Chemical Quality of Ground Water

IN HAWAII

Report R48

Prepared by the
UNITED STATES GEOLOGICAL SURVEY
in cooperation with
Division of Water and Land Development
DEPARTMENT OF LAND AND NATURAL RESOURCES
State of Hawaii

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By LINDSAY A. SWAIN

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DEPARTMENT OF LAND AND NATURAL RESOURCES
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Introduction

As the quantity of water needed in certain localities of Hawaii is rapidly approaching the quantity of usable water available, identification and protection of the quality of existing and potential water supplies are becoming ever more critical. Certain factors are already identifiable as problems affecting the quality of ground water in Hawaii: (1) overdevelopment leads to salt-water encroachment by local upconing; (2) agricultural and industrial uses and discharges deteriorate both present and potential water supplies; and (3) the increasing practice of underground disposal of domestic wastes, with insufficient information to protect the water resource creates a potential hazard to developed and future supplies.

PURPOSE AND SCOPE

This study was begun in mid-1971 by the U.S. Geological Survey in cooperation with the Division of Water and Land Development, Department of Land and Natural Resources, State of Hawaii. The purpose of the study was to identify present ground-water quality conditions, both natural and as affected by usage, to show readily identifiable changes in quality with time and usage, and to relate water-quality conditions to the development of ground-water supplies.

The study included a thorough research of all published data regarding chloride levels and complete chemical analyses for ground water in Hawaii; acquisition of data from local agencies collecting ground-water quality information; compilation of extensive unpublished water-quality data in U.S. Geological Survey files; coding of all data, where possible, for use in computer storage and retrieval systems; analysis of the collected and compiled data; and development of preliminary conclusions regarding the effects of pumpage and land use on water quality.

The report presents the results of a 2-year study of ground-water quality for the entire State of Hawaii.

PREVIOUS WORK

Concern for the quality of ground water in Hawaii dates back more than 85 years. The initial recorded sampling for chemical content of ground waters in Hawaii was made in early 1886 by Professor Lucius Van Slyke of Oahu College with the intent of determining water supplies of good, bad, or doubtful quality (Honolulu Water Commission, 1917).

Most water-quality studies of Hawaiian ground-water supplies are concerned primarily with chloride concentrations. Only a limited number have dealt with total chemical quality. Stearns and Vaksvik (1935) published the first extensive chemical analyses for Oahu. Bryson (1951) made an interpretive study of water quality in the Honolulu area. In 1961, Mink discussed the chemical characteristics of the intruded saline water underlying the fresh-water lens. Mink (1962) also discussed the effects of irrigation return water on the concentration of silica and nitrate in the ground water. Other studies on silica concentration in ground water and the effects of irrigation return water on ground-water chemistry were made by Davis (1969) and Tenorio and others (1969, 1970), respectively.

ACKNOWLEDGMENTS

Special appreciation for cooperation and assistance during this study is extended to employees of the Honolulu Board of Water Supply, Departments of Water Supply of Maui, Hawaii, and Kauai Counties and the Division of Water and Land Development, State Department of Land and Natural Resources. Particular appreciation is expressed to the State of Hawaii Department of Health, especially Mr. William Wong, for his assistance in identifying much of the water-quality data. Numerous sugar and agricultural companies also graciously supplied chloride information from their files.

Factors Determining Ground-Water Quality

Ground-water quality is initially the result of effects or stresses caused by the various aspects of the hydrochemical cycle as the water moves through the system. Environmental factors creating the initial water quality are: (1) the chemistry of rain; (2) the effects of vegetation, soil, and geologic units on the water as it infiltrates; and (3) the results of mixing with saline water at depth within the aquifer. Further changes are caused by the activities of man, either by increased stress placed on the existing system or by simple addition of chemicals to the zone of infiltration.

RAINFALL

The source of almost all fresh water in Hawaii is rainfall; therefore, the chemical quality of rainwater is the genesis of ground-water chemistry in Hawaii.

Rainwater originates as water vapor from the ocean condensing upon salt nuclei, which are also of oceanic origin. The various ionic ratios in the rainwater are, therefore, quite similar to that of ocean water (Visher and Mink, 1964). Slight differences in the ratios that exist probably result from additional chemicals of atmospheric, industrial, or even domestic origin.

The atmosphere may contribute gases, such as nitrogen in the form of nitrate and ammonium, carbon dioxide and oxygen. Industry contributes particulate matter from a wide spectrum of chemical constituents. Agricultural contributions may be windblown dust and particulate matter in the smoke from burning fields. Urban areas and domestic activities contribute numerous particulates to serve as nuclei.

