Action
012	Laie Well (1.0 mgd)	W	D	P & E Funds Budgeted
020	Maakua Well (1.0 mgd)	W	U	No Action
024	Punaluu Well IV (0.5 mgd)	W	D	No Action
025	Punaluu Well V-A (1.0 mgd)	W	U	No Action
026	Punaluu Well V-B (0.2 mgd)	W	U	No Action
027	Punaluu Well V-C (1.0 mgd)	W	U	No Action
028	Punaluu Well V-D (1.0 mgd)	B	U	No Action
029	Punaluu Well V-E (1.0 mgd)	W	D	No Action
014	Wailele Well (1.0 mgd)	W	D	P & E Funds Budgeted

BOARD OF WATER SUPPLY

Map No.	North Shore	Timing Code	Site Code	Project Implementation Status
044	Kam Hwy 12-Inch Main-Pukea Road to Crawfords Convalescent Home	W	D	No Action
025	Kawailoa Well (0.1 mgd)	W	D	No Action
004	Mokuleia Well (1.0 mgd)	W	D	No Action
030	Waimea Well (0.25 mgd)	W	D	No Action
	Waianae			
042	Makaha 242 Reservoir No. 2	B	D	No Action
005	Makaha Well II (1.0 mgd)	W	D	Land Acq./Constr. Funds Budgeted
004	Makaha Well III (1.0 mgd)	W	D	Land Acq./Construction Underway
003	Makaha Well IV (1.0 mgd)	W	D	Land Acq./Constr. Funds Budgeted
006	Makaha Well VI (1.0 mgd)	W	D	No Action
043	Nanakuli 242 Reservoir	B	D	No Action
009	Waianae Well I (0.4 mgd)	W	D	Land Acq./Constr. Funds Budgeted
008	Waianae Well II (1.0 mgd)	W	D	Land Acq./Constr. Funds Budgeted

PRIVATELY FUNDED PROJECTS

Map No.	Primary Urban Center	Timing Code	Site Code	Implementation Status
459	Palolo Heights 605" Reservoir	P	D	Land Acq./Constr. Funds Budgeted
	Ewa			
050	Campbell Ind Park Non-Potable Water Main Sec. 1	P	D	Land Acq./Construction Underway
051	Campbell Ind Park Non-Potable Water Main Sec. 2	P	D	No Action
052	Campbell Ind Park Non-Potable Well	P	D	No Action
049	Campbell Industrial Park Reservoir Non-potable Res. (mauka of H-1)	P	D	No Action
098	Ewa Marina Force Main	P	D	No Action
120	Ewa Marina Non-Potable Water System Phase I	P	D	No Action
088	Ewa Marina Non-Potable Water System Phase II (Ewa)	P	D	No Action
114	Ewa Marina Non-Potable Water System Phase III	P	D	No Action
123	Ewa Marina Potable Water System Phase I	P	D	No Action
116	Ewa Marina Potable Water System Phase II	P	D	No Action
109	Ewa Marina Potable Water System Phase III	P	D	No Action
105	Ewa Marina Potable Water System Phase IV	P	D	No Action
154	Ewa Plantation Project Dual Waterline No. 1 (Ewa Villages, Ewa)	P	D	Land Acq./Construction Underway
139	Ewa Plantation Waterline No. 2 (Ewa Villages, Ewa)	P	D	Land Acq./Construction Underway
066	Ewa Water Transmission Main I	P	D	Land Acq./Construction Underway
067	Ewa Water Transmission Main II	P	D	Land Acq./Construction Underway
132	Gentry-Ewa Water Line I	P	D	Land Acq./Construction Underway
081	Honouliuli "North-South" Potable Water Line	P	D	Land Acq./Construction Underway
070	Honouliuli 228" Tank (Reservoir) I (Honouliuli 280 Res. I)	P	D	Land Acq./Construction Underway
071	Honouliuli 280' Reservoir II (Kunia)	P	D	No Action
064	Honouliuli 280' Well I	P	U	Land Acq./Construction Underway
063	Honouliuli 410' Well I (Honouliuli Well "B")	P	U	Land Acq./Construction Underway
061	Honouliuli 410' Well II (Honouliuli 280' Well II)	P	D	Land Acq./Construction Underway
062	Honouliuli 440' Tank (Reservoir) (Honouliuli Res. "A")	P	D	Land Acq./Construction Underway
065	Honouliuli Well "D"	P	U	Land Acq./Construction Underway
181	Kapolei Town Center-Waterline 1	P	D	No Action
182	Kapolei Town Center-Waterline 2	P	D	No Action
183	Kapolei Town Center-Waterline 3	P	D	No Action

Map No.		Timing Code	Site Code	Project Implementation Status
	Ewa (cont.)			
055	Makakilo 900′ Well	P	U	No Action
113	Oneula Non-Potable Water Line "A"	P	D	No Action
097	Oneula Sewer Line "B"	P	D	No Action
095	Oneula Water Line "A"	P	D	No Action
	Central Oahu			
026	Melemanu Woodlands Water Line	P	D	No Action
022	Melemanu Woodlands 900′ Water Reservoir	P	D	No Action
019	Mililani HighTech Park Water Reservoir	P	U	Land Acq./Construction Underway
021	Mililani HighTech Park Water System Section 1	P	D	Land Acq./Construction Underway
018	Mililani HighTech Park Water System Section 2	P	D	No Action
168	Mililani Mauka Water Reservoir #1	P	D	No Action
170	Mililani Mauka Water Reservoir #2	P	D	No Action
169	Mililani Mauka Water Reservoir #3	P	D	No Action
171	Mililani Mauka Water Transmission Main #1	P	D	No Action
172	Mililani Mauka Water Transmission Main #2	P	D	No Action
190	Mililani Mauka Water Wells	P	D	No Action
052	Village Park - Deep Well No. 1	P	U	No Action
067	Village Park - Water Main No. 1 (portion)	P	D	No Action
046	Waiawa Ridge Reservoir No. 1	P	U	No Action
047	Waiawa Ridge Water Main No. 1 (portion)	P	D	No Action
045	Waiawa Ridge Well No. 1	P	U	No Action
187	Waiawa Water Main #1	P	D	No Action
188	Waiawa Water Main #2	P	D	No Action
189	Waiawa Water Main #3	P	D	No Action
185	Waiawa Water Reservoir #1	P	D	No Action
186	Waiawa Water Reservoir #3	P	D	No Action
183	Waiawa Water Well #1	P	D	No Action
184	Waiawa Water Well #3	P	D	No Action
025	Waikakalaua Stream Realignment (Melemanu Woodlands)	P	D	No Action
138	Waikele 20-Inch Water Main	P	D	Project is Imminent
077	Waikele Water Main No. 1 (Section 2)	P	D	Project is Imminent
061	Waikele Water Main No. 2	P	D	Project is Imminent
139	Waikele Water Pump Station	P	U	Project is Imminent
137	Waikele Water Reservoirs	P	U	Project is Imminent

BOARD OF WATER SUPPLY

Map No.	Koolauloa	Timing Code	Site Code	Project Implementation Status
047	Turtle Bay 12 Inch Water Transmission Mains	P	D	No Action
046	Turtle Bay Water Wells	P	D	No Action

the State's water use allocations and reporting requirements, but ultimately the State has no authority to require the military's compliance with water limits which are imposed in the Pearl Harbor Water Management Area.

4.2.3 State Water Development Plans

State water development projects identified as part of capital improvement projects for Fiscal Year 1989 to 1991 are listed in Table 18. The projects include Agricultural Park irrigation systems and exploratory wells in Mokuleia. Alternative water development projects planned include a one-million gallon desalting plant in Ewa, impoundment of Waikele Stream for non-potable irrigation use, a study of watershed checkdams to induce increased infiltration into underground aquifers, and a demonstration project to reuse wastewater effluent.

4.3 ALTERNATIVE WATER STRATEGIES

4.3.1. Greater Use of Non-Potable Sources

The use of non-potable water for agricultural and industrial purposes indirectly enhances potable water supplies for municipal use. In the Ewa plain, three major classes of brackish water--caprock water, saline water in the basal lens, and basal springs-- provide most of the water for agricultural needs. Caprock water for sugarcane irrigation provides approximately 27 mgd; high salinity water from the basal lens about 30 mgd; and basal springs provide another 30 to 40 mgd (BWS, 1982). The basal springs which emerge near the Pearl Harbor shoreline east of Waipahu are used for several water-intensive wet-culture crops, as well as for power plant auxiliary cooling and washdown. Use of non-potable sources in this way frees up potable water sources.

Blending brackish springflow with low salinity water while maintaining its potable quality can also extend present resources. This could be implemented at Hawaiian Electric Company's Waiau Tunnel where a springflow of up to 8 mgd, averaging 300 ppm salinity, may be blended with diluting sources from Waipahu or Kunia. The water would be blended to maintain desirable chloride levels of between 150 to 200 ppm. In addition to blending, brackish surface water supplies already provide alternate sources for landscape irrigation. Kalauao Spring Station in Honolulu presently irrigates some State highways, the airport, and may eventually irrigate some parks and golf courses as well.

Six well sites designated most promising in the Pearl Harbor Brackish Water Study deserve attention as future alternative sources. See Figure 34. Basal well Nos. 2006-01/11 below Honokai Hale on Pump 10 Road are most recommended for brackish water development since the site is relatively isolated from major freshwater pumping centers. Chloride count ranges from 470 to 690 ppm and pumping rate from 13.5 to

TABLE 18
CAPITAL IMPROVEMENTS PROJECTS-STATE OF HAWAII

	Fiscal Year 1989-90	Fiscal Year 1990-91	Total Biennium 1989-91
		(Appropriations in $1,000's)	
Waimanalo Irrigation System Improvements, Koolaupoko, Oahu. Plans, Design & Incremental construction of improvements to the Waimanalo irrigation system consisting of a 60mg reservoir and a closed pressurized distribution pipeline as outlined in the Waimanalo watershed plan and as authorized under PL-566 for matching federal funds. This project is deemed necessary to qualify for Federal aid financing or reimbursement.			
Land Acquisition	750		750
Total Funding	750		750
Improvements to Maunawili Ditch intake structures, Waimanalo irrigation system, Oahu. Plans, design and construction of improvements to intake structures together with appurtenant facilities.			
Plans	5		5
Design	10		10
Construction	120		120
Total Funding	135		135
Investigation and development of Desalting Plant technology. Plans, Land Acquisition, design and construction of a one mgd desalting demonstration plant.			
Plans	100	100	100
Total Funding	100	100	100
Waiahaole Ditch Bulkheading Project, Oahu. Plans, design and construction of improvements to capture, store and control the water from the dike complex that feeds the Waiahaole ditch system including other incidental and appurtenant work.			
Design	50		50
Construction	1,450		1,450
Total Funding	1,500		1,500
Kawaihapai Exploratory Well, Mokuleia, Oahu. Plan, design and drilling of an exploratory well including installing casing, pump testing and other incidental and related work.			
Plans		10	10
Land Acquisition		1	1
Design		25	25
Construction		300	300
Total Funding		336	336
Mokuleia Exploratory Well, Oahu. Plans, design, and drilling of an exploratory well including casing pump testing an other incidental and related works.			
Plans	10		10
Land Acquisition	1		1
Design	25		25
Construction	300		300
Total Funding	336		336
Alternative Water Source Development, Waikele Stream impoundment, Oahu. Plans, design, and construction of a dam including other appurtenant and related work to impound Waikele Stream water for non-potable irrigation use.			
Plans	50		50
Design	50		50
Total Funding	100		100
Wastewater Effluent Recycling Project, Oahu. Plan, design, and construction of demonstration project to obtain data on recycling wastewater effluent.			
Plans	50		50
Land Acquisition		1	1
Total Funding	50	1	51
Alternative Water Source Development Checkdams, Oahu. Plans, design and construction of watershed checkdams to induce increased infiltration into underground aquifers.			
Plans		50	50
Total Funding		50	50

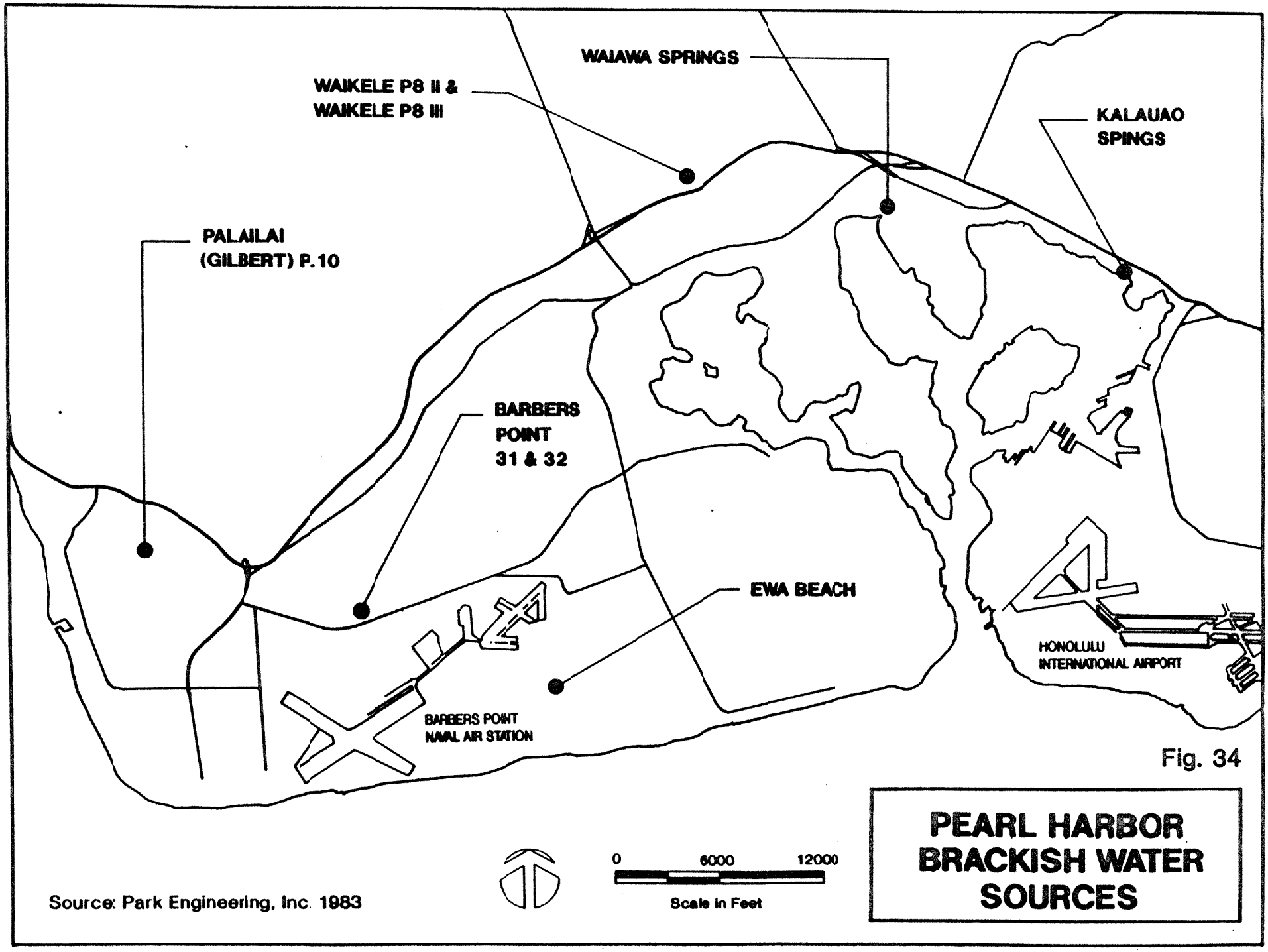

Fig. 34

PEARL HARBOR BRACKISH WATER SOURCES

Source: Park Engineering, Inc. 1983

17.5 mgd. The other basal wells in Waikele, Nos. 2301-11/32, are too close to major freshwater wells to currently merit further development.

Caprock well No. 1902-01 (Ewa Beach) shows promise on account of its location and past pumping rates, though long term effects on salinity and recharge at higher pumping rates are uncertain. It is relatively isolated from the basal aquifer: chlorides range from 650 to 800 ppm, and pumping rates range from 5 to 7 mgd. Well No. 1904-01 at Barber's Point is also isolated from the areas basal aquifer and is favorable for that reason. Chlorides range from 400 to 800 ppm, and pumping rates from 3.5 to 7.0 mgd.