The data-base for chemical quality of rainfall in Hawaii is quite deficient. The few existing analyses were made by Eriksson (1957, p. 520) for Project Shower on the island of Hawaii. Citing Eriksson's data and chloride-only analyses made by the U.S. Geological Survey, Visher and Mink (1964, p. 82) made additional interpretations of rain chemistry in a detailed study of southern Oahu. Analyses of rain chemistry are shown in table 1. Sea-water origin is apparent from the significantly greater concentrations of sodium and chloride, the major sea-water components.

The data ignore the existence of accumulated salts upon the land from interception of the daily aerosol or "dry rain" conditions in areas exposed to strong trade winds. The data available on water quality for high-level sources, however, indicate that the maximum natural-chloride concentration will usually not exceed 25 mg/l (milligrams per liter) in Hawaii.

The relatively low pH of the rainfall indicates slightly acid conditions. This would cause the water to react with the rocks to bring about chemical weathering.

ROOT ZONE OF VEGETATION

The first terrestrial strata to have an effect upon the chemistry of the slightly acid infiltrating rainwater is the root zone of vegetation. As a result of plant respiration, carbon dioxide (CO_2) is trapped in the pore space of the root zone. Upon contact with the infiltrating water, carbonic acid (H_2CO_3) is formed:

$$H_2O + CO_2 \rightleftharpoons H_2CO_3$$

Passage through this zone thus adds carbonate (CO_3) and bicarbonate (HCO_3) ions to the infiltrating ground water.

GEOLOGY

The Hawaiian Islands are principally shield volcanoes of olivine basalt, which, in limited areas, may be capped by volcanics of either higher silica content or more ultrabasic character. Calcareous and alluvial deposits overlay these volcanics in some areas.

As chemical weathering plays a greater part in rock alteration than mechanical weathering in Hawaii, rainwater undergoes significant chemical changes depending upon the rock type and structure of the geologic unit through which it infiltrates.

Island Volcanics. The mineralogical composition of most island volcanics is such that the major minerals are readily decomposable. According to Macdonald and Abbott (1970, p. 153), the principal minerals that produce soluble products are olivine, anorthite, nepheline, pigeonite, augite, and albite. From decomposition of these minerals, the products released to solution are: $MgCO_3$, $FeCO_3$, Na_2CO_3, and SiO_2. The abundance of each will depend upon the chemical composition or ease of decomposition of each mineral. Thus, from the volcanics the infiltrating water acquires calcium, magnesium, sodium, silica, and iron, although the amount is limited.

Table 1. Average composition of rainfall caught at high- and low-rainfall localities on Hawaii and Oahu (Constituents in parts per million)

Locations	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	pH	Source of data
1. Slopes of Mauna Kea, Hawaii. Altitudes: 1,325-2,630 ft. Distance from coast: 3.9-7.6 miles.	0.39	0.45	1.62	0.11	0.89	3.11	0.39	5.1	Eriksson (1957, p. 520).
2. Kipapa drainage basin, Oahu. Altitudes: 1,200-2,785 ft. Distance from coast: 3.0-7.6 miles.	.8	.9	3.4	.2	1.9	6.5	.4	--	Chloride analysis by U.S.Geol. Survey. Other constituents, except nitrate, calculated from ionic ratios determined from Eriksson's data.
3. Hilo coast, Hawaii Altitude: 30 ft. Distance from coast: 0.6 mi.	1.11	1.54	6.4	.66	2.26	11.0	.61	5.4	Eriksson (1957, p. 520).
4. Honolulu, Oahu. Altitudes: as much as 50 ft. Distance from coast: less than 1 mile.	1.1	1.5	6.4	.7	2.3	11.0	.6	--	Chloride data from Bryson (1951, unpublished data) and Stearns and Vaksvik (1935, p. 364). Other constituents, except nitrate, calculated from ionic ratios determined from Eriksson's data.

Reprinted from Visher and Mink, 1964, p. 82.

Calcareous Deposits. Although information about water quality within the coralline reef or other calcareous deposits is limited, Visher and Mink (1964, p. 116) have noted the major soluble products from the decomposition of these rocks. These products include higher proportions of carbon dioxide (CO_2), bicarbonate (HCO_3) and calcium (Ca) from the calcareous rock than from other rock types. The proportions are also higher than in ocean water. In addition, slightly increased concentrations of magnesium may result from minor impurities in calcareous rock.

Because of the significantly increased bicarbonate concentrations in the calcareous rock zone, analyses with bicarbonate ion concentrations greater than 140 mg/l (that of ocean water) may indicate solution of calcium carbonate rock. Exceptions to this condition may exist when there is considerable recycling of irrigation water or possible volcanic gases being released into the ground-water source.