Two basal springs targeted by the Pearl Harbor study, both artesian, are probably subject to contamination from time to time. Flow rates vary seasonally and both wells currently wash into the ocean. The Pearl Harbor Spring at Kalauao flows at 7.36 to 12.9 mgd; chloride count 156 to 420 ppm. The flow rate at Waiawa Springs (Station 9) varies from 8.92 to 17.2 mgd, with a chloride count of 605 to 1600 ppm.

4.3.2. Re-use of Wastewater Effluent

Results of the recent test project in Ewa support the potential benefits of wastewater effluent re-use as a source for replenishing non-potable water and maintaining low salinity caprock water, as well as producing usable biomass (sugarcane and California grass). The project, conducted by the University of Hawaii Water Resources Center (WRRC) in conjunction with DLNR, flooded six half-acre plots adjacent to Honouliuli's treatment plant with primary-treated effluent once a day. Using flood irrigation on California grass produced 68,000 gpd of recharge water per acre, or 14.6 acres per 1 mgd. On sugarcane, recharge was about 81,000 gpd but was accompanied by a loss in crop quality due to a failure in the drip-irrigation system which alternately watered the crop. Estimates of total land eventually desired for this type of recycling vary from 100 to 500 acres. The resulting water, percolated through a "living filter", nearly approached potable quality.

Possible contamination of the soil does pose a hazard if the proposed use of primary effluent (non-chlorinated) was implemented without careful monitoring. Otherwise, in addition to replenishing the Ewa aquifer and diluting its salinity, this project presents an alternative to ocean disposal and costly upgrades for secondary treatment facilities.

4.3.3 Desalting Plant

The high salinity of Ewa's caprock water can also be transformed by desalting plants to create potable supplies. By mid-1990 a $5.7 million desalting plant built over Palailai basal well No. 2301-11,32 near Campbell Industrial Park is expected to produce 1 mgd for household use, with a potential production capacity of 10 mgd. This high technology facility will rely on either reverse osmosis or electrodialysis, the

two most commercially proven methods. Reverse osmosis uses the natural phenomenon of osmosis to obtain desalted water from brackish water subjected to high pressure. Electrodialysis removes salt by attracting its positive and negative-charged ions. Both methods can produce purified water which is only one-fourth as salty as normal tap water. An eventual choice between them will be based upon feedwater characteristics, the product waters' intended use, disposal options for waste brine solution, operating costs, removal requirements for contaminants, and the blending of the product water with other supplies.

The U.S. Environmental Protection Agency standard for chlorides is 250 milligrams per liter but the standard or limit for chlorides for the project has been established at 160 milligrams per liter to conform to the BWS's operating guidelines for palatability. The lower level for chlorides is based on experience with customer preference.

The Ewa desalting plant is a joint undertaking of the State DLNR, University of Hawaii's WRRC and the BWS. The project site and other funds were donated by Campbell Estate. Its most important function will be to provide information on the viability of such technology in Hawaii, giving first-hand experience with the facilities construction, design, operation, maintenance and cost. If the project is successful, future plants can be developed to meet water needs.

With respect to cost, the plants production should be competitive with the current BWS rate of $1.22 per 1,000 gallons. With BWS rates expected to increase to $1.38 by 1991, purified water done at $1.50 to $3.00 per 1,000 gallons is not unreasonable. It should be noted that the plant will not be designed to desalt sea-water.

4.3.4. Conservation Measures

The Board of Water Supply has implemented extensive water conservation programs. These programs fall into two major categories: Water System Conservation and Consumer Conservation.

Water system conservation involves efforts by the BWS to account for the transmission and distribution of water supply. All water services are metered, including those "free" water privileges which the public enjoys but from which the BWS derives no revenue. Even water used for fire-fighting and street and sewer flushing is measured through various means. This careful monitoring enables the BWS to pinpoint discrepancies within the system and to institute conservation measures where required.

Furthermore, the BWS has an ongoing leak detection program, begun in 1976, to minimize losses that inevitably occur in such a large system. Under certain circumstances, leaks in piping may go undetected for a long time and cause large losses. The leak detection program can be a preventive program too, sometimes revealing a need for pipe replacements.

While the BWS has the ability to regulate its own systems, regulating consumer consumption is of far greater difficulty and necessity. Because a reduction in per capita consumption can partially offset population increases, the BWS continues to emphasize long-range public information and awareness campaigns. In 1977, after an unusually dry winter, The BWS fostered a public awareness campaign which reduced per capita usage by 10 percent over 3 years. This success has since prompted the development of educational material such as informative comic books and pamphlets with tips on water-saving which can be distributed in schools and at home.

In 1978, the BWS modified their water rate structure to penalize above-average per capita consumers and to provide incentives for conservation. This remains an option today, as do special seasonal rates which could prompt a reduction in summer demand. Adjusting water costs can also encourage the installation of water saving devices in all residences. Amending the plumbing code to require such devices in all new construction could speed their use as well. Many low-rise and single-family condominiums are also developed without individual water meters for each residential unit. Such master metering intended to save development costs does not enable economic incentives for conservation.

One conservation initiative test project, conducted by the City Department of Public Works in Hawaii Kai (Laulima subdivision), is experimenting with ultra-low flush toilets (1.5 to 1.6 gallons per flush, as opposed to 3.5 to 5.0 gallons). If feasible, requiring such devices for remodeling could spawn efforts to eventually replace conventional fixtures.

In many Oahu residential areas, about half or more of the total water consumption is for landscaping irrigation; therefore; the BWS has been working on programs to encourage the use of water conserving xeriscape landscaping wherever possible. A sample xeriscape garden using a wide variety of drought-resistant plants has been installed at the BWS Halawa Shaft facility for public viewing and to further develop public awareness and interest. A water conservation garden contest for consumers has also been initiated.

5. PLAN IMPLEMENTATION

5.1 FUTURE WATER DEMAND SCENARIOS

Future water demand on Oahu depends on the needs of the two largest water users - the sugar plantations and the Board of Water Supply. With respect to sugar plantation demand, a major area of uncertainty lies with the economic outlook for the sugar industry. Sugar presently consumes nearly half of the total water use on Oahu. Projected decreases in sugar production are based on the M-K economic forecasts, but these could be subject to considerable variability due to external forces on the industry. Several scenarios covering alternative futures for sugar and their implication with respect to water demand are reviewed.

Future water needs of the Board of Water Supply reflect the projections of municipal water demand. Although presently constituting less than half of the water use on Oahu, municipal water demand is expected to steadily increase in both the near and long term, largely as a function of population growth.

5.1.1 Sugar Demand Scenarios

As described in a report of the State Department of Business and Economic Development on the outlook of the sugar industry (Decision Analysts, Hawaii, 1989), further declines in sugar production are expected. Of Hawaii's 11 sugar companies, only three are profitable, while four are experiencing large losses. U.S. sugar prices are expected to remain unchanged, but companies are faced with increased costs for labor and materials, and increased competition from expanding acreages of sugar growers on the mainland and new artificial sweetners.

Oahu Sugar Company lands in Ewa and Central Oahu are faced with intense development pressures, while Castle and Cooke has recently contemplated phasing out Waialua Sugar's operations. The plantations are taking a number of steps to increase profitability, including conversion to drip irrigation, exploring the potential for a 1-year rather than 2-year crop, streamlining production costs, and planting and irrigation of fallow lands.

To account for the potential alternative sugar futures, three demand scenarios for sugar are presented: 1) M-K decline, 2) closure of one sugar plantation, and 3) closure of both plantations. The inclusion of these scenarios are significant to water demand projections in view of the high water consumption rates of the sugar plantations.

Scenario 1: M-K Decline in Sugar. In the State economic projections, the DBED projects a 26 percent or 1.5 percent annual decline between 1990 and 2010 in export value statewide for raw sugar. Such a decline could translate to a reduction in sugar water demand of approximately 48 mgd. Such a decline could well occur as the result

of various development proposals on Oahu Sugar Company lands, one estimate of which totals nearly 5,000 acres. Whether sugar will be replaced by other agricultural crops or by urbanization will in large part depend upon future sugar prices, the disposition of lease arrangements, and State and City land use policies. Regardless of what activities replace the withdrawn sugar acreage, there would be a reduced demand for water given the high water use of sugarcane cultivation.

Scenario 2: Closure of One Plantation. Hawaii sugar operations which are potential candidates for being closed include producers that 1) have relatively high production costs, 2) lack adequate financial resources, and 3) use land for which there are more profitable uses, such as urbanization (Plash, 1981). The threat of urbanization is most acute for the Oahu Sugar Company, a plantation which leases all its lands and is situated directly in the path of Ewa and Central Oahu urban expansion plans. Overall, only about 8,000 acres of Oahu Sugar's 1988 land area of 13,490 acres remain free from urbanization pressures, but this includes 3,100 acres of land which are being purchased by the State for eventual housing development (Decision Analysts Hawaii, 1989). With its major land leases set to expire in the mid-1990's, much uncertainty surrounds continued operations. Oahu Sugar consumes an estimated 110 mgd of ground water, Waiahole Ditch, and caprock aquifer supplies, water which upon the company's closure would become available in abundant supply for other uses.

Scenario 3: Closure of Both Plantations. Given the unfavorable outlook for the sugar industry, the closure of both Oahu Sugar and Waialua Sugar is a possibility in the mid to long-term scenario. Waialua Sugar, despite high yields and efficient operations, is only marginally profitable. Castle and Cooke has seriously investigated the possibility of gradually phasing out of sugar and converting most of its lands to macadamia nuts and pineapple. However, this strategy is not being pursued because of the high cost of subdividing the land and planting macadamia nuts. Efforts have instead focused on improving the economic efficiency of the plantation and exploring alternate crops to replace sugar. The majority of Waialua Sugar's lands are owned by Castle and Cooke, although 5,000 acres are leased from Bishop Estate with lease expiration in the year 2000. Waialua Sugar also uses substantial quantities of water, estimated at 38 mgd of ground water and 33 mgd of surface water.

Replacing Sugar with Diversified Agriculture. The withdrawal of sugar and availability of substantial agricultural lands could result in the gradual relocation or replacement of diversified agriculture activities from the Neighbor Islands to Oahu, where growers would be closer to the large Honolulu consumer and supply markets, and could also avoid inter-island shipping costs. The State could also facilitate diversified agriculture through the development of additional agricultural parks. Over the next 20 years, land requirements for diversified agriculture destined for the local market can be expected to increase by 30 percent, or approximately 1,500 acres. Diversified agriculture catering to the local market alone is not sufficient to replace sugar acreage and additional crops for the export market will also need to be pursued.

Sugar companies have been actively exploring replacement crops for sugar, including macadamia nuts, coffee, tea, cocoa, citrus, and aquaculture. Of the potential

replacement crops, the only land-extensive crop of proven profitability is macadamia nut orchards. However, extensive planting on the Neighbor Islands by sugar companies has given way to concerns over market saturation, the planting of macadamia nuts in California, and high initial investment (Decision Analysts, Hawaii 1989).

5.1.2 Municipal Demand Scenarios

In the municipal sector of water demand, the future scenarios are provided by the General Plan's population distribution, which provide a range of population objectives for each of the Development Plan areas. These population objectives are implemented through the Development Plan and zoning approval processes. Alternative scenarios affecting water demand are largely related to the extent to which the population objectives in each of the Development Plan areas are attained. Development is channeled via land use approvals into areas with available population capacity.

Two scenarios feasible for consideration in water use planning include: A) the mid-point of the General Plan population range (mid-point of the M-K estimate), and B) the upper limit of the General Plan population range (105 percent of the M-K estimate).

5.1.3 Summary of Future Oahu Water Demand

Future water demand on Oahu is primarily dependent on the two major categories of water use: municipal supply as provided by the Board of Water Supply and sugarcane irrigation by the two plantations on Oahu. A number of scenarios based on alternative sugar futures and population growth are possible which could significantly alter the future water needs for the island. The alternative scenarios for water demand in the year 2010 include:

Scenario 1A: M-K forecast decline in sugar; and
Midpoint of the General Plan population range (M-K population projection).

Scenario 1B: M-K forecast decline in sugar; and
Upper limit of GP population range (105 percent of the M-K estimate).

Scenario 2A: Closure of one plantation (Oahu Sugar Co. assumed);
Midpoint of the GP population range.

Scenario 2B: Closure of one plantation (Oahu Sugar Co. assumed);
Upper limit of GP population range.

Scenario 3A: Closure of both plantations; and
Midpoint of the GP population range.

Scenario 3B: Closure of both plantations; and
Upper limit of GP population range.

For the purpose of projecting future water demand, it is assumed that the projected declines in sugar production will result in corresponding water demand reductions. (See Table 19) In Scenario 1A, for example, a 26 percent decrease in sugar is anticipated by the year 2010. It may be expected that the "released" acreage will be subject to urbanization as well as replacement crops. Assuming one-third is urbanized and two-thirds are replacement crops (with average water demand three-quarters that of sugar cane), the combined water demand for sugar and the replaced acreage is expected to decrease from 186 mgd in 1988 to 162 mgd by the year 2010.

Scenarios 1A and 1B are the recommended scenarios on which to base planning decisions, especially since the scenarios which involve the closure of plantations would release more than adequate quantities of water to meet Oahu's future needs.

The military presence on Oahu, although substantial, is expected to remain relatively stable in terms of the number of active military personnel and dependents stationed on the island. The major increase in demand is expected to arise from the anticipated decision to homeport a battleship group at Pearl Harbor. Private systems and industrial use are expected to remain stable in usage through the planning period.

Municipal water demand is driven primarily by population increases and associated land use allowances for increased residential and other urban activities. The overall impact on water resources, however, may not be significant if such increased demand is offset by a reduced demand for agricultural water use. Projected declines in sugar acreage would free up water for urban uses, and lessen the need to develop new water sources.

5.2 ADEQUACY OF FUTURE SUPPLY

Based on the findings and projections of this study, Oahu should have an adequate supply of water to meet islandwide needs at least until the year 2010. Overall, increases in municipal demand are expected to be largely offset by reductions in plantation water requirements. Based on the State projections for declines in the sugar industry, an estimated additional 31 to 40 mgd will be required by the year 2010 to meet Oahu's total water needs (Scenarios 1A and 1B). In view of the available remaining ground water which can be safely developed, the planned or proposed water source development projects, and alternative water development projects underway, future demand is capable of being accommodated.

Sustainable ground water yield. A determination of Oahu's sustainable ground water yield undertaken as part of the Water Resource Protection Plan indicates there are substantial quantities of ground water available for development. The total sustainable yield of ground water which can be developed without affecting the aquifers is

TABLE 19

WATER DEMAND SCENARIOS
1988 AND 2010 (MGD)

	BWS	SUGAR	MILITARY	PRIVATE	SUGAR REPLACE-MENT	TOTAL	ADDTL WATER NEEDS
1988:							
ACTUAL	150	181	26	51	-	408	-
2010:							
SCENARIO 1A M-K Sugar M-K Pop.	199	138	29	51	22	439	31
SCENARIO 1B M-K Sugar GP Pop Limit	208	138	29	51	22	448	40
SCENARIO 2A 1-Sugar Closed M-K Pop.	199	76	29	51	53	408	-
SCENARIO 2B 1-Sugar Closed GP Pop Limit	208	76	29	51	53	417	9
SCENARIO 3A 2-Sugar Closed M-K Pop.	199	0	29	51	91	370	-
SCENARIO 3B 2-Sugar Closed GP Pop Limit	208	0	29	51	91	379	-

NOTE: See text for explanation of scenarios.

estimated at 495 mgd. 1988 ground water withdrawals totaled 339 mgd, which should leave an available remaining supply of approximately 156 mgd which theoretically could be safely developed. Section 3.2 discusses some of the particular considerations mitigating full use of the remaining sustainable yield.

It should be noted that the estimated sustainable yield is to be used as a guide for planning and is not meant to be an exact final number. Not enough is known about the extent and behavior of ground water resources to allow more than an estimate of sustainable yield. Only in southern Oahu (Pearl Harbor and Honolulu aquifer sectors) where there has been many years of investigation can the sustainable yield be employed with confidence.