Alluvial Deposits. Because alluvial deposits are limited in extent throughout the islands and the unit is generally of low permeability, this rock unit is a very minor source of fresh water. In addition, where drilled wells pass through the unit to reach the volcanic aquifer beneath, the entire thickness of alluvial rock is usually cased off. Thus, the information on quality within this aquifer is extremely limited. However, the chloride-only information that is available shows a great variation of values which is apparently due to permeability differences affecting the movement of sea water into the rock unit. Visher and Mink (1964) indicate that calcium and magnesium concentrations are increased by cation exchange within the sediments.

SEA WATER

The aquifers of Hawaii exist in an island environment and are everywhere surrounded by sea water. Unless these highly permeable water-bearing rocks are capped by low-permeability material or contain low-permeability dikes, the ocean may freely penetrate wherever the aquifer is exposed below sea level and fluid pressure gradients are such as to permit it. Where fresh-water heads are at or near sea level, tidal fluctuation and other head variations tend to create a zone of mixing and broad zone of transition from ocean water to fresh water.

Ghyben-Herzberg Lens. According to the Ghyben-Herzberg principle, density differences between fresh and salt water in a static system will allow infiltrating fresh water to float upon salt water. The ratio of densities is such that for every unit of head of fresh water above sea level, the salt-fresh water interface will be depressed approximately 40 times that unit below sea level.

However, as Hubbard (1940) pointed out, the Ghyben-Herzberg lens is a dynamic, not static, system. Thus, as movement occurs within the water bodies, the fresh and salt waters mix and change the interface from a sharp line to a gradational zone of transition. The thickness of the zone depends upon the magnitude of mixing caused by tidal influences, upconing of the salt water from pumpage, and variation in recharge.

Chloride as a Sea-Water Indicator. Because the chloride concentration is quite high in sea water, chloride has long been used as the principal indicator of sea-water intrusion. It takes little more than 1 percent sea water to reach the 250-mg/l chloride limit for drinking water. Thus, the determination of the chloride concentration of ground waters aids in determining the probable extent of sea-water intrusion.

The utility of chloride as a sensitive indicator of sea-water intrusion is enhanced by its inherent qualities. It will not readily enter into chemical reaction with other chemical constituents in the ground-water environment, nor is it subject to appreciable ionic exchange. Also, there are no known major sources of chloride within the lavas of Hawaii.

Chemical Characteristics of Intruded Water. Each aquifer unit has fresh water with its own inherent quality. However, when the influence from salt-water intrusion becomes prominent, the high chemical concentrations of the sea water overshadow the fresh-water concentration. In some instances, the intruding sea water will also undergo chemical changes as it moves into the aquifer from the ocean.

Mink (1961) noted that when sea water intrudes a volcanic aquifer, which is overlain by an alluvial caprock, the intruded water has a chemical character significantly different from that of ocean water. His analysis of water from a deep test hole in the Pearl Harbor area of Oahu showed more calcium and magnesium and less sodium and potassium than would exist in ocean water diluted to the chloride concentration of the deep-well sample. This change has been attributed to a cation exchange as the ocean water penetrates the ocean-bottom sediments and areas of permeable caprock, exchanging the high concentrations of sodium for calcium and magnesium in the clay structure of these deposits.

In addition, the sulfate and bicarbonate ions are also less than would be expected from simple dilution of sea water. The lesser sulfate is believed to result from sulfide reduction in the bottom sediments (Mink, 1961). The anomalous decrease in bicarbonate is hypothesized to occur as a result of pressure loss as water under aquifer pressure reaches the reduced pressure of the well, with the resultant release of carbon dioxide and deposition of calcium carbonate.

INTRODUCED CONTAMINANTS

The numerous and varying activities of man have, in some instances, altered the chemical character of the ground-water bodies beyond that acquired from environmental sources. Man's effects fall into three broad categories: agriculture, industry, or domestic waste disposal.

Agriculture. Studies on Maui and Oahu have described the water-quality change effects of irrigation in sugarcane areas (Tenorio and others, 1970; Takasaki and Valenciano, 1969). These changes have been attributed to both stress on the fresh-water lens by pumping, and to the addition of chemicals as a by-product of fertilizer and other surface chemical application.

Intensive pumping of the basal fresh water has been shown to cause local upconing of the saline-water body, resulting in higher concentrations of most ions, especially chloride. Irrigation with this water of higher-chloride concentration will further increase the chloride concentration in the fresh-water lens, as excess irrigation water infiltrates back to the fresh-water lens.

Fertilizer and other surface chemical applications add soluble products to the ground-water bodies but, at present, none of these additive chemicals have been detected in excess of the limitations for drinking water. Nitrate and sulfate have been the most extensively studied of these additive products. These chemicals infiltrate from the irrigated fields, and often a concentration, which decreases with depth, is found accumulated above intruded saline water.

Nitrate (NO_3) has an average concentration in rainfall, in native fresh water and even in sea water of less than 1.1 milligrams per liter (Mink, 1961). Where concentrations greater than this occur beneath areas of irrigation, the parameter may be considered a reliable indicator of return irrigation water.

Because sulfate is also a soluble product of fertilizer, it too is a good indicator of return irrigation water. However, sulfate concentration in sea water is about 2,600 mg/l, and high concentrations may simply indicate sea-water intrusion unless other constituents such as chloride are not in proper proportion.

Visher and Mink (1964) recognized that even though phosphate and potassium are highly concentrated in fertilizers, they are poor indicators of return irrigation water. Phosphate is immediately fixed in the soil as an insoluble product, and potassium is subject to ion-exchange reaction; the unconsumed amount usually remaining in the soil.

Tenorio and others (1970) noted that increased application and recycling of water in certain geologic environments will accelerate solution of specific minerals by the infiltrating water. This situation is prevalent in central Maui where high concentrations of bicarbonate are encountered in ground waters below heavily irrigated areas. Because the zone of infiltration in this area is composed largely of calcareous deposits, it is not known for certain whether the high bicarbonate values are the result of continuous recycling through the root zone of vegetation or whether from solution of the carbonate rock, or both.

Industry. Although various wastes, such as hydrocarbons, metals, detergents, and other chemical products are created by industrial activities, only very limited information is available regarding the influence of such industrial waste upon the ground-water quality in Hawaii.

In one recent study, Zaidi (1973) found the levels of organic carbon in Oahu ground water to be well below suggested limits for potable water, and that in the artesian aquifer beneath the industrialized Honolulu-Pearl Harbor area, the levels are quite low. This is most likely attributable to a thick, nearly impermeable alluvial caprock and the upward pressure in the artesian aquifer.

A recent reconnaissance of domestic ground-water supplies by the Honolulu Board of Water Supply found the mercury concentration of all the numerous ground-water sources sampled to be well below the recommended limit of 5 micrograms per liter.

No other extensive studies are known to have been made on other trace metals or possible industrial contaminants in Hawaii. However, as industry expands with population to areas beyond the caprock area and over the recharge areas for the islands' main aquifers, monitoring of the ground-water system for industrial contaminants will become important.

Domestic Waste Disposal. Solid and liquid domestic waste-disposal practices and their chemical effect on specific ground-water bodies have not been studied in great detail for Hawaii. Takasaki (1973) has inventoried the extent and type of domestic waste-disposal practices in the State, has identified present practices, and has delineated, generally, areas where the possibility for contamination may exist.

Other than significant nitrate concentrations in some cesspool areas, relatively little data exist to identify specific chemical effects from domestic waste-disposal practices in Hawaii.

The Ground-Water Quality Data Base

Since 1886, when the first chloride determinations were made on Oahu, various private and governmental agencies have been collecting chemical-quality information about ground-water sources in Hawaii. Since then many agencies and private organizations or individuals have collected chemical-quality data at various locations for a variety of purposes. Principal among those concerned were the agricultural interests who were the principal users of ground water for irrigation. As more ground water began to be used for domestic and municipal purposes, the Territorial, State, and City and County agencies became more involved. Chloride was the primary indicator of usability, and the great bulk of data contains only chloride determinations. Some uses, however, required more detailed knowledge of dissolved constituents, and a small body of data from complete analyses was developed.

TYPE AND AMOUNT OF DATA AVAILABLE

As noted, by far the majority of all water-quality data consists of only chloride-concentration analyses. Although some sources may have only one chloride analysis available, others have more than 60 years of regular analysis for chloride. The amount of this data from the more than 1,700 ground-water sources on Oahu alone is voluminous. Although less extensive, a great amount of data is also available for the other major islands. The chloride-only data base used herein was developed from analyses compiled during this study from various sugar and agricultural companies, county water departments, and the files of the U.S. Geological Survey.

In addition to the chloride-only data, more than 2,000 complete chemical anslyses of ground-water sources within the State were obtained during this study. These analyses were made in the laboratories of the City and County water departments, State of Hawaii Department of Health, University of Hawaii, the U.S. Geological Survey, and a few private agencies. Many recent analyses with wide geographic distribution were available for the study through a concurrent ground-water data network program being carried on by the Geological Survey wherein a large number of sources were sampled and complete analyses were made.

EVALUATION OF THE DATA

Because the complete chemical analyses were made by different agencies, they vary greatly in precision owing to differences in sampling purpose and analytical technique. The State Department of Health and the Honolulu Board of Water Supply take samples of domestic supplies to ensure that no chemical parameter exceeds recommended limits as set forth by the U.S. Public Health Service (1962). The University of Hawaii made analyses during 1968, 1969, and 1970 on some irrigation sources to find a means of identifying irrigation return water in the ground-water bodies. The U.S. Geological Survey has taken extensive samples on a state-wide basis, in order to evaluate the chemical quality of all ground-water resources in Hawaii.