Since the sustainable yield is of critical importance in determining future available supply, continuing monitoring and investigation are warranted to ascertain with a greater degree of confidence these estimated yields. Accuracy of sustainable yield at the aquifer system level will help guide decisions regarding future exploration and development of water sources.

Surface water supply. While a fair amount of data is available on Oahu's ground water withdrawals, much less is known about surface water use and consumption. This is particularly so in Windward Oahu, where stream diversions are commonplace for diversified agriculture. For the purpose of determining existing use and projecting future use, it is important to inventory surface water use. As a followup to the water registration program undertaken by the DLNR, the unreported and undetermined quantities of surface water use in Windward Oahu should be certified.

There is also the need to obtain near and long term projections of diversified agricultural activity on the island. Towards this end, a separate inventory of diversified agriculture should be undertaken which includes the irrigated acreage, method of irrigation, source of water, and quantity and quality of water used. Ideally, such information could be compiled as part of the State Agricultural Functional Plan which is expected to be updated within the next year. This would be consistent with the thrust of the Functional Plan since the interests of protecting and promoting diversified agriculture are served by ensuring an adequate supply of water.

Proposed Source Developments. From 1990 to 1995, the BWS proposes source developments with a potential capacity of 19 mgd. Most of these projects are in the Windward area, with 13 well projects projected to yield 10 mgd. Although an additional 23 well sites in Windward Oahu have been identified, many of these projects may not materialize because of instream and other environmental problems. Aside from the BWS, the agricultural, military, and private systems operators have no specific or significant water development plans.

Alternative Water Strategies. Optimal use of Oahu's water resources will require an ongoing program of water conservation and the development of alternative sources. Principal among these is maximizing the use of Oahu's non-potable water in a manner consistent with the protection of ground water quality. The BWS has actively pursued

the use of brackish sources at Kalauao and at Hawaiian Electric Company's Waiau plant.

In Ewa, a demonstration desalting plant is under construction by the State near Campbell Industrial Park. The desalting plant is expected to initiate operations this year, and produce one mgd of potable water, with a potential production capacity of 10 mgd.

Reuse of wastewater effluent for irrigation or ground water recharge has been proven effective and should be pursued, provided that such measures do not constrain the City's wastewater management operations and do not occur at the expense of wastewater users. Despite some setbacks in the successful use of secondary effluent for agricultural and golf course irrigation, efforts to reuse the effluent should be continued as a viable long term alternative for extending Oahu's limited potable supply.

5.3 WATER ALLOCATION PLAN

5.3.1 Allocations for Future Demand/Supply

The basic directions for growth on Oahu established by the City's General Plan call for the full development of the Primary Urban Center and promotion of development within the secondary urban center at Kapolei and the Ewa and Central Oahu urban-fringe areas to relieve developmental pressures in other areas. Future water demand on Oahu has been projected based on the implementation of these primary land use directives. Table 20 and Figure 35 show future municipal water needs by DP area and the additional amounts of water needed in each area to satisfy the upper limits of the General Plan population range.

The DP areas requiring the greatest amounts of water by the year 2010 are Ewa, the Primary Urban Center, and Central Oahu. Ewa will need 33.0 mgd additional water supply to meet the projected population and land use allocations for the area. The Primary Urban Center and Central Oahu follow with additional needs of 13.1 mgd and 5.6 mgd, respectively. All other areas will require about 2 mgd or less by the year 2010.

The Ewa area is already importing its potable water from the Pearl Harbor area, but the Pearl Harbor aquifers are rapidly approaching their maximum sustainable yield. This problem has been made more acute by a reduction in the determined sustainable yield for the Pearl Harbor Water Management Area from 225 mgd to 195 mgd by the State Commission on Water Resource Management. Future increases in demand for the Primary Urban Center will require importing water from other areas, principally the Windward areas and North Shore.

Given the projected declines in the sugar industry, it is noteworthy that urban uses or other diversified agricultural crops which might be proposed on sugarcane lands

TABLE 20

FUTURE WATER NEEDS BY DP AREA
(mgd)

DEVELOPMENT PLAN AREA	1988 USE	2010 DEMAND* (GP Limit)	ADDITIONAL WATER NEEDS
PRIMARY URBAN CENTER	83.7	96.8	13.1
EWA	9.4	42.4	33.0
CENTRAL OAHU	15.1	20.7	5.6
EAST HONOLULU	9.0	10.9	1.9
KOOLAUPOKO	17.6	18.1	0.5
KOOLAULOA	1.8	2.5	0.7
NORTH SHORE	3.6	5.4	1.8
WAIANAE	9.6	11.5	1.9
TOTALS:	149.9	208.3	58.5

* 2010 demand provides for the upper limit of the General Plan population range

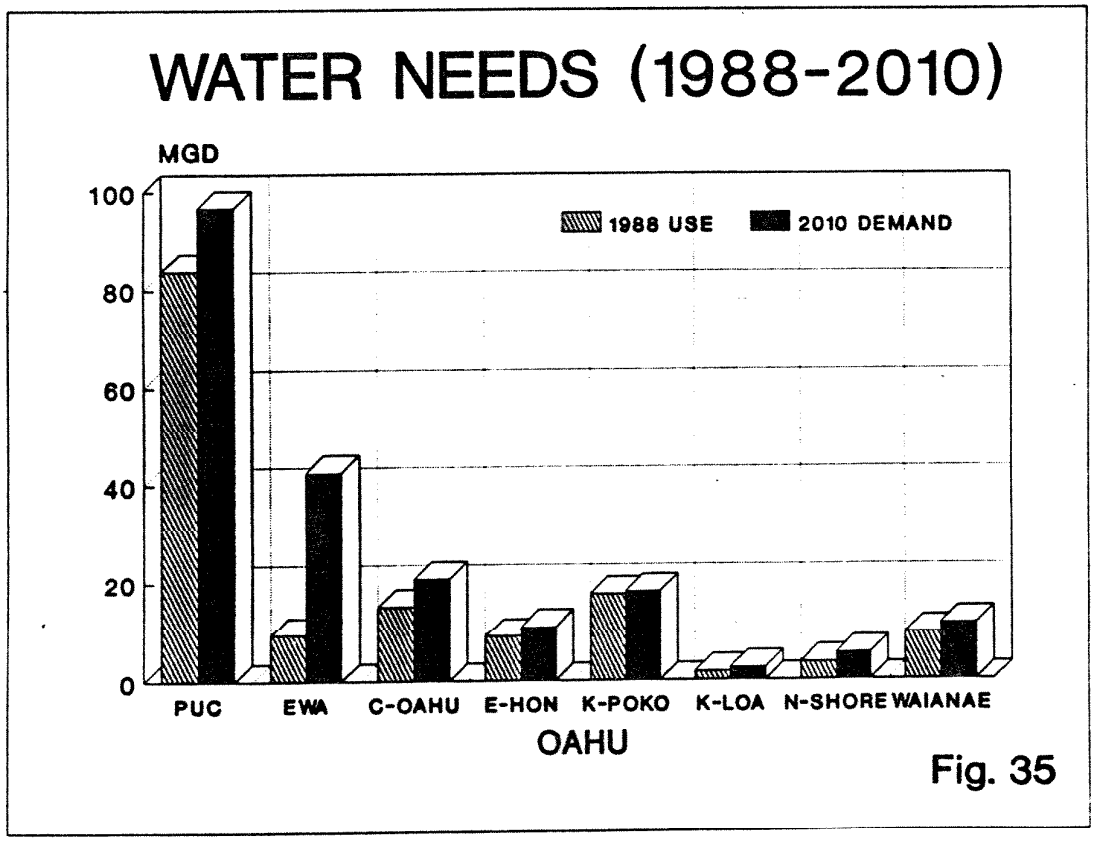

Fig. 35

would in all likelihood require much less water. In allocating ground water within designated Water Management Areas, the State Commission on Water Resource Management should establish the necessary procedures to more readily transfer water allocations, especially where urban or other agricultural uses replace sugarcane lands. This is important to ensure that water does not unnecessarily pose a constraint to development.

In the Ewa and Central Oahu DP areas, the allocation of water to meet the projected municipal demand of 33.0 and 5.6 mgd, respectively, should first be accommodated with the transfer of water allocations from lands withdrawn from sugar. Assuming that 5,000 sugarcane acres are withdrawn from cultivation, 35 mgd should be released and available to support urban and residential development. Upon successful demonstration of the State's desalting plant, expansion of the plant to its 10 mgd capacity would provide additional potable supply to meet the urban demands in the Ewa area. Furthermore, the projected increase in pineapple production (14 percent by 2010) is expected to occur as a replacement of sugarcane lands. This conversion could result in an estimated savings of 9 mgd.

To satisfy the future additional water demands in other areas, it may be necessary to rely on the development of new water sources in other areas of substantial undeveloped ground water supply. Such areas include the northern areas of Mokuleia, Waialua, and Kawailoa whose sustainable yields are understated because spillover from the Wahiawa aquifer is not included. This could add about 37 mgd to the sustainable yields of these areas. The Windward region also appears to have surplus supplies, on the order of about 38 mgd based on current withdrawals. Ground water sources in Windward Oahu, however, should only be developed to the extent that surface water supplies are not unduly impaired. The BWS has developed over the years an extensive water distribution network. This system could take advantage of the exploration and development of these sources to provide the necessary additional supply for the Primary Urban Center and other areas over the next twenty years.

5.3.2 Allocations for Major Public Projects

In addition to the need for allocations based on the General Plan population distribution guidelines and the land use policies contained in the Development Plans and depicted on the Development Plan land use maps, consideration is warranted for major public projects which can also require substantial amounts of water. This is part of the purpose for the State Water Projects Plan which establishes the framework for implementation of the State water development program. The State Water Projects Plan reviews current and future State water programs and projects to insure orderly authorization and development of the State's water resources.

In a similar manner, the identification of significant City public projects and their water requirements will help to provide indications of where future water demands are most significant and the potential critical areas requiring more detailed evaluation and increased water supplies.

Housing. Of primary importance to the City is securing adequate water supplies for the planned affordable housing developments anticipated in the near future. A number of major City-sponsored residential developments shown on the Development Plan land use maps and/or processed under Chapter 201E, HRS, is planned within the next decade which will result in approximately 18,200 new residential units to help meet the high demand for affordable housing on the island. These residential developments will result in a potable and non-potable water demand of approximately 10.4 mgd. See Table 21. There will be other affordable housing projects in the future. The list is not intended to be all-inclusive, but identifies known housing projects at this time.

TABLE 21
PLANNED CITY HOUSING DEVELOPMENTS AND
ANTICIPATED WATER DEMAND

PROJECT	DESCRIPTION	WATER DEMAND (mgd)*	1st DELIVERY
EWA DP AREA:			
West Loch Bluffs	1,687 units (1,012 single-family, 675 multi-family) Golf course	1.68	1993-1995
Ewa Villages Revitalization	850 single-family units	0.43	1992-1994
Ewa Villages Expansion	1,150 single and multi-family units Golf course	1.14	1994-1997
Hale Ola	8,714 units (7,343 single-family, 1,371 multi-family) Golf course	4.82	1997
Honouliuli	262 multi-family units	0.11	1991
CENTRAL OAHU:			
Kipapa Ridge Estates	1,345 units (847 single-family, 498 multi-family) Golf course and regional park	0.92	1992
PRIMARY URBAN CENTER:			
Foster Gardens Estate	1,600 multi-family units	0.48	1993
Maunakea Smith	262 units (22 studio, 112 one-bedrm, 128 two-bedrm)	0.11	1992
Kekaulike Parking Lot	132 rental units (84 studio, 42 one-bedrm, 6 two-bedrm)	0.04	1992
Park Place	422 units (211 one-bedrm, 211 two-bedrm)	0.13	1992
Kaahumanu Parking Lot	122 luxury two-bedroom units	0.04	1993
Pawaa	1,600 multi-family units	0.48	1993
	TOTAL WATER DEMAND	10.38	

* Water demand based on 500 gallons/unit for single-family, 400 gallons/ unit for multi-family low rise, 300 gallons/unit for multi-family high rise, and 4,000 gallons/day/acre for golf course.

Source: Department of Housing and Community Development

Of the 18,200 new units, about two-thirds of these units (12,700 units) will be located in Ewa, one of the drier areas on the island with a high per capita water demand. To accommodate the anticipated 8.2 mgd demand in Ewa which would be generated, an increased allocation will be required from the State Commission on Water Resource Management. Since most of these developments replace sugarcane lands, the associated water allocations should be transferred to the municipal supply.

Parks and Golf Courses. Golf courses and parks have been incorporated into the master plans for several of the above housing developments. As with other Ewa developments, water demand will be met with the use of potable and non-potable water. Whenever feasible, non-potable water should be used to irrigate golf courses and landscaping in common areas.

A recent City study of golf courses (Department of Land Utilization, 1989) recommends that golf courses should be part of an integrated plan for the surrounding area, to help with drainage, provide a buffer between potentially incompatible uses (sugar cane fields and blast zones), and preserve viewplanes and vistas. Water demand for golf courses can be significant, depending on the location and rainfall in the area. In the Ewa area, an estimated 600,000 to 700,000 gallons per day could be required for irrigation (4,000 gallons per day per acre [gda]). This amount is still less than sugarcane (6,000-10,000 gda) but is greater than the residential usage (2,500 gda). As with sugar, however, golf courses can be irrigated with non-potable water.

In the Ewa area, irrigation of golf courses and parks is anticipated to be provided by non-potable water, such as by brackish groundwater sources in the caprock aquifer. Priority consideration should be for the use of non-potable water for irrigation. The use of treated effluent for irrigation, if and when available, should also be pursued, provided that groundwater quality would not be adversely affected. The State Department of Health has established a set of conditions applicable to new golf course developments which protect groundwater sources and address the impacts of total minerals, heavy metals, and organic substances.

Table 22 summarizes City plans for future parks and golf course developments which would affect the water demand in the respective Development Plan areas.

TABLE 22

WATER DEMAND FOR
PROPOSED PARKS AND GOLF COURSES

PROJECT	ACRES (Approx.)	WATER DEMAND (mgd)*
EWA:		
Kapolei Regional Park	90	0.36
Ewa Regional Park	100	0.40
Sports Complex	100	0.40
District Parks	60	0.24
Neighborhood/Community Parks	80	0.32
Beautification/Street Trees/Parkways	20	0.08
CENTRAL OAHU:		
Neighborhood/Community Parks	60	0.24
Mililani District Park	25	0.10
NORTH SHORE:		
Various Beach Parks	150	0.60
KOOLAULOA:		
Municipal Golf Course	150	0.60
Beach Parks	30	0.12
KOOLAUPOKO:		
Bellows Regional Park (includes 36-hole golf course)	1,200	4.80
EAST HONOLULU:		
Koloko Beach (Queen's Beach)	20	0.08
	TOTAL:	8.34

* Based on 4,000 gallons per day per acre.

Source: Department of Parks and Recreation

Other Major Facilities. Other major public projects which require water include wastewater treatment plants (WWTP) and the H-POWER resource recovery plant. Existing and future water demands are shown in Table 23 below.

TABLE 23

FUTURE WATER DEMAND FOR OTHER MAJOR FACILITIES

FACILITY	CURRENT AVE. CONSUMPTION (mgd)	FUTURE WATER DEMAND (Year 2010)
Sand Island WWTP	0.14	0.18
Honouliuli WWTP	0.33	1.0
Kailua WWTP	0.03	0.06
H-POWER	1.0	N/A

Note: Water demand includes use of potable and non-potable water.

Source: Department of Public Works

REFERENCES

Artesian Water Centennial Symposium. Groundwater in Hawai'i: A Century of Progress. Honolulu: 1981.

Belt, Collins and Associates. Ewa Water Master Plan (Revised). Prepared for the Ewa Plain Water Development Corporation. Honolulu: August 1987.

Belt, Collins and Associates. Hawaii Technology Park Mililani, Oahu, Hawaii Final Environmental Impact Statement. Prepared for Oceanic Properties, Inc. November 1985.

Castle and Cooke. Castle and Cooke, Inc. 1988 Annual Report. Honolulu: 1989.

Castle and Cooke Diversified Agricultural Task Force. Castle and Cooke Hierarchy of Agricultural Lands Study -- Central Oahu Lands. Honolulu: March 1984.

CH2MHill, A Study of Integrating Hawaii's Energy and Water Resources. Prepared for the State of Hawaii Department of Planning and Economic Development and the Department of Land and Natural Resources. Honolulu: February 1987.