For the collected data to be useful in evaluation of the total chemical-quality conditions, or to show changes for certain parameters, the data from all agencies had to be made comparable in content and precision.

The major content discrepancies existed because the methods of reporting constituents were not uniform. Some agencies reported the individual ion not as ion concentration, but as ion complexes or alkalinity values. In addition, the computed values of calculated solids, carbonate and noncarbonate hardness, and alkalinity were either not reported, or were determined by varying methods. Thus, to make these analyses comparable it was necessary to recompute them to their individual ion concentrations. Finally, the calculated values were recomputed, using nationally accepted methods as set forth by Rainwater and Thatcher (1960).

Each individual analysis was intensively examined to determine which analyses were of reliable precision. The initial step in identifying unreliable analyses was a check of the cation-anion balance. To be truly representative of the actual chemistry of the sample, total cations in milliequivalents per liter (meq/l) should approximately equal total anions in meq/l. However, because analytical technique varies considerably among analyzing laboratories, the balance is rarely exact. An arbitrary limit of cation-anion difference of 5 percent of the total was set as the level of analysis precision acceptable for this study. To further complicate data evaluation, analyses made prior to

1940 sometimes reported sodium concentration as calculated from the cation-anion difference, rather than as determined directly. For these analyses checks were made by comparing the individual parameters in each analysis with values on other dates for the same source or with other sources in the same aquifer located nearby. By this check, analyses which contained gross variations from the normal were eliminated.

Following the checks on content and precision, approximately 900 analyses that met the qualifications for the study were processed. The data are shown graphically and by numerical value on the accompanying plates, and are tabulated in Appendix A at the end of this report.

WELL-NUMBERING SYSTEM

The ground-water data-point identification system for Hawaii has recently been standardized, and is the system in use by the U.S. Geological Survey and the State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development. This system makes areal location of any ground-water data source easily obtainable from its identification number. Each island is divided into minutes of latitude and longitude, and each one-minute-square block is identified by a four-digit number; the first two numbers being minutes of latitude and the last two numbers being minutes of longitude. Within each one-minute-square area, ground-water sources are numbered serially by a two-digit number, preceded by a dash following the four-digit block number. Thus, the first source numbered in the one-minute-square block at 34 minutes of latitude and 26 minutes of longitude would be identified as 3426-01. Wherever possible, the serial number assigned is based on the chronological order in which the source was identified or (if a well) constructed. In a few instances where the water-quality analysis is from a combination of wells, the first well identified in the active battery will bear the serial identifier and this will be followed by the letter Z to identify a combination sample.

WATER-QUALITY TYPES

In this report, the names used for water-quality types identify ground water of a particular chemical character and are applied as in the following examples: (1) "sodium chloride" designates a water in which sodium amounts to 50 percent or more of the cations, and chloride amounts to 50 percent or more of the anions, in milliequivalents; (2) "calcium magnesium chloride" designates a water in which calcium and magnesium are first and second, respectively, in order of abundance among the cations but neither individually amounts to 50 percent of the cations; (3) "calcium bicarbonate chloride" designates a water in which bicarbonate and chloride are first and second in order of abundance among the anions, as above; (4) "calcium magnesium sodium chloride" designates a water in which calcium, magnesium, and sodium are each of approximately equal percentage of the total cations.

Ground-Water Quality by Island

Although the magnitude of each chemical parameter may vary considerably, the basic conditions determining ground-water quality can generally be applied for each of the islands. From the large amount of data acquired during this study, the water-quality types, their distribution, and even some conclusions as to specific causes of greatly varying conditions can be described for ground-water sources on each of the five major islands.

KAUAI

Kauai, oldest and northernmost of the islands, is the most geologically complicated. The island was formed from a major shield volcano of principally basaltic composition. The volcano later collapsed to form the State's largest caldera, and lava flows subsequently erupted on its periphery. Following a long period of quiescence and erosion, more recent and extensive lava flows occurred within the eastern two-thirds of the island (Macdonald and others, 1960).

Ground-Water Zones. Kauai's ground water occurs mainly in the Koloa Volcanic Series and in the Napali formation of the Waimea Volcanic Series. Water in these volcanics may occur as perched water, dike-impounded water, or as a basal lens.

The perched water occurs mostly in the poorly permeable to moderately permeable Koloa Volcanic Series at lower elevations, where it is perched by ash or tuffaceous soil beds (Macdonald and others, 1960).

The dike-impounded water is found mostly in the highly permeable Napali formation along the Napali Coast and in the Makaleha Mountains.

Basal water occurs in both rock units but owing to the complicated geology and wide-permeability ranges of the lava flows, conditions are not favorable for large, well-developed, fresh-water lenses.