City and County of Honolulu Board of Water Supply, Yee, Phillip K. H. A Survey of Principal Private and Government Water Systems of Suburban Oahu. May, 1960.

City and County of Honolulu Board of Water Supply, Customer Service Division. Updated Summary of Principal Private Water Systems of Oahu. December, 1976.

City and County of Honolulu Board of Water Supply; Department of Planning and Economic Development; Center for Science Policy and Technology Assessment; University of Hawaii Water Resources Research Center. Information Report for a Proposed Demonstration Desalting Facility for Leeward Oahu, Hawaii. July, 1978.

City and County of Honolulu Board of Water Supply. Honolulu Board of Water Supply Annual Report and Statistical Summary July 1, 1987 - June 30,1988. Honolulu: 1988.

City and County of Honolulu Board of Water Supply. Municipal Water Use Plan Pearl Harbor Ground Water Control Area. Honolulu: October 1981.

City and County of Honolulu Board of Water Supply. Oahu Water Plan. 1975.

City and County of Honolulu Board of Water Supply. Oahu Water Plan (Fourth Edition). Honolulu: July 1982.

City and County of Honolulu Board of Water Supply. Six-Year Capital Improvements Program July 1, 1988 to June 30, 1994. Honolulu: 1988.

City and County of Honolulu Board of Water Supply. State of the Groundwater Resources of Southern Oahu. Honolulu: 1980.

City and County of Honolulu Department of General Planning. General Plan Objectives and Policies. 1988.

City and County of Honolulu Department of General Planning. Resolution No. 88-404 Amending the General Plan. March, 1989.

Decision Analysts Hawaii, Inc. Hawaii's Sugar Industry and Sugarcane Lands: Outlook, Issues and Options. Prepared for State of Hawaii, Department of Business and Economic Development. April, 1989.

Estate of James Campbell. Kapolei Master Plan. May, 1989.

Eyre, Paul, Charles Ewart, and Patricia Shade. Hydrology of the Leeward Aquifers, Southeast Oahu, Hawaii (U.S. Geological Survey Water-Resources Investigations Report 85-4270). Honolulu: 1986.

First Hawaiian Bank Research Department. "Economic Indicators." May/June 1989.

George A. L. Yuen and Associates, Inc. Review and Re-Evaluation of Groundwater Conditions in the Pearl Harbor Groundwater Control Area Oahu, Hawaii (Report R-78). Prepared for the State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management. Honolulu: May 1988.

George A. L. Yuen and Associates, Inc. Groundwater Resources and Sustainable Field, Ewa Plain Caprock Aquifer. Report R-79. Honolulu: March, 1989.

George A. L. Yuen and Associates, Inc. State Water Resources Protection Plan, Volume I, Draft. Prepared for State Water Resources Management Commission. Department of Land and Natural Resources. Honolulu: January, 1990.

Group 70. Laie Master Plan. Draft. December, 1987.

Hawaii Agricultural Reporting Service. Agricultural Water Use: A Special Survey of Selected Water Districts - Leeward Oahu. Prepared for the State of Hawaii Department of Agriculture Marketing and Consumer Services Division and United States Department of Agriculture Statistical Reporting Service. Honolulu: December 1982.

Hawaii Agricultural Reporting Service. Agricultural Water Use: A Special Survey of Selected Water Districts - Windward Oahu. Prepared for the State of Hawaii Department of Agriculture Marketing and Consumer Services Division and United States Department of Agriculture Statistical Reporting Service. Honolulu: May 1982.

Hawaii Agricultural Statistics Service. Statistics of Hawaiian Agriculture 1988. A Cooperative Function of State of Hawaii, Department of Agriculture, Marketing Division; United States, Department of Agriculture, National Agricultural Statistics Service. September, 1989.

Hawaii Visitors Bureau, Market Research Department. Visitor Plant Inventory. Honolulu: February, 1988.

Hawaii Water Resources Regional Study. Hawaii Water Resources Plan. Honolulu: January 1975.

H. Mogi Planning and Research, Inc. Statewide Agricultural Park Action Plan Phase I. Program Assessment. Prepared for State of Hawaii Governor's Agriculture Coordinating Committee. Honolulu: May 1982.

H. Mogi Planning and Research, Inc. Statewide Agricultural Park Action Plan Phase II. Implementation Program. Prepared for State of Hawaii Governor's Agriculture Coordinating Committee. Honolulu: February 1984.

Keith, Kent M. Effects of the Proposed State Water Code on Hawaii's Economy. Honolulu: September 1984.

Lau, Dr. L. Stephen, Water Resources Research Center. Land Treatment and Reuse of Sewage Effluent by Irrigation: A Perspective for Hawaii. EPA-430/9-78-005. February, 1978.

Mink, John F. and L. Stephen Lau. Aquifer Identification and Classification For O'ahu: Groundwater Protection Strategy For Hawai'i. Technical Report No. 179. Water Resources Research Center, University of Hawaii at Manoa. November 1987.

Mink & Yuen, Inc. State Water Resources Protection Plan, Aquifer Classification - Oahu. February 17, 1989.

Miyamoto, Susan E., Cynthia E. Miyaji and Leonora L.K. Fukuda. Summary of Available Ground-Water Data for the Island of Oahu, Hawaii (U.S. Geological Survey Open-File Report 86-233). Honolulu: 1986.

Morgan, Joseph R. Hawaii: A Geography. Westview Press. Boulder, Colorado: 1983.

Nakahara, Richard H., Johnson J.S. Yee, and Jerome A. Domingo. Water Resources Data Hawaii and Other Pacific Areas Water Year 1987 Volume 1. Hawaii (U.S. Geological Survey Water-Data Report HI-87-1). Prepared in cooperation with the State of Hawaii Department of Land and Natural Resources, Division of Water and Land Development and with other agencies. Honolulu: 1988.

Oahu Sugar Company, Ltd. Water Management Plan for the REcertified 92.5 MGD Preserved Use Withdrawals from the Pearl Harbor Groundwater Control Area. Honolulu: March 1985.

Oliver, John E. and John J. Hidore. Climatology: An Introduction. Columbus, Ohio: 1984.

Park Engineering, Inc. Pearl Harbor Brackish Water Study. Honolulu: January, 1983.

Plasch, Bruce S. Hawaii's Sugar Industry: Problems, Outlook and Urban Growth Issues. Prepared for the State of Hawaii Department of Planning and Economic Development. Honolulu: 1981.

Prasifka, David W. Current Trends in Water-Supply Planning. New York: Van Nostrand Reinhold. 1988.

R. M. Towill Corporation. Preliminary Report (50% Submittal) Kapolei Water Master Plan. Prepared for the Hawaii Housing Authority, State of Hawaii and the Estate of James Campbell.

Russell, Clifford S., David G. Arey and Robert W. Kates. Drought and Water Supply; Implications of the Massachusetts Experience for Municipal Planning. Washington, D.C.: 1970.

S & S Engineers, Inc., Part II Final Report, Interim Drinking Water Study, Private Water Systems, State of Hawaii. Honolulu: April, 1978.

Solley, Wayne B., Edith B. Chase, and William B. Mann IV. Estimated Use of Water in the United States in 1980 (U.S. Geological Survey Circular 1001). Washington D.C.: 1983.

Soroos, Ronald L. and Charles J. Ewart. Ground-Water Status Report, Pearl Harbor Area, Hawaii 1978 (U.S. Geological Survey Water Resources Investigations Open-File Report 79-1542). Prepared in coordination with State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. Honolulu: 1979.

State of Hawaii Department of Agriculture. State Agriculture Functional Plan. Honolulu: June 1985.

State of Hawaii Department of Agriculture. State Agriculture Functional Plan Technical Reference Document. Honolulu: September 1981.

State of Hawaii Department of Agriculture. State Agriculture Functional Plan Technical Reference Document. Honolulu: June 1985.

State of Hawaii Department of Agriculture. State Agriculture Plan. Honolulu: October 1982.

State of Hawaii Department of Business and Economic Development. The State of Hawaii Data Book 1988; A Statistical Abstract. Honolulu: 1988.

State of Hawaii Department of Business and Economic Development. Facts and Figures: 1987 City and County of Honolulu. 1987.

State of Hawaii Department of Business and Economic Development. Military Personnel and Dependents in Hawaii, 1987. Statistical Report 207. November 30, 1987.

State of Hawaii Department of Labor and Industrial Relations. State Employment Functional Plan. Honolulu: 1989.

State of Hawaii Department of Land and Natural Resources, Division of Water and Land Development. A Proposal to Construct a Demonstration Desalting Plant. Circular C-96. Honolulu: March, 1984.

State of Hawaii Department of Land and Natural Resources, Division of Water and Land Development. Interim Report, Proposed Demonstration Desalting Plant, State of Hawaii. Honolulu: January, 1985.

State of Hawaii Department of Land and Natural Resources, Division of Water and Land Development, Hydrologic Advisory Committee. Recommendations For Ground Water Use Regulation, Circular C80. Honolulu: February 1980.

State of Hawaii Department of Land and Natural Resources. State of Hawaii Department of Land and Natural Resources Report to the Governor 1985-1986. Honolulu: 1986.

State of Hawaii Department of Land and Natural Resources. State of Hawaii Department of Land and Natural Resources Report to the Governor 1986-1987 Volume I. Honolulu: 1988.

State of Hawaii Department of Land and Natural Resources. State of Hawaii Department of Land and Natural Resources Report to the Governer 1986-1987 Volume II. Honolulu: 1988.

State of Hawaii Department of Land and Natural Resources. State Water Resources Development Functional Plan. Honolulu: June 1984.

State of Hawaii Department of Land and Natural Resources. State Water Resources Development Plan. Honolulu: October 1981.

State of Hawaii Department of Land and Natural Resources. State Water Resources Development Plan Technical Reference Document. Honolulu: October 1981.

State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management. A Progress Report on the Implementation of the State Water Code. Honolulu: January 1988.

State of Hawaii Housing Finance & Development Corporation. State Housing Functional Plan. Honolulu: 1989.

State of Hawaii Office of the Legislative Reference Bureau Advisory Study Commission on Water Resources. Report of the Advisory Study Commission on the Water Resources to the Thirteenth Legislature State of Hawaii. Honolulu: January 14, 1985.

State of Hawaii Office of the Legislative Reference Bureau Land Evaluation and Site Assessment Commission. A Report on the State of Hawaii Land Evaluation and Site Assessment System. Honolulu: February 1986.

Stearns, Harold T. and Knute N. Vaksvik. Geology and Ground-Water Resources of the Island of Oahu, Hawaii. Hawaii: 1935.

Stearns, Harold T. Geology of the State of Hawaii (Second Edition). Palo Alto, California: 1985.

Takasaki, K.J. Summary Appraisals of the Nation's Ground-Water Resources-Hawaii Region (U.S. Geological Survey Professional Paper 813-M). Washington, D.C.: 1978.

United States Army Corps of Engineers. Kaneohe Bay Urban Water Resources Study Summary Report. Honolulu 1978.

United States Geological Survey. "Ground-Water Resources Hawaii-Pacific Region" National Water Summary 1984 Hydrologic Events, selected Water-Quality Trends, and Ground-Water Resources (United States Geological Survey Water-Supply Paper 2275). Washington D.C.: 1985.

United States Geological Survey. "Hawaii Surface-Water Resources" National Water Summary - Hawaii (United States Geological Survey Water-Supply Paper 2300). Washington D.C.

United States Geological Survey. Water Use in Hawaii 1975 (Report R58). Prepared for the State of Hawaii Department of Land and Natural Resources Division of Water and Land DEvelopment. Honolulu: October 1978.

United States Geological Survey. Water Use in Hawaii 1980 (Report R71). Prepared for the State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. Honolulu: June 1984.

United States Water Resources Council. The Nation's Water Resources 1975 - 2000 Volume 4: Hawaii Region. Washington D.C.: December 1978.

University of Hawaii Department of Geography. Atlas of Hawaii (Second Edition). Honolulu: 1983.

VTN Pacific. City and County of Honolulu Board of Water Supply Final Environmental Impact Statement for Windward Oahu Regional Water System Improvements Volume I. Honolulu: August 1988.

VTN Pacific. City and County of Honolulu Board of Water Supply Technical Appendices for the Final Environmental Impact Statement for Windward Oahu Regional Water System Improvements Volume II. Honolulu: March 1987.

Water Resources Research Center, University of Hawaii at Manoa. Rainfall Atlas of Hawai'i (Report R76). Prepared for The State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. Honolulu: June 1986.

Water Resources Research Center, University of Hawaii at Manoa, John F. Mink and L. Stephen Lau. Aquifer Identification and Classification for Oahu; Groundwater Protection Strategy for Hawaii. Technical Report No. 179. November, 1987.

Wentworth, Chester K. Geology and Ground-water Resources of the Honolulu-Pearl Harbor Area Oahu, Hawaii. Prepared for the City and County of Honolulu Board of Water Supply. Honolulu: 1951.

Wilson Okamoto and Associates. City and County of Honolulu Board of Water Supply Final Environmental Impact Statement for Waialua - Kahuku regional Water System Improvements. Prepared for the City and County of Honolulu Board of Water Supply. Honolulu: September 1988.

Wilson Okamoto and Associates Inc. City and County of Honolulu Board of Water Supply Final Regional Environmental Impact Statement for Development of Wells Reservoirs, Transmission Lines and Appurtenances at Honolulu, Hawaii. Prepared for the City and County of Honolulu Board of Water Supply. Honolulu: September 1986.

Wilson Okamoto and Associates Inc. Instream Use Study Windward Oahu (Report R68). Prepared for the State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. Honolulu: April 1983.

Wilson Okamoto and Associates Inc. Ko Olina Phase II Final Environmental Impact Statement. Prepared for West Beach Estates. April 1989.

Yee, Johnson J.S. Hawaii Ground-Water Quality (U.S. Geological Survey Open-File 87-021). Washington, D.C.: 1987.

APPENDIX A

WATER USE BY HYDROLOGIC UNITS, 1988

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	BARBERS POINT	2006-14,15	1.00	0.00	0.00	EWA	EWA	PEARL HARBOR
HONOLULU BWS	MAKAKILO WELLS	2004-04	1.50	1.28	0.37	EWA	EWA	PEARL HARBOR
MILITARY	BARBERS PT. SHAFT	2103-03	2.34	2.40	2.31	EWA	EWA	PEARL HARBOR
OAHU SUGAR CO	EP10	2006-01 TO 11	7.00	7.35	8.43	EWA	EWA	PEARL HARBOR
PRIVATE USERS	GRACE PACIFIC CORP	1906-03 TO 06	0.50	0.00	0.00	EWA	EWA	PEARL HARBOR
PRIVATE USERS	STATE DOWALD	1905-04	0.50	0.00	0.00	EWA	EWA	PEARL HARBOR
PRIVATE USERS	WEST BEACH G C	2006-13	0.70	0.10	0.01	EWA	EWA	PEARL HARBOR
PRIVATE USERS	GRACE PACIFIC	2104-1		0.10		EWA	EWA	PEARL HARBOR
PRIAVTE USERS	HAWAII REFINERY	1805-03		0.01		EWA	EWA	PEARL HARBOR
PRIAVTE USERS	WEST BEACH ESTATES	2006-13,14,15				EWA	EWA	PEARL HARBOR
TOTAL -- EWA			13.54	11.24	11.13			
HONOLULU BWS	HAKIPUU WELL					KOOLAUPOKO	KAHANA	OTHER
HONOLULU BWS	KAAAWA WELLS					KOOLAULOA	KAHANA	OTHER
HONOLULU BWS	KAHANA WELLS	3353-01,02		0.74		KOOLAULOA	KAHANA	OTHER
PRIVATE USERS	KOOLAU AGRICULTURE	3454-01,3453-10, 3452-01		3.70		KOOLAULOA	KAHANA	OTHER
TOTAL -- KAHANA			----	4.44	----			
HONOLULU BWS	JONATHAN SPRINGS	2052-12	1.00	0.94	0.10	P.U.C.	KALIHI	HONOLULU
HONOLULU BWS	KALIHI STATION	1952-06 TO 08, 16 TO 19,22	6.22	6.93	6.33	P.U.C.	KALIHI	HONOLULU
HONOLULU BWS	NUUANU TUNNELS IIIA					P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	CASTLE & COOKE FDS	1952-11,13,20,21	2.00	2.24	1.88	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	DEL MONTE CORP	1952-12	0.24	0.09	0.08	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	HONOLULU GAS CO	1952-14	2.50	1.44	0.00	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	KAMEHAMEHA SCHOOLS	2052-07,11	0.23	0.20	0.19	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	PALAMA SETTLEMENT	1952-15	0.02	0.00	0.01	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	KAMEHAMEHA SCHOOL	2052-07		0.14		P.U.C.	KALIHI	HONOLULU
TOTAL -- KALIHI			12.22	11.98	8.59			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	KAWAILOA WELL					NORTH SHORE	KAWAILOA	WAIALUA
HONOLULU BWS	SUNSET BEACH WELL	4002-04		0.00		NORTH SHORE	KAWAILOA	WAIALUA
HONOLULU BWS	WAIMEA WELL					NORTH SHORE	KAWAILOA	OTHER
PRIVATE USERS	MEADOW GOLD	3704-01	0.43			NORTH SHORE	KAWAILOA	WAIALUA
WAIALUA SUG CO	PUMP 4	3605-01 TO 04	5.53	4.28	5.12	NORTH SHORE	KAWAILOA	WAIALUA
		06 TO 08						
		11 TO 13						
		15 TO 25						
PRIAVTE USERS	UNIV. HAWAII	4101-10		0.04		NORTH SHORE	KAWAILOA	WAIALUA
TOTAL -- KAWAILOA			5.96	4.32	5.12			
HONOLULU BWS	MAKAHA WELLS II					WAIANAE	KEAAU	OTHER
HONOLULU BWS	MAKAHA WELLS III					WAIANAE	KEAAU	OTHER
HONOLULU BWS	MAKAHA WELLS IV					WAIANAE	KEAAU	OTHER
HONOLULU BWS	MAKAHA WELLS V			0.19		WAIANAE	KEAAU	OTHER
TOTAL -- KEAAU			----	0.19	----			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	HAUULA WELL	3655-01		0.24		KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	KAHUKU WELLS	4057-15,16		0.43		KOOLAULOA	KOOLAULOA	WAIALUA
HONOLULU BWS	KAIPAPAU WELL					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	KALUANUI WELL					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	LAIE WELL					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	MAAKUA WELL					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	PUNALUU WELL I	3553-02		0.32		KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	PUNALUU WELLS II	3553-03 TO 08		3.84		KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	PUNALUU WELL III	3453-06.07		1.20		KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	PUNALUU WELL IV,V					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	WAIALEE WELL I	4101-07		0.33		KOOLAULOA	KOOLAULOA	WAIALUA
HONOLULU BWS	WAIALEE WELL II	4101-08		0.45		KOOLAULOA	KOOLAULOA	WAIALUA
PRIVATE USERS	KAHUKU FARM ASSOC	4057-01,02,08, 4057-13,14		5.00		KOOLAULOA	KOOLAULOA	
PRIVATE USERS	POMAI INC.	4057-06,07		1.70		KOOLAULOA	KOOLAULOA	
PRIVATE USERS	MALAEKAHANA C/E	3956-01		0.50		KOOLAULOA	KOOLAULOA	
PRIVATE USERS	KAHUKU AIRBASE C/E	4158-12		0.22		KOOLAULOA	KOOLAULOA	
PRIVATE USERS	AMORIENT	4157-04,4159-01 4258-04		2.32		KOOLAULOA	KOOLAULOA	
PRIVATE USERS	ARNOLD PALMER GC	4100-10		0.10		KOOLAULOA	KOOLAULOA	
ZION	CAMPUS WELLS					KOOLAULOA	KOOLAULOA	OTHER
ZION	CHILDS WELLS					KOOLAULOA	KOOLAULOA	OTHER
ZION	QUARRY WELLS					KOOLAULOA	KOOLAULOA	OTHER
ZION	TEMPLE WELLS					KOOLAULOA	KOOLAULOA	OTHER
ZION	ZION			1.83		KOOLAULOA	KOOLAULOA	OTHER
ZION	ZION					KOOLAULOA	KOOLAULOA	OTHER
ZION	ZION					KOOLAULOA	KOOLAULOA	OTHER
TOTAL -- KOOLAULOA			----	18.48	----			
HONOLULU BWS	HAIKU TUNNEL			1.19		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	HAIKU WELL			0.00		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	IOLEKAA WELL	2549-01		0.11		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	KAHALUU TUNNEL			2.04		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	KAHALUU WELL					KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	KAMOOALII WELL					KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	KUOJU WELLS	2348-02,03		2.78		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	LULUKU TUNNEL			0.70		KOOLAUPOKO	KOOLAUPOKO	OTHER

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	LULUKU WELL I					KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	LULUKU WELL II					KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	WAIAHEE TUNNEL			4.55		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	WAIHEE INCLINED WELLS			1.55		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	WAIHEE WELLS	2751-02,03		0.00		KOOLAUPOKO	KOOLAUPOKO	OTHER
PRIVATE USERS	STATE HOSP DOH	2448-01		0.09		KOOLAUPOKO	KOOLAUPOKO	
PRIVATE USERS	VALLEY OF TEMPLES	2550-01		0.17		KOOLAUPOKO	KOOLAUPOKO	
PRIVATE USERS	WAIAHOLE IRRIGATION CO	2853-01		25.00		KOOLAUPOKO	KOOLAUPOKO	
TOTAL -- KOOLAUPOKO			----	38.17	----			
PRIVATE USERS	DEL MONTE CORP	2703-01	0.15	0.02	0.01	CENTRAL OAHU	KUNIA	PEARL HARBOR
PRIVATE USERS	HAWAII COUNTRY CLUB	2603-01	0.22	0.16	0.16	CENTRAL OAHU	KUNIA	PEARL HARBOR
TOTAL -- KUNIA			0.37	0.18	0.17			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	MAKAHA SHAFT	2812-01		0.34		WAIANAE	MAKAHA	OTHER
HONOLULU BWS	MAKAHA WELL	2911-03		0.39		WAIANAE	MAKAHA	OTHER
TOTAL -- MAKAHA			----	0.72	----			
HONOLULU BWS	KALIHI SHAFT	2052-08	8.11	8.13	8.15	P.U.C.	MOANALUA	HONOLULU
HONOLULU BWS	KALIHI TUNNELS			0.27		P.U.C.	MOANALUA	HONOLULU
HONOLULU BWS	KALIHI VALLEY WELLS					P.U.C.	MOANALUA	HONOLULU
HONOLULU BWS	MOANALUA WELLS	2153-10 TO 12	3.79	3.48	3.41	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	AMERON HC&D	2053-05	0.14	0.00	0.07	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	ARMY-FT SHAFTER	2053-10,11	1.04	0.84	0.96	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	ARMY-TRIPLER	2153-07,08	0.61	0.31	0.47	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	HAWAII MEAT CO	2053-09	0.08	0.08	0.08	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	HNL INTNL C C	2154-01	0.35	0.31	0.32	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	S M DAMON ESTATE	2153-02	0.02	0.08	0.03	P.U.C.	MOANALUA	HONOLULU
TOTAL -- MOANALUA			14.13	13.49	13.48			
HONOLULU BWS	MOKULEIA WELL					NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	AIR FORCE-KAENA PT	3314-03	0.02			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	ARMY-DILLINGHAM	3412-02	0.06			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA ASSOC	3409-16	0.00			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3310-01	0.00			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3410-01	0.50			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3410-03	1.50			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3410-05	0.00			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3310-02				NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 5	3411-04 06 TO 11,13	2.55	1.28	2.06	NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 5 DRIP			0.30	0.19	NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 11	3409-13	0.53	0.45		NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 11A			0.44	0.55	NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 11B			0.00	0.01	NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA LAND CO	3410-01,03		0.91		NORTH SHORE	MOKULEIA	WAIALUA
TOTAL -- MOKULEIA			5.15	3.38	2.81			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	ALEWA HEIGHTS SPRINGS			0.10		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	BERETANIA STATION	1851-12,13,24, 31 TO 35,67	7.00	10.12	8.45	P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	BOOTH SPRINGS			0.00		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	KAHUAWAI SPRINGS					P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	MAKIKI SPRINGS			0.09		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	MANOA WELLS					P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	NUUANU TUNNELS III			1.08		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	NUUANU TUNNELS IV			0.36		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	NUUANU TUNNELS IVB					P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	NUUANU WELLS					P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	WILDER WELLS	1849-13 TO 16	7.00	6.60	6.71	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	KAWAIAHAO CHURCH	1851-09	0.03	0.03	0.01	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	MTL, INC	1851-20	0.02	0.00	0.00	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	PACIFIC CLUB	1851-07	0.04	0.01	0.01	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	PACIFIC LAUNDRY	1851-58	0.10	0.00	0.07	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	PAGODA HOTEL	1750-09	0.02			P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	PUNAHOU SCHOOL	1849-10	0.14	0.17	0.15	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	QUEEN'S MEDICAL CTR	1851-54	0.24	0.27	0.28	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	SHAMROCK HLDNGS	1851-26	0.06			P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	KAWAIAHAO CHURCH	1851-73		0.05		P.U.C.	NUUANU	HONOLULU
TOTAL -- NUUANU			14.65	18.87	15.69			
HONOLULU BWS	KAIMUKI STATION	1748-03 TO 10	4.00	6.78	4.09	P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	MANOA TUNNEL III			0.34		P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	MANOA WELL II	1948-01	0.70	0.02	0.00	P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	PALOLO TUNNEL			0.34		P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	PALOLO WELLS	1847-01	1.31	1.33	1.30	P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	UH MANOA WELLS					P.U.C.	PALOLO	HONOLULU
PRIVATE USERS	KOKUSAI KOGYO	1749-19	0.34	0.21	0.29	P.U.C.	PALOLO	HONOLULU
PRIVATE USERS	LOVE'S BAKERY	1749-18	0.04	0.02	0.03	P.U.C.	PALOLO	HONOLULU
PRIVATE USERS	ALA WAI GC	1749-23,1649-18		1.40		P.U.C.	PALOLO	HONOLULU
TOTAL -- PALOLO			6.39	10.44	5.71			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	WAHIAWA II	2902-01	1.00	0.00	0.00	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
HONOLULU BWS	WAHIAWA WELLS	2901-08,11,12	3.27	3.89	3.46	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
HONOLULU BWS	WAHIAWA WELLS I					CENTRAL OAHU	WAHIAWA	PEARL HARBOR
MILITARY	SCHOFIELD SHAFT	2901-02 TO 04,10	5.46	4.13	4.20	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
PRIVATE USERS	DEL MONTE CORP	2803-07		0.59	0.29	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
PRIVATE USERS	DEL MONTE CORP	2803-05	2.12	0.56	0.16	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
WAIALUA SUG CO	PUMP 24	3102-02	2.58	0.58	1.91	NORTH SHORE	WAHIAWA	WAIALUA
WAIALUA SUG CO	PUMP 25	3203-01	3.10	0.13	1.36	NORTH SHORE	WAHIAWA	WAIALUA
WAIALUA SUG CO	PUMP 26	3203-02	2.76	0.79	2.20	NORTH SHORE	WAHIAWA	WAIALUA
TOTAL -- WAHIAWA			20.29	10.66	13.58			
HONOLULU BWS	AINA KOA WELL	1746-01	0.40	0.04	0.33	EAST HONOLULU	WAIALAE	HONOLULU
HONOLULU BWS	WAIALAE IKI WELL	1746-02	0.19	0.21	0.18	EAST HONOLULU	WAIALAE	HONOLULU
HONOLULU BWS	WAIALAE NUI WELL	1747-08	0.70	0.00	0.00	EAST HONOLULU	WAIALAE	HONOLULU
HONOLULU BWS	WAIALAE SHAFT	1747-02	0.24	0.00	0.09	P.U.C.	WAIALAE	HONOLULU
HONOLULU BWS	WAILUPE WELL			0.15		EAST HONOLULU	WAIALAE	HONOLULU
PRIVATE USERS	WAIALAE C C	1646-01	0.46	0.34	0.26	EAST HONOLULU	WAIALAE	HONOLULU
TOTAL -- WAIALAE			1.99	0.74	0.87			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	HALEIWA WELLS	3405,03,04	1.00	0.71		NORTH SHORE	WAIALUA	WAIALUA
HONOLULU BWS	WAIALUA WELLS	3405-01,02	1.73	1.49		NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	DEL MONTE	3103-01	2.00			NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	KAWAGUCHI, HOWARD	3506-07	0.06			NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	KAWAMATA, KENGO	3406-03	0.10			NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	KUNIHIRO, SHIZUO	3406-06,3407-02	0.20			NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	POLYNESIAN SHORES	3406-08	0.14			NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 1	3407-04 TO 06	2.33	2.44	2.08	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 2	3307-01 TO 09	4.37	3.24	4.94	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 2A	3307-10 TO 14	4.45	1.02	3.17	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 2B			0.86	1.66	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 3	3505-01 TO 20	3.16	2.07		NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 3A			2.03	2.48	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 7	3407-01,11,12 18,19	3.93	1.26		NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 7A			1.23	2.51	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 7DW			0.13	0.10	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 8	3506-03,04	1.66	1.59		NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 8A			1.05	1.13	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 8B			0.51	0.45	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 8C			0.64	0.93	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 9	3406-02	0.16	0.14	0.19	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 10	3306-01 TO 12	6.62	1.49		NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 10HL			0.43	1.93	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 10LL			1.02	1.86	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 17	3404-01	8.63	3.62	6.48	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	MILL PUMPS	3407-07 TO 10,13 16,17,20,21	4.63	5.15	4.80	NORTH SHORE	WAIALUA	WAIALUA
TOTAL -- WAIALUA			45.17	32.11	34.71			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	KAMAILE WELLS	2712-30,31		0.45		WAIANAE	WAIANAE	OTHER
HONOLULU BWS	WAIANAE PLNT TNLS			0.68		WAIANAE	WAIANAE	OTHER
HONOLULU BWS	WAIANAE TUNNEL			1.61		WAIANAE	WAIANAE	OTHER
PRIVATE USERS	ASATO FARM	2210-11		0.01		WAIANAE	WAIANAE	OTHER
PRIVATE USERS	TERUYA FARM	2710-03		0.02		WAIANAE	WAIANAE	
TOTAL -- WAIANAE			----	2.77	----			
HONOLULU BWS	HECO WAIAU WELLS					P.U.C.	WAIAWA	PEARL HARBOR
HONOLULU BWS	MILILANI WELLS I	2800-01 TO 04	2.98	2.39	2.67	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	MILILANI WELLS II	2859-01,02	1.90	1.18	0.40	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	PEARL CITY SHAFT	2458-01	1.32	1.08	1.14	P.U.C.	WAIAWA	PEARL HARBOR
HONOLULU BWS	PEARL CITY WELLS III	2557-03	0.50	0.22	0.05	P.U.C.	WAIAWA	PEARL HARBOR
HONOLULU BWS	WAIPIO HTS WELLS	2459-19,20	0.63	0.40	0.43	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	WAIPIO WELLS I	2459-23,24	0.00	0.03	0.08	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	WAIPIO WELLS II	2500-01,02	2.00	1.17	0.58	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	WAIPIO WELLS III	2659-02,03	0.85	0.00	0.00	CENTRAL OAHU	WAIAWA	PEARL HARBOR
MILITARY	WAIAWA SHAFT	2558-10	14.98	11.15	14.12	CENTRAL OAHU	WAIAWA	PEARL HARBOR
OAHU SUGAR CO	WP6A,6B	2459-01 TO 14	0.00	0.00	1.82	CENTRAL OAHU	WAIAWA	PEARL HARBOR
PRIVATE USERS	CHURCH/NAZARENE	2358-59	0.00	0.00	0.00	CENTRAL OAHU	WAIAWA	PEARL HARBOR
PRIVATE USERS	YOSHIMURA	2459-21	0.01	0.01	0.01	CENTRAL OAHU	WAIAWA	PEARL HARBOR
PRIVATE USERS	NUHUNIA ESTATE	2359-17		0.80		CENTRAL OAHU	WAIAWA	PEARL HARBOR
TOTAL -- WAIAWA			25.17	18.41	21.28			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	AIEA GULCH WELLS	2355-03,05	0.79	0.85	0.78	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	AIEA WELLS	2355-06,07	1.03	1.17	0.93	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	HALAWA SHAFT	2354-01	14.28	11.13	11.03	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	HALAWA WELLS	2255-37 TO 39	1.00	1.44	1.27	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAAHUMANU FLOWMETER (-)			0.00		P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAAHUMANU WELLS I	2357-23,24	1.11	1.09	1.09	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAAMILO FLOWMETER (-)			0.00		P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAAMILO WELLS	2356-58,59	1.99	0.46	1.60	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KALAUAO SPRINGS			0.03		P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KALAUAO WELLS	2355-09 TO 014	11.75	10.85	10.46	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAONOHI WELLS I	2356-55,56	1.10	1.30	1.29	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAONOHI WELLS II	2356-61,62,65	0.00	0.00	0.21	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	NEWTOWN WELLS	2456-01 TO 03	1.50	1.12	1.27	P.U.C.	WAIMALU	PEARL HARBO
HONOLULU BWS	PEARL CITY WELLS I	2458-03,04	0.31	0.49	0.34	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	PEARL CITY WELLS II	2457-01 TO 03	2.19	1.76	2.00	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	PUNANANI WELLS	2457-5,6,9 TO 12	11.97	11.21	11.33	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	WAIAU WELLS	2457-13 TO 15	1.89	1.56	1.44	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	WAIMALU WELLS I	2356-49,50	0.08	0.10	0.09	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	WAIMALU WELLS II	2356-60,63,64	0.00	0.00	0.12	P.U.C.	WAIMALU	PEARL HARBOR
MILITARY	HALAWA SHAFT	2255-32	0.70	0.57	0.68	P.U.C.	WAIMALU	PEARL HARBOR
MILITARY	RED HILL SHAFT	2254-01	4.66	5.38	4.61	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	C&H REFINERY	2255-36	0.79			P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	C&H REFINERY	2255-35	0.91	1.57	1.74	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	HECO	2357-10		9.90		P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	LAU TARO FARM	2356-70	0.10	0.02	0.00	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	PEARL COUNTRY CLUB	2356-54	0.22	0.29	0.15	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	WAIMANO TRNG SCHOOL	2557-01,02	0.14	0.17	0.17	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	SUMIDA FARM			6.00		P.U.C.	WAIMALU	PEARL HARBOR
TOTAL -- WAIMALU			58.50	68.46	52.63			