Water-Quality Types by Zone. As depicted on plate 1, the overall chemical quality of ground water from 25 sources on Kauai is excellent. However, previous hydrologic studies have noted that chloride concentrations exceeding 250 mg/l exist for Kauai, primarily along the western coastal plain. An examination of the available analyses, coupled with available hydrologic information on the water sources, shows a vague pattern of water-quality variation according to area and aquifer type.

The two analyses of perched water from wells 1225-01 and 5823-01 are calcium bicarbonate and magnesium sodium bicarbonate types, respectively. Each analysis shows a low dissolved-solids concentration.

The analyses of dike-zone water from wells 1331-01, 0623-01, and 0623-02 show that all three are of the magnesium sodium bicarbonate type with low dissolved-solids concentrations.

The remaining analyses, which are all believed to be from basal-water sources, vary considerably in water-quality type. In addition, they each show higher dissolved-solids concentrations than those for dike-impounded or perched waters. The major anion in all but five of these samples is bicarbonate. Where sea-water intrusion is evident, as in well 0120-01, chloride is the dominant anion. The increased chloride of this well is accompanied, however, by a significant percentage increase of calcium and magnesium and a decrease of percentage of sodium over what would result from simple mixing. Thus, it is interpreted that the intruding sea water has been altered by cation exchange.

The significant differences in water quality in wells close together, such as 5534-02 and 5534-03, demonstrate the great variabilities encountered in the water bodies of Kauai. In this example, the variability may be caused by an effective ground-water barrier of Hanapepe Stream Valley fill between them. In other localities, differences may result because of differing rock types, because of local geologic structural feature, or from varying land-use practices in the recharge areas.

OAHU

Oahu is the third largest of the islands. It is the population and industrial center of the State with the capital city, Honolulu, on its southern shore. The island had its origin from two volcanoes, which now exist as the eroded Koolau and Waianae Mountain Ranges interconnected by a central plateau. Oahu's very irregular coastline exhibits the effects of Pleistocene relative sea-level fluctuations, with coralline and beach deposits existing far inland from the present-day shoreline. In addition, Oahu has by far the most extensive alluvial deposits of any of the islands. Thus, the ground water of Oahu exists in three major aquifers of great extent: the volcanic bedrock, calcareous sedimentary deposits, and noncalcareous sedimentary material.

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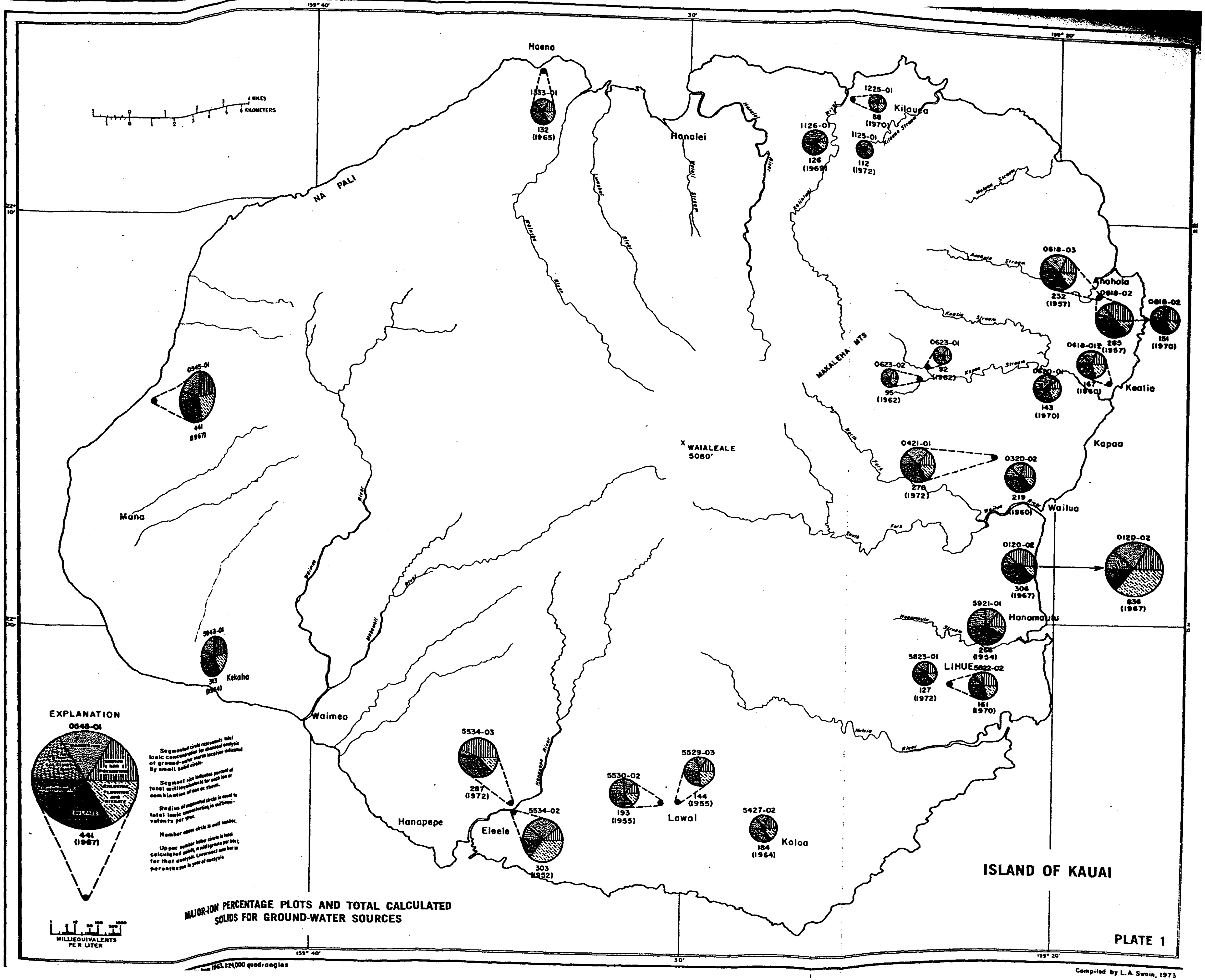