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	WAIMANALO TNLS I & II			0.36		KOOLAUPOKO	WAIMANALO	OTHER
HONOLULU BWS	WAIMANALO TNLS III & IV			0.54		KOOLAUPOKO	WAIMANALO	OTHER
HONOLULU BWS	WAIMANALO WELL I	2043-02		0.09		KOOLAUPOKO	WAIMANALO	OTHER
HONOLULU BWS	WAIMANALO WELL II	1943-01		0.11		KOOLAUPOKO	WAIMANALO	OTHER
PRIVATE USERS	STATE DOA	2045-01,02		0.17		KOOLAUPOKO	WAIMANALO	OTHER
		2046-03				KOOLAUPOKO	WAIMANALO	OTHER
		2146-01,02				KOOLAUPOKO	WAIMANALO	OTHER
		2147-01				KOOLAUPOKO	WAIMANALO	OTHER
TOTAL -- WAIMANALO			----	1.28	----			
HONOLULU BWS	HOAEAE WELLS	2301-34 TO 39	6.61	8.94	8.38	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	HONOULIULI	2303-01,02	2.00	0.00	0.00	EWA	WAIPAHU	PEARL HARBOR
HONOLULU BWS	KUNIA WELLS I	2302-01 TO 04	6.00	5.28	6.21	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	KUNIA WELLS II	2402-01,02	1.26	0.94	0.43	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	MILILANI 7	2600-03	0.10	0.00	0.00	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	WAIPAHU II	2400-05,06	2.10	0.00	0.00	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	WAIPAHU WELLS	2400-01 TO 04	6.00	3.71	2.68	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP2	2201-03,04,07	0.00	0.00	0.88	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP3,4	2102-02,04 TO 22	5.36	3.73	3.76	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP5,6	2202-03 TO 14	11.70	8.94	10.27	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP7,8	2202-15 TO 20	8.51	8.53	7.73	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP15,16	2202-21	19.15	18.15	14.97	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP1	2301-01 TO 10	1.15	1.29	1.72	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP2A,2B	2301-21 TO 26	6.75	1.37	4.60	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP2C,4C	2301-27 TO 32	6.25	2.00	4.39	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP4A,4B	2301-11 TO 20	6.48	4.47	4.24	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP5	2203-01 TO 06	6.00	4.01	6.63	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP7A,7B,7C	2300-07 TO 09	13.00	10.59	10.94	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP17A,17B	2658-01,02	0.30	0.00	0.86	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	C&C DEPT. PARKS/REC	2201-03,04,07	0.50	0.00	0.00	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	GENIRT PACIFIC	2001-02		0.11		EWA	WAIPAHU	PEARL HARBOR
PRIVATE USERS	HARRIS RUG	2201-14	0.00	0.00	0.00	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	KAHUA MEAT CO.	2101-01	0.11	0.06	0.03	EWA	WAIPAHU	PEARL HARBOR
PRIVATE USERS	WATANABE	2300-11	0.68	0.79	0.38	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	WATANABE	2300-20	0.40			CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	SEIBU HAWAII	1900-02		1.60		EWA	WAIPAHU	PEARL HARBOR

EXISTING WATER USE AND DEVELOPMENT
BY HYDROLOGIC UNIT

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
TOTAL -- WAIPAHU			110.41	84.53	89.11			
			333.9370	354.8543	274.8826			

APPENDIX B

WATER USE BY DEVELOPMENT
PLAN AREAS, 1988

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	HOAEAE WELLS	2301-34 TO 39	6.61	8.94	8.38	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	KUNIA WELLS I	2302-01 TO 04	6.00	5.28	6.21	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	KUNIA WELLS II	2402-01,02	1.26	0.94	0.43	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	MILILANI 7	2600-03	0.10	0.00	0.00	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	MILILANI WELLS I	2800-01 TO 04	2.98	2.39	2.67	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	MILILANI WELLS II	2859-01,02	1.90	1.18	0.40	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	WAHIAWA II	2902-01	1.00	0.00	0.00	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
HONOLULU BWS	WAHIAWA WELLS	2901-08,11,12	3.27	3.89	3.46	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
HONOLULU BWS	WAHIAWA WELLS I					CENTRAL OAHU	WAHIAWA	PEARL HARBOR
HONOLULU BWS	WAIPAHU II	2400-05,06	2.10	0.00	0.00	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	WAIPAHU WELLS	2400-01 TO 04	6.00	3.71	2.68	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
HONOLULU BWS	WAIPIO HTS WELLS	2459-19,20	0.63	0.40	0.43	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	WAIPIO WELLS I	2459-23,24	0.00	0.03	0.08	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	WAIPIO WELLS II	2500-01,02	2.00	1.17	0.58	CENTRAL OAHU	WAIAWA	PEARL HARBOR
HONOLULU BWS	WAIPIO WELLS III	2659-02,03	0.85	0.00	0.00	CENTRAL OAHU	WAIAWA	PEARL HARBOR
MILITARY	SCHOFIELD SHAFT	2901-02 TO 04,10	5.46	4.13	4.20	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
MILITARY	WAIAWA SHAFT	2558-10	14.98	11.15	14.12	CENTRAL OAHU	WAIAWA	PEARL HARBOR
OAHU SUGAR CO	WP1	2301-01 TO 10	1.15	1.29	1.72	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP2A,2B	2301-21 TO 26	6.75	1.37	4.60	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP2C,4C	2301-27 TO 32	6.25	2.00	4.39	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP4A,4B	2301-11 TO 20	6.48	4.47	4.24	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP6A,6B	2459-01 TO 14	0.00	0.00	1.82	CENTRAL OAHU	WAIAWA	PEARL HARBOR
OAHU SUGAR CO	WP7A,7B,7C	2300-07 TO 09	13.00	10.59	10.94	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP17A,17B	2658-01,02	0.30	0.00	0.86	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	CHURCH/NAZARENE	2358-59	0.00	0.00	0.00	CENTRAL OAHU	WAIAWA	PEARL HARBOR
PRIVATE USERS	C&C DEPT. PARKS/REC	2201-03,04,07	0.50	0.00	0.00	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	DEL MONTE CORP	2803-05	2.12	0.56	0.16	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
PRIVATE USERS	DEL MONTE CORP	2803-07		0.59	0.29	CENTRAL OAHU	WAHIAWA	PEARL HARBOR
PRIVATE USERS	DEL MONTE CORP	2703-01	0.15	0.02	0.01	CENTRAL OAHU	KUNIA	PEARL HARBOR
PRIVATE USERS	HARRIS RUG	2201-14	0.00	0.00	0.00	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	HAWAII COUNTRY CLUB	2603-01	0.22	0.16	0.16	CENTRAL OAHU	KUNIA	PEARL HARBOR
PRIVATE USERS	WATANABE	2300-20	0.40			CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	WATANABE	2300-11	0.68	0.79	0.38	CENTRAL OAHU	WAIPAHU	PEARL HARBOR
PRIVATE USERS	YOSHIMURA	2459-21	0.01	0.01	0.01	CENTRAL OAHU	WAIAWA	PEARL HARBOR
PRIVATE USERS	NUHUNIA ESTATE	2359-17		0.80		CENTRAL OAHU	WAIAWA	PEARL HARBOR
TOTAL -- CENTRAL OAHU			93.15	65.85	73.22			

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	AINA KOA WELL	1746-01	0.40	0.04	0.33	EAST HONOLULU	WAIALAE	HONOLULU
HONOLULU BWS	WAIALAE IKI WELL	1746-02	0.19	0.21	0.18	EAST HONOLULU	WAIALAE	HONOLULU
HONOLULU BWS	WAIALAE NUI WELL	1747-08	0.70	0.00	0.00	EAST HONOLULU	WAIALAE	HONOLULU
HONOLULU BWS	WAILUPE WELL			0.15		EAST HONOLULU	WAIALAE	HONOLULU
PRIVATE USERS	WAIALAE C C	1646-01	0.46	0.34	0.26	EAST HONOLULU	WAIALAE	HONOLULU
TOTAL -- EAST HONOLULU			1.75	0.74	0.77			
HONOLULU BWS	BARBERS POINT	2006-14,15	1.00	0.00	0.00	EWA	EWA	PEARL HARBOR
HONOLULU BWS	HONOULIULI	2303-01,02	2.00	0.00	0.00	EWA	WAIPAHU	PEARL HARBOR
HONOLULU BWS	MAKAKILO WELLS	2004-04	1.50	1.28	0.37	EWA	EWA	PEARL HARBOR
MILITARY	BARBERS PT. SHAFT	2103-03	2.34	2.40	2.31	EWA	EWA	PEARL HARBOR
OAHU SUGAR CO	EP2	2201-03,04,07	0.00	0.00	0.88	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP3,4	2102-02,04 TO 22	5.36	3.73	3.76	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP5,6	2202-03 TO 14	11.70	8.94	10.27	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP7,8	2202-15 TO 20	8.51	8.53	7.73	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	EP10	2006-01 TO 11	7.00	7.35	8.43	EWA	EWA	PEARL HARBOR
OAHU SUGAR CO	EP15,16	2202-21	19.15	18.15	14.97	EWA	WAIPAHU	PEARL HARBOR
OAHU SUGAR CO	WP5	2203-01 TO 06	6.00	4.01	6.63	EWA	WAIPAHU	PEARL HARBOR
PRIVATE USERS	GRACE PACIFIC CORP	1906-03 TO 06	0.50	0.00	0.00	EWA	EWA	PEARL HARBOR
PRIVATE USERS	KAHUA MEAT CO.	2101-01	0.11	0.06	0.03	EWA	WAIPAHU	PEARL HARBOR
PRIVATE USERS	STATE DOWALD	1905-04	0.50	0.00	0.00	EWA	EWA	PEARL HARBOR
PRIVATE USERS	WEST BEACH G C	2006-13	0.70	0.10	0.01	EWA	EWA	PEARL HARBOR
PRIVATE USERS	SEIBU HAWAII	1900-02		1.60		EWA	WAIPAHU	PEARL HARBOR
PRIVATE USERS	GRACE PACIFIC	2104-01		0.10		EWA	EWA	PEARL HARBOR
PRIVATE USERS	HAWAII REFINERY	1805-03		0.01		EWA	EWA	PEARL HARBOR
PRIVATE USERS	ASATO FARM	2201-11		0.01		EWA	WAIANAE	
PRIVATE USERS	GENTRY PACIFIC	2001-02		0.11		EWA	WAIPAHU	PEARL HARBOR
PRIVATE USERS	TERUYA FARM	2710-03		0.02		EWA	WAIANAE	
TOTAL -- EWA			66.37	56.41	55.40			

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	HAUULA WELL	3655-01		0.24		KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	KAAAWA WELLS					KOOLAULOA	KAHANA	OTHER
HONOLULU BWS	KAHANA WELLS	3353-01,02		0.74		KOOLAULOA	KAHANA	OTHER
HONOLULU BWS	KAHUKU WELLS	4057-15,16		0.43		KOOLAULOA	KOOLAULOA	WAIALUA
HONOLULU BWS	KAIPAPAU WELL					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	KALUANUI WELL					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	LAIE WELL					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	MAAKUA WELL					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	PUNALUU WELL I	3553-02		0.32		KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	PUNALUU WELLS II	3553-03 TO 08		3.84		KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	PUNALUU WELL III	3453-06,07		1.20		KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	PUNALUU WELL IV,V					KOOLAULOA	KOOLAULOA	OTHER
HONOLULU BWS	WAIALEE WELL I	4101-07		0.33		KOOLAULOA	KOOLAULOA	WAIALUA
HONOLULU BWS	WAIALEE WELL II	4101-08		0.45		KOOLAULOA	KOOLAULOA	WAIALUA
ZION	CAMPUS WELLS					KOOLAULOA	KOOLAULOA	OTHER
ZION	CHILDS WELLS					KOOLAULOA	KOOLAULOA	OTHER
ZION	QUARRY WELLS					KOOLAULOA	KOOLAULOA	OTHER
ZION	TEMPLE WELLS					KOOLAULOA	KOOLAULOA	OTHER
ZION	ZION			1.83		KOOLAULOA	KOOLAULOA	OTHER
ZION	ZION					KOOLAULOA	KOOLAULOA	OTHER
ZION	ZION					KOOLAULOA	KOOLAULOA	OTHER
PRIVATE USERS	KUHUKU FARMS	4057-01,02,08		5.00		KOOLAULOA	KOOLAULOA	
		4057-13,14				KOOLAULOA	KOOLAULOA	
PRIVATE USERS	POMAI INC.	4057-06,07		1.70		KOOLAULOA	KOOLAULOA	
PRIVATE USERS	MALAEKAHANA	3956-01		0.50		KOOLAULOA	KOOLAULOA	
PRIVATE USERS	KAHUKU AIRBASE C/E	4158-12		0.22		KOOLAULOA	KOOLAULOA	
PRIVATE USERS	KOOLAU AGRICULTURE	3454-01,3453-10		3.70		KOOLAULOA	KAHANA	
		3452-01						
PRIVATE USERS	AMORIENT	4157-04,4159-01		2.32		KOOLAULOA	KOOLAULOA	
		4258-04						
PRIVATE USERS	ARNOLD PALMER GC	4100-01		0.10		KOOLAULOA	KOOLAULOA	
TOTAL -- KOOLAULOA			----	22.92	----			

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	HAIKU TUNNEL			1.19		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	HAIKU WELL			0.00		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	HAKIPUU WELL					KOOLAUPOKO	KAHANA	OTHER
HONOLULU BWS	IOLEKAA WELL	2549-01		0.11		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	KAHALUU TUNNEL			2.04		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	KAHALUU WELL					KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	KAHOOALII WELL					KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	KUOU WELLS	2348-02,03		2.78		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	LULUKU TUNNEL			0.70		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	LULUKU WELL I					KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	LULUKU WELL II					KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	WAIAHEE TUNNEL			4.55		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	WAIHEE INCLINED WELLS			1.55		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	WAIHEE WELLS	2751-02,03		0.00		KOOLAUPOKO	KOOLAUPOKO	OTHER
HONOLULU BWS	WAIMANALO TNLS I & II			0.36		KOOLAUPOKO	WAIMANALO	OTHER
HONOLULU BWS	WAIMANALO TNLS III & IV			0.54		KOOLAUPOKO	WAIMANALO	OTHER
HONOLULU BWS	WAIMANALO WELL I	2043-02		0.09		KOOLAUPOKO	WAIMANALO	OTHER
HONOLULU BWS	WAIMANALO WELL II	1943-01		0.11		KOOLAUPOKO	WAIMANALO	OTHER
PRIVATE USERS	STATE DOA	2045-01,02		0.17		KOOLAUPOKO	WAIMANALO	
		2046-03				KOOLAUPOKO		
		2146-01,02				KOOLAUPOKO		
		2147-01				KOOLAUPOKO		
PRIVATE USERS	STATE HOSP DOH	2448-01		0.09		KOOLAUPOKO	KOOLAUPOKO	
PRIVATE USERS	VALLEY OF TEMPLES	2550-01		0.17		KOOLAUPOKO	KOOLAUPOKO	
PRIVATE USERS	WAIAHOLE TUNNELS	2853-01		25.00		KOOLAUPOKO	KOOLAUPOKO	
TOTAL -- KOOLAUPOKO			----	39.45	----			
HONOLULU BWS	HALEIWA WELLS	3405,03,04	1.00	0.71		NORTH SHORE	WAIALUA	WAIALUA
HONOLULU BWS	KAWAILOA WELL					NORTH SHORE	KAWAILOA	WAIALUA
HONOLULU BWS	MOKULEIA WELL					NORTH SHORE	MOKULEIA	WAIALUA
HONOLULU BWS	SUNSET BEACH WELL	4002-04		0.00		NORTH SHORE	KAWAILOA	WAIALUA
HONOLULU BWS	WAIALUA WELLS	3405-01,02	1.73	1.49		NORTH SHORE	WAIALUA	WAIALUA
HONOLULU BWS	WAIMEA WELL					NORTH SHORE	KAWAILOA	OTHER
PRIVATE USERS	AIR FORCE-KAENA PT	3314-03	0.02			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	ARMY-DILLINGHAM	3412-02	0.06			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	DEL MONTE	3103-01	2.00			NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	KAWAGUCHI, HOWARD	3506-07	0.06			NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	KAWAMATA, KENGO	3406-03	0.10			NORTH SHORE	WAIALUA	WAIALUA

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
PRIVATE USERS	KUNIHIRO, SHIZUO	3406-06,3407-02	0.20			NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	MEADOW GOLD	3704-01	0.43			NORTH SHORE	KAWAILOA	WAIALUA
PRIVATE USERS	MOKULEIA ASSOC	3409-16	0.00			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3310-02				NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3410-05	0.00			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3410-03	1.50			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3310-01	0.00			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	MOKULEIA HASTDS	3410-01	0.50			NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	POLYNESIAN SHORES	3406-08	0.14			NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 1	3407-04 TO 06	2.33	2.44	2.08	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 2	3307-01 TO 09	4.37	3.24	4.94	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 2A	3307-10 TO 14	4.45	1.02	3.17	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 2B			0.86	1.66	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 3	3505-01 TO 20	3.16	2.07		NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 3A			2.03	2.48	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 4	3605-01 TO 04	5.53	4.28	5.12	NORTH SHORE	KAWAILOA	WAIALUA
		06 TO 08						
		11 TO 13						
		15 TO 25						
WAIALUA SUG CO	PUMP 5	3411-04	2.55	1.28	2.06	NORTH SHORE	MOKULEIA	WAIALUA
		06 TO 11,13						
WAIALUA SUG CO	PUMP 5 DRIP			0.30	0.19	NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 7	3407-01,11,12	3.93	1.26		NORTH SHORE	WAIALUA	WAIALUA
		18,19						
WAIALUA SUG CO	PUMP 7A			1.23	2.51	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 7DW			0.13	0.10	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 8	3506-03,04	1.66	1.59		NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 8A			1.05	1.13	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 8B			0.51	0.45	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 8C			0.64	0.93	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 9	3406-02	0.16	0.14	0.19	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 10	3306-01 TO 12	6.62	1.49		NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 10HL			0.43	1.93	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 10LL			1.02	1.86	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 11	3409-13	0.53	0.45		NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 11A			0.44	0.55	NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 11B			0.00	0.01	NORTH SHORE	MOKULEIA	WAIALUA
WAIALUA SUG CO	PUMP 17	3404-01	8.63	3.62	6.48	NORTH SHORE	WAIALUA	WAIALUA
WAIALUA SUG CO	PUMP 24	3102-02	2.58	0.58	1.91	NORTH SHORE	WAHIAWA	WAIALUA
WAIALUA SUG CO	PUMP 25	3203-01	3.10	0.13	1.36	NORTH SHORE	WAHIAWA	WAIALUA
WAIALUA SUG CO	PUMP 26	3203-02	2.76	0.79	2.20	NORTH SHORE	WAHIAWA	WAIALUA

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
WAIALUA SUG CO	MILL PUMPS	3407-07 TO 10,13 16,17,20,21	4.63	5.15	4.80	NORTH SHORE	WAIALUA	WAIALUA
PRIVATE USERS	MOKULEIA LAND CO	3410-01,03		0.91		NORTH SHORE	MOKULEIA	WAIALUA
PRIVATE USERS	UNIV OF HAWAII	4101-10		0.04		NORTH SHORE	KAWAILOA	WAIALUA
TOTAL -- NORTH SHORE			64.73	41.31	48.11			

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	AIEA GULCH WELLS	2355-03,05	0.79	0.85	0.78	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	AIEA WELLS	2355-06,07	1.03	1.17	0.93	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	ALEWA HEIGHTS SPRINGS			0.10		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	BERETANIA STATION	1851-12,13,24, 31 TO 35,67	7.00	10.12	8.45	P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	BOOTH SPRINGS			0.00		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	HALAWA SHAFT	2354-01	14.28	11.13	11.03	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	HALAWA WELLS	2255-37 TO 39	1.00	1.44	1.27	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	HECO WAIAU WELLS					P.U.C.	WAIAWA	PEARL HARBOR
HONOLULU BWS	JONATHAN SPRINGS	2052-12	1.00	0.94	0.10	P.U.C.	KALIHI	HONOLULU
HONOLULU BWS	KAAHUMANU FLOWMETER (-)			0.00		P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAAHUMANU WELLS I	2357-23,24	1.11	1.09	1.09	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAAMILO FLOWMETER (-)			0.00		P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAAMILO WELLS	2356-58,59	1.99	0.46	1.60	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAHUAWAI SPRINGS					P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	KAIMUKI STATION	1748-03 TO 10	4.00	6.78	4.09	P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	KALAUAO SPRINGS			0.03		P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KALAUAO WELLS	2355-09 TO 014	11.75	10.85	10.46	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KALIHI SHAFT	2052-08	8.11	8.13	8.15	P.U.C.	MOANALUA	HONOLULU
HONOLULU BWS	KALIHI STATION	1952-06 TO 08, 16 TO 19,22	6.22	6.93	6.33	P.U.C.	KALIHI	HONOLULU
HONOLULU BWS	KALIHI TUNNELS			0.27		P.U.C.	MOANALUA	HONOLULU
HONOLULU BWS	KALIHI VALLEY WELLS					P.U.C.	MOANALUA	HONOLULU
HONOLULU BWS	KAONOHI WELLS I	2356-55,56	1.10	1.30	1.29	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	KAONOHI WELLS II	2356-61,62,65	0.00	0.00	0.21	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	MAKIKI SPRINGS			0.09		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	MANOA TUNNEL III			0.34		P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	MANOA WELL II	1948-01	0.70	0.02	0.00	P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	MANOA WELLS					P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	MOANALUA WELLS	2153-10 TO 12	3.79	3.48	3.41	P.U.C.	MOANALUA	HONOLULU
HONOLULU BWS	NEWTOWN WELLS	2456-01 TO 03	1.50	1.12	1.27	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	NUUANU TUNNELS III			1.08		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	NUUANU TUNNELS IIIA					P.U.C.	KALIHI	HONOLULU
HONOLULU BWS	NUUANU TUNNELS IV			0.36		P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	NUUANU TUNNELS IVB					P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	NUUANU WELLS					P.U.C.	NUUANU	HONOLULU
HONOLULU BWS	PALOLO TUNNEL			0.34		P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	PALOLO WELLS	1847-01	1.31	1.33	1.30	P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	PEARL CITY SHAFT	2458-01	1.32	1.08	1.14	P.U.C.	WAIAWA	PEARL HARBOR
HONOLULU BWS	PEARL CITY WELLS I	2458-03,04	0.31	0.49	0.34	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	PEARL CITY WELLS II	2457-01 TO 03	2.19	1.76	2.00	P.U.C.	WAIMALU	PEARL HARBOR

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	PEARL CITY WELLS III	2557-03	0.50	0.22	0.05	P.U.C.	WAIAWA	PEARL HARBOR
HONOLULU BWS	PUNANANI WELLS	2457-5,6,9 TO 12	11.97	11.21	11.33	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	UH MANOA WELLS					P.U.C.	PALOLO	HONOLULU
HONOLULU BWS	WAIALAE SHAFT	1747-02	0.24	0.00	0.09	P.U.C.	WAIALAE	HONOLULU
HONOLULU BWS	WAIAU WELLS	2457-13 TO 15	1.89	1.56	1.44	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	WAIMALU WELLS I	2356-49,50	0.08	0.10	0.09	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	WAIMALU WELLS II	2356-60,63,64	0.00	0.00	0.12	P.U.C.	WAIMALU	PEARL HARBOR
HONOLULU BWS	WILDER WELLS	1849-13 TO 16	7.00	6.60	6.71	P.U.C.	NUUANU	HONOLULU
MILITARY	HALAWA SHAFT	2255-32	0.70	0.57	0.68	P.U.C.	WAIMALU	PEARL HARBOR
MILITARY	RED HILL SHAFT	2254-01	4.66	3.38	4.61	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	AMERON HC&D	2053-05	0.14	0.00	0.07	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	ARMY-FT SHAFTER	2053-10,11	1.04	0.84	0.96	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	ARMY-TRIPLER	2153-07,08	0.61	0.31	0.47	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	CASTLE & COOKE FDS	1952-11,13,20,21	2.00	2.24	1.88	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	C&H REFINERY	2255-35	0.91	1.57	1.74	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	C&H REFINERY	2255-36	0.79			P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	DEL MONTE CORP	1952-12	0.24	0.09	0.08	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	HAWAII MEAT CO	2053-09	0.08	0.08	0.08	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	HNL INTNL C C	2154-01	0.35	0.31	0.32	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	HONOLULU GAS CO	1952-14	2.50	0.00	0.00	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	KAMEHAMEHA SCHOOLS	2052-07,11	0.23	0.20	0.19	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	KAWAIAHAO CHURCH	1851-09	0.03	0.03	0.01	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	KOKUSAI KOGYO	1749-19	0.34	0.21	0.29	P.U.C.	PALOLO	HONOLULU
PRIVATE USERS	LANDPRO		0.00	0.00	0.00	P.U.C.		HONOLULU
PRIVATE USERS	LAU TARO FARM	2356-70	0.10	0.02	0.00	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	LOVE'S BAKERY	1749-18	0.04	0.02	0.03	P.U.C.	PALOLO	HONOLULU
PRIVATE USERS	MTL, INC	1851-20	0.02	0.00	0.00	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	PACIFIC CLUB	1851-07	0.04	0.01	0.01	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	PACIFIC LAUNDRY	1851-58	0.10	0.00	0.07	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	PAGODA HOTEL	1750-09	0.02			P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	PALAMA SETTLEMENT	1952-15	0.02	0.00	0.01	P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	PEARL COUNTRY CLUB	2356-54	0.22	0.29	0.15	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	PUNAHOU SCHOOL	1849-10	0.14	0.17	0.15	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	QUEEN'S MEDICAL CTR	1851-54	0.24	0.27	0.28	P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	S M DAMON ESTATE	2153-02	0.02	0.08	0.03	P.U.C.	MOANALUA	HONOLULU
PRIVATE USERS	SHAMROCK HLDNGS	1851-26	0.06			P.U.C.	NUUANU	HONOLULU
PRIVATE USERS	SUMIDA FARM			6.00		P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	WAIMANO TRNG SCHOOL	2557-01,02	0.14	0.17	0.17	P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	GASCO, INC.	1952-14		1.44		P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	HECO	2357-10		9.90		P.U.C.	WAIMALU	PEARL HARBOR
PRIVATE USERS	ALA WAI GC	1749-23,1649-18		1.40		P.U.C.	PALOLO	HONOLULU

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
PRIVATE USERS	KAM SCHOOL	2052-07		0.14		P.U.C.	KALIHI	HONOLULU
PRIVATE USERS	KAWAIAHAO CHRUCH	1851-73		0.05		P.U.C.	NUUANU	HONOLULU
TOTAL -- PRIMARY URBAN CENTER			107.95	124.53	97.38			

EXISTING WATER USE AND DEVELOPMENT
BY DEVELOPMENT PLAN AREA

USER	SOURCE	WELL NO.	TOTAL AUTHORIZED USE (MGD)	AVERAGE ANNUAL USE 87 OR 88 (MGD)	USE 80-87 OR 80-88 (MGD)	DEVELOPMENT PLAN AREA	HYDROLOGIC UNIT	WATER MANAGEMENT AREA
HONOLULU BWS	KAMAILE WELLS	2712-30,31		0.45		WAIANAE	WAIANAE	OTHER
HONOLULU BWS	MAKAHA SHAFT	2812-01		0.34		WAIANAE	MAKAHA	OTHER
HONOLULU BWS	MAKAHA WELL	2911-03		0.39		WAIANAE	MAKAHA	OTHER
HONOLULU BWS	MAKAHA WELLS II					WAIANAE	KEAAU	OTHER
HONOLULU BWS	MAKAHA WELLS III					WAIANAE	KEAAU	OTHER
HONOLULU BWS	MAKAHA WELLS IV					WAIANAE	KEAAU	OTHER
HONOLULU BWS	MAKAHA WELLS V			0.19		WAIANAE	KEAAU	OTHER
HONOLULU BWS	WAIANAE PLNT TNLS			0.68		WAIANAE	WAIANAE	OTHER
HONOLULU BWS	WAIANAE TUNNEL			1.61		WAIANAE	WAIANAE	OTHER
TOTAL -- WAIANAE			----	3.65	----			
			333.9380	354.8543	274.8826			

APPENDIX C

BOARD OF WATER SUPPLY SIX-YEAR CAPITAL IMPROVEMENTS PROGRAM

BOARD OF WATER SUPPLY
SIX-YEAR CAPITAL IMPROVEMENTS PROGRAM
FISCAL YEARS 1990 - 1995

PROJECT		FISCAL YEAR (000) 1990-1991	1992-1993	1994-1995
I.	FACILITIES FOR THE PRODUCTION OF WATER			
1.	HECO WAIAU WELLS (5.0 MGD)	4,900	---	---
2.	WAILUPE WELL II (1.0 MGD)	1,365	---	---
3.	MAAKUA WELL (1.0 MGD)	350	1,985	---
4.	WAIMEA WELL (0.25 MGD)	285	4,650	---
5.	PUNALUU WELLS V (5.0 MGD)	450	9,405	6,740
6.	LAIE WELL (1.0 MGD)	1,135	---	---
7.	WAILELE WELL (1.0 MGD)	3,050	---	---
8.	MOKULEIA WELL (1.0 MGD)	---	315	3,650
9.	KAWAILOA WELL (0.1 MGD)	---	250	3,040
10.	KAHUAWAI SPRINGS (0.2 MGD)	---	160	1,160
11.	KAAAWA WELL I (0.5 MGD)	---	180	3,200
12.	KAAAWA WELL II (0.5 MGD)	---	130	2,040
13.	HAKIPUU WELL (0.5 MGD)	---	115	2,040
14.	KAIPAPAU WELL (1.0 MGD)	---	170	2,880
15.	MANOA WELL I (0.5 MGD)	---	85	1,095
16.	PUNALUU WELL IV (0.5 MGD)	---	---	930
	SOURCE TOTAL: 19.05 MGD			
	SUBTOTALS:	$13,535	$17,445	$26,775
II.	WATER STORAGE FACILITIES			
1.	WAAHILA 405 RESERVOIR (4.0 MG)	8,085	---	---
2.	HEEIA KAI 272 RESERVOIR (1.5 MG)	225	3,660	---
3.	HAUULA 180 RESERVOIR (1.0 MG)	190	3,300	---
4.	BARBERS' POINT 215 RESERVOIR NO.5 (4.0 MG)	270	5,070	---
5.	BARBERS' POINT 215 RESERVOIR NO.6 (5.0 MG)	---	340	6,930
6.	MAKAHA 242 RESERVOIR NO. 2 (3.0 MG)	---	285	4,825
7.	KAILUA 272 RESERVOIR (4.0 MG)	---	30	7,875