MAJOR-ION PERCENTAGE PLOTS AND TOTAL CALCULATED SOLIDS FOR GROUND-WATER SOURCES

Water in the Noncalcareous Sedimentary Materials. Noncalcareous sedimentary material in Oahu is shown on plate 2, and consists mostly of talus and alluvium derived from the volcanic bedrock or the reworking of older talus and alluvium. Stearns and Vaksvik (1935) divided this material into two units, the Pleistocene consolidated sediments (older alluvium) and the Holocene unconsolidated sediments (younger alluvium). The older alluvium, which is moderately to well consolidated, is poorly permeable. The younger alluvium is more permeable than the older, but is usually less than 20 feet (6.1 meters) thick and situated above the water table. At and near the shore it is usually saturated with brackish to salty water. On plate 2 the two alluvial units are combined and their distribution is shown as the combined unit.

Only a small number of wells on Oahu tap the alluvial unit for water. Most of these exist only because of failure to develop a suitable supply in deeper, more permeable lava flows or, in some coastal areas, in coral limestone. In 1962, about 25 shallow test borings along the west coast of Oahu, and about 10 test borings in north-central Oahu, were drilled to investigate ground water in the sedimentary sectons along the coasts. Much of the information on plate 2 was taken from findings of that investigation.

The relatively low permeability of the noncalcareous sedimentary materials helps to retard sea-water intrusion. Therefore, this aquifer generally contains fresher ground water than that found in the more permeable lava flows and coralline limestone along coastal areas. The range of chloride contents for sources within the alluvial deposits during 1958-70 is shown on plate 2. Even though individual well yields are generally low, the aquifer supplies much needed water for small truck farms in the Waianae area.

Only a limited number of chemical analyses are available for water in the alluvial deposits. However, Visher and Mink (1964, p. 112) have noted that cation exchange within the sediments is significant, as shown by magnesium and calcium concentrations, which are increased from that of water in other aquifers.

Water in the Calcareous Sedimentary Materials. Calcareous sedimentary material in Oahu is shown on plate 3, and consists mostly of coral limestone with minor amounts of dune and beach sand. Logs of drilled wells indicate coral limestone to a depth of at least 1,178 feet (359 meters) below sea level in at least one locality. Most of the limestone, however, is found in the interval from about 30 feet (9.1 meters) above sea level to about 250 feet (76 meters) below sea level.

According to Stearns and Vaksvik (1935, p. 169), lithified dune sand from ancient beaches has a maximum thickness of about 125 feet (38 meters) in Oahu. Most of this material lies above the water table, as does unconsolidated dune sand blown inland from existing beaches. Unconsolidated beach sand rarely exceeds 25 feet (7.6 meters) in thickness and usually contain brackish or highly saline water. The exposures of limestone, dune sand, and beach sand are combined and shown as a single unit on plate 3.

The most important aquifers of this unit are in the coral limestone. Ground water pumped from the unit is the major source of water for sugarcane irrigation in the Ewa area west of Pearl Harbor. Another important use of the coral limestone aquifers is for cooling water for air-conditioning units in Honolulu. The calcareous unit is also an important source of water for irrigation of small truck farms in the Waianae area.

The high permeability of most of the calcareous deposits permits extensive sea-water intrusion which, in turn, greatly limits the usage of water from this unit. The chloride levels for sources within this unit are shown on plate 3.