PROJECT		FISCAL YEAR (000) 1990-1991	1992-1993	1994-1995
8.	NANAKULI 242 RESERVOIR (3.0 MG)	---	---	8,235
	SUBTOTALS:	$8,770	$12,685	$27,865
III.	PUMP STATIONS	(NO PROJECTS SCHEDULED)		
IV.	NEW PIPELINES			
1.	KAMEHAMEHA HIGHWAY 20-INCH MAIN, PUNALUU TO HAUULA (7,450 LF)	2,400	---	---
2.	WATER STREET AND KILI DRIVE 20-INCH MAIN: FARRINGTON HIGHWAY TO MAKAHA 242 RESERVOIR (4,600 LF)	1,200	---	---
3.	KILI DRIVE 16-INCH MAIN: HUIPU DRIVE TO MAKAHA 242 RESERVOIR ACCESS ROAD (3,100 LF)	750	---	---
4.	DOLE STREET 24-INCH MAIN: (From University Faculty to Waialae Avenue) (3,000 LF)	1,200	---	---
5.	PLANTATION ROAD 12-INCH MAIN: FARRINGTON HIGHWAY TO WAIANAE VALLEY ROAD (3,600 LF)	675	---	---
6.	IHUKU STREET AND KAWILA STREET 16-INCH MAIN: LUALUALEI HOMESTEAD ROAD TO WAIANAE 242 RESERVOIR (1,800 LF)	230	---	---
7.	LUALUALEI HOMESTEAD ROAD 12-INCH MAIN: LEIHOKU ROAD TO HALONA ROAD (1,600 LF)	275	---	---
8.	MOANALUA ROAD 36-INCH MAIN: PUNANANI CHANNEL TO AIEA (6,800 LF)	360	2,920	---

PROJECT		FISCAL YEAR (000) 1990-1991	1992-1993	1994-1995
9.	KAMEHAMEHA HIGHWAY AND KAHEKILI HIGHWAY 42-INCH MAIN: KAHALUU UTILITY TUNNEL TO WAIHEE LINE BOOSTER (14,670 LF)	8,450	900	---
10.	KAMEHAMEHA HIGHWAY 12-INCH MAIN: KAIPAPAU TO LAIE (7,250 LF)	2,415	---	---
11.	KAMEHAMEHA HIGHWAY 16-INCH MAIN: HAUULA TO KAIPAPAU (9,300 LF)	2,940	---	---
12.	KAMEHAMEHA HIGHWAY 16-INCH MAIN: PUPUKEA ROAD TO SUNSET BEACH RESERVOIR AND FROM KAHAUOLA STREET TO CRAWFORD'S CONVALESCENT HOME (17,500 LF)	1,395	3,070	---
13.	KALANIANAOLE HIGHWAY 36-INCH TRANSMISSION MAIN: WAIMANALO REALIGNED PORTION (10,700 LF)	---	4,325	---
14.	KAHEKILI HIGHWAY AND LIKELIKE HIGHWAY 42-INCH MAIN: KANEOHE TO KAHALUU UTILITY TUNNEL (14,400 LF)	---	9,610	---
15.	DILLINGHAM BOULEVARD 42-INCH MAIN: KALIHI TO LILIHA (5,560 LF)	---	5,450	---
16.	KAMEHAMEHA HIGHWAY 30-INCH MAIN: WAIKANE TO KAAWA (24,700 LF)	---	215	13,115
17.	KAMEHAMEHA HIGHWAY 30-INCH MAIN: WAIHEE LINE BOOSTER TO WAIKANE (14,800 LF)	---	3,960	3,805
18.	KAMEHAMEHA HIGHWAY 30-INCH MAIN: KAAAWA TO PUNALUU (25,000 LF)	---	200	12,770
19.	SALT LAKE BOULEVARD 36-INCH MAIN: FOSTER VILLAGE TO ALIAMANU (8,300 LF)	---	---	2,760
	SUBTOTALS:	$22,290	$30,650	$32,450

PROJECT		FISCAL YEAR (000) 1990-1991	1992-1993	1994-1995
V.	SUPPORT FACILITIES			
1.	MANANA CORPORATION YARD	925	---	---
2.	HEEIA CORPORATION YARD	1,130	---	---
3.	BERETANIA MICROBIOLOGICAL FACILITIES	585	---	---
4.	KALIHI CORPORATION YARD	6,000	---	---
	SUBTOTALS:	$8,640	---	0
VI.	WATER TREATMENT FACILITIES	(NO PROJECTS SCHEDULED)		
	SUBTOTAL:	**$53,235**	**$60,780**	**$87,090**

TOTAL: $201,105

APPENDIX D

POPULATION AND WATER DEMAND TABLES

TABLE D-1

OAHU WATER DEMAND
1980, BY DP AREA

DP AREA	1980 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	1980 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	417,215	3,963	62,315	475,567	41,594	433,973	77.1	177.7
EWA	35,709	342	334	35,701	10,753	24,948	7.8	312.7
CENTRAL OAHU	101,494	963	694	101,225	23,177	78,048	11.5	147.3
EAST HONOLULU	43,242	413	252	43,081	0	43,081	6.2	143.9
KOOLAUPOKO	109,373	1,036	762	109,099	870	108,229	16.0	147.8
KOOLAULOA	11,123	101	809	11,831	4,140	7,691	1.5	195.0
NORTH SHORE	12,921	123	94	12,892	1,000	11,892	2.3	193.4
WAIANAE	31,487	297	1,421	32,611	0	32,611	7.7	236.1
TOTALS	762,564	7,238	66,681	822,007	81,534	740,473	130.1	

TABLE D-2

OAHU WATER DEMAND
1985, BY DP AREA

DP AREA	1985 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	1985 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	439,841	7,968	61,279	493,152	41,594	451,558	76.18	168.7
EWA	36,738	662	199	36,275	10,753	25,522	7.86	308.0
CENTRAL OAHU	114,611	2,073	573	113,111	23,177	89,934	11.87	132.0
EAST HONOLULU	46,029	838	223	45,414	0	45,414	8.04	177.0
KOOLAUPOKO	113,769	2,058	723	112,434	870	111,564	15.47	138.7
KOOLAULOA	11,977	221	805	12,561	4,140	8,421	1.58	187.6
NORTH SHORE	13,227	235	88	13,080	1,000	12,080	3.22	266.6
WAIANAE	34,903	633	1,410	35,680	0	35,680	7.58	212.4
TOTALS	811,095	14,688	65,300	861,707	81,534	780,173	131.80	

TABLE D-3

OAHU WATER DEMAND
1988, BY DP AREA

DP AREA	1988 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	1988 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	443,195	8,622	71,665	506,238	41,594	464,644	83.73	180.2
EWA	38,682	750	1,227	39,159	10,753	28,406	9.41	331.3
CENTRAL OAHU	127,723	2,477	1,606	126,852	23,177	103,675	15.14	146.0
EAST HONOLULU	48,205	929	601	47,877	0	47,877	9.02	188.4
KOOLAUPOKO	119,115	2,315	1,654	118,454	870	117,584	17.61	149.8
KOOLAULOA	12,417	245	1,166	13,338	4,140	9,198	1.81	196.8
NORTH SHORE	13,983	277	586	14,292	1,000	13,292	3.56	267.8
WAIANAE	35,180	685	1,895	36,390	0	36,390	9.61	264.1
TOTALS	838,500	16,300	80,400	902,600	81,534	821,066	149.89	

TABLE D-4

PROJECTED OAHU WATER DEMAND
1995, BY DP AREA
(M-K)

DP AREA	1995 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	1995 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	466,100	8,532	77,417	534,985	41,594	493,391	88.91	180.2
EWA	64,600	1,311	2,418	65,707	10,753	54,954	18.21	331.3
CENTRAL OAHU	140,200	2,457	2,070	139,813	23,177	116,636	17.03	146.0
EAST HONOLULU	51,900	930	761	51,731	0	51,731	9.75	188.4
KOOLAUPOKO	122,000	2,175	1,960	121,785	870	120,915	18.11	149.8
KOOLAULOA	12,800	232	1,457	14,025	4,140	9,885	1.95	196.8
NORTH SHORE	14,500	266	998	15,232	1,000	14,232	3.81	267.8
WAIANAE	37,300	697	2,219	38,822	0	38,822	10.25	264.1
TOTALS	909,400	16,600	89,300	982,100	81,534	900,566	168.01	

TABLE D-5

PROJECTED OAHU WATER DEMAND
1995, BY DP AREA
(GP LIMIT)

DP AREA	1995 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	1995 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	488,500	8,968	77,417	556,949	41,594	515,355	92.87	180.2
EWA	68,800	1,399	2,418	69,819	10,753	59,066	19.57	331.3
CENTRAL OAHU	147,200	2,586	2,070	146,684	23,177	123,507	18.03	146.0
EAST HONOLULU	54,500	980	761	54,281	0	54,281	10.23	188.4
KOOLAUPOKO	128,100	2,290	1,960	127,770	870	126,900	19.01	149.8
KOOLAULOA	13,400	244	1,457	14,613	4,140	10,473	2.06	196.8
NORTH SHORE	16,200	298	998	16,900	1,000	15,900	4.26	267.8
WAIANAE	39,200	735	2,219	40,684	0	40,684	10.74	264.1
TOTALS	955,900	17,500	89,300	1,027,700	81,534	946,166	176.77	

TABLE D-6

PROJECTED OAHU WATER DEMAND
YEAR 2000, BY DP AREA
(M-K)

DP AREA	2000 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	2000 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	465,500	8,584	81,253	538,169	41,594	496,575	89.48	180.2
EWA	84,000	1,625	4,255	86,631	10,753	75,878	25.14	331.3
CENTRAL OAHU	144,600	2,582	2,313	144,331	23,177	121,154	17.69	146.0
EAST HONOLULU	52,200	941	833	52,093	0	52,093	9.81	188.4
KOOLAUPOKO	119,400	2,155	2,067	119,312	870	118,442	17.74	149.8
KOOLAULOA	13,000	222	1,998	14,776	4,140	10,636	2.09	196.8
NORTH SHORE	15,900	291	1,797	17,406	1,000	16,406	4.39	267.8
WAIANAE	38,200	701	2,284	39,783	0	39,783	10.51	264.1
TOTALS	932,800	17,100	96,800	1,012,500	81,534	930,966	176.86	

TABLE D-7

PROJECTED OAHU WATER DEMAND
YEAR 2000, BY DP AREA
(GP LIMIT)

DP AREA	2000 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	2000 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	488,700	9,033	81,253	560,920	41,594	519,326	93.58	180.2
EWA	88,100	1,709	4,255	90,646	10,753	79,893	26.47	331.3
CENTRAL OAHU	151,800	2,718	2,313	151,395	23,177	128,218	18.72	146.0
EAST HONOLULU	54,800	990	833	54,643	0	54,643	10.29	188.4
KOOLAUPOKO	125,400	2,268	2,067	125,199	870	124,329	18.62	149.8
KOOLAULOA	13,700	235	1,998	15,463	4,140	11,323	2.23	196.8
NORTH SHORE	16,700	307	1,797	18,190	1,000	17,190	4.60	267.8
WAIANAE	40,200	740	2,284	41,744	0	41,744	11.02	264.1
TOTALS	979,400	18,000	96,800	1,058,200	81,534	976,666	185.55	

TABLE D-8

PROJECTED OAHU WATER DEMAND
YEAR 2005, BY DP AREA
(M-K)

DP AREA	2005 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	2005 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	468,100	8,540	85,541	545,101	41,594	503,507	90.73	180.2
EWA	103,800	1,943	6,162	108,019	10,753	97,266	32.22	331.3
CENTRAL OAHU	149,900	2,692	2,605	149,813	23,177	126,636	18.49	146.0
EAST HONOLULU	53,800	963	929	53,766	0	53,766	10.13	188.4
KOOLAUPOKO	117,300	2,118	2,199	117,381	870	116,511	17.45	149.8
KOOLAULOA	13,500	228	2,541	15,813	4,140	11,673	2.30	196.8
NORTH SHORE	16,300	298	2,585	18,587	1,000	17,587	4.71	267.8
WAIANAE	38,400	718	2,338	40,020	0	40,020	10.57	264.1
TOTALS	961,100	17,500	104,900	1,048,500	81,534	966,966	186.60	

TABLE D-9

PROJECTED OAHU WATER DEMAND
YEAR 2005, BY DP AREA
(GP LIMIT)

DP AREA	2005 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	2005 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	491,500	8,977	85,541	568,064	41,594	526,470	94.87	180.2
EWA	109,000	2,043	6,162	113,119	10,753	102,366	33.91	331.3
CENTRAL OAHU	157,400	2,834	2,605	157,171	23,177	133,994	19.56	146.0
EAST HONOLULU	56.500	1,012	929	56,417	0	56,417	10.63	188.4
KOOLAUPOKO	123,100	2,226	2,199	123,073	870	122,203	18.31	149.8
KOOLAULOA	14,100	238	2,541	16,403	4,140	12,263	2.41	196.8
NORTH SHORE	17,200	314	2,585	19,471	1,000	18,471	4.95	267.8
WAIANAE	40,400	756	2,338	41,982	0	41,982	11.09	264.1
TOTALS	1,009,200	18,400	104,900	1,095,700	81,534	1,014,166	195.73	

TABLE D-10

PROJECTED OAHU WATER DEMAND
YEAR 2010, BY DP AREA
(M-K)

DP AREA	2010 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	2010 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	474,300	8,645	90,129	555,784	41,594	514,190	92.66	180.2
EWA	126,400	2,311	8,141	132,230	10,753	121,477	40.25	331.3
CENTRAL OAHU	156,900	2,857	2,916	156,959	23,177	133,782	19.53	146.0
EAST HONOLULU	55,500	1,002	1,019	55,517	0	55,517	10.46	188.4
KOOLAUPOKO	115,900	2,111	2,315	116,104	870	115,234	17.26	149.8
KOOLAULOA	13,500	237	3,094	16,357	4,140	12,217	2.40	196.8
NORTH SHORE	17,000	309	3,375	20,066	1,000	19,066	5.11	267.8
WAIANAE	40,000	728	2,411	41,683	0	41,683	11.01	264.1
TOTALS	999,500	18,200	113,400	1,094,700	81,534	1,013,166	198.67	

TABLE D-11

PROJECTED OAHU WATER DEMAND
YEAR 2010, BY DP AREA
(GP LIMIT)

DP AREA	2010 RESIDENT POP	RESIDENTS ABSENT	VISITORS PRESENT	DE FACTO POPULATION	PRIVATE SYSTEMS	BWS-SERVED POPULATION	2010 DEMAND MGD	PER CAPITA DEMAND-GPD
PRIMARY URBAN CTR	497,800	9,073	90,129	578,856	41,594	537,262	96.81	180.2
EWA	132,900	2,426	8,141	138,615	10,753	127,862	42.36	331.3
CENTRAL OAHU	164,900	2,999	2,916	164,817	23,177	141,640	20.68	146.0
EAST HONOLULU	58,000	1,049	1,019	57,970	0	57,970	10.92	188.4
KOOLAUPOKO	121,900	2,217	2,315	121,998	870	121,128	18.14	149.8
KOOLAULOA	14,000	249	3,094	16,845	4,140	12,705	2.50	196.8
NORTH SHORE	18,000	324	3,375	21,051	1,000	20,051	5.37	267.8
WAIANAE	42,000	764	2,411	43,647	0	43,647	11.53	264.1
TOTALS	1,049,500	19,100	113,400	1,143,800	81,534	1,062,265	208.32	