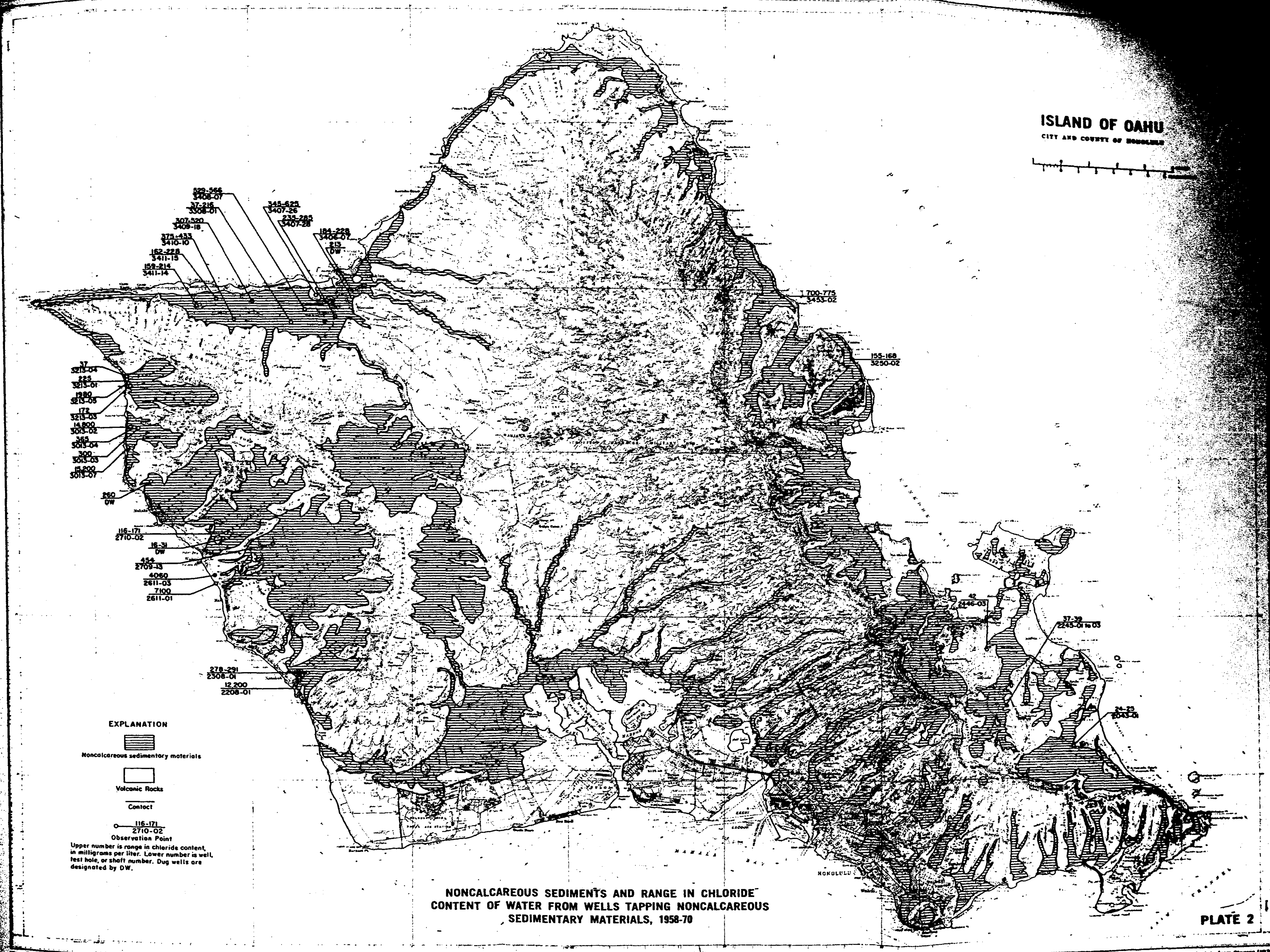
During recent years, the coral limestone and unconsolidated sands have been used increasingly as receptacles for liquid waste. Initially, the materials were discovered to be good, reliable, recipients of cesspool seepage. Later, liquid waste of this and other kinds was injected by means of trenches, dug wells, and drilled wells. The liquid waste included air-conditioning water return, car-wash effluent, flood water, and drainage water. The practice of disposing of effluent from private sewage-disposal systems into limestone and beach deposits has been increasing, owing to increasing development of residential subdivisions and hotels remote from existing sewers.

Only three complete water-quality analyses from calcareous sedimentary aquifer were available for this study. The analyses, as shown on plate 4 (labeled "limestone"), show the water to be a sodium chloride type, in both the Waialua and Waimanalo wells. However, water from the limestone aquifer in Pearl Harbor is a sodium magnesium chloride type.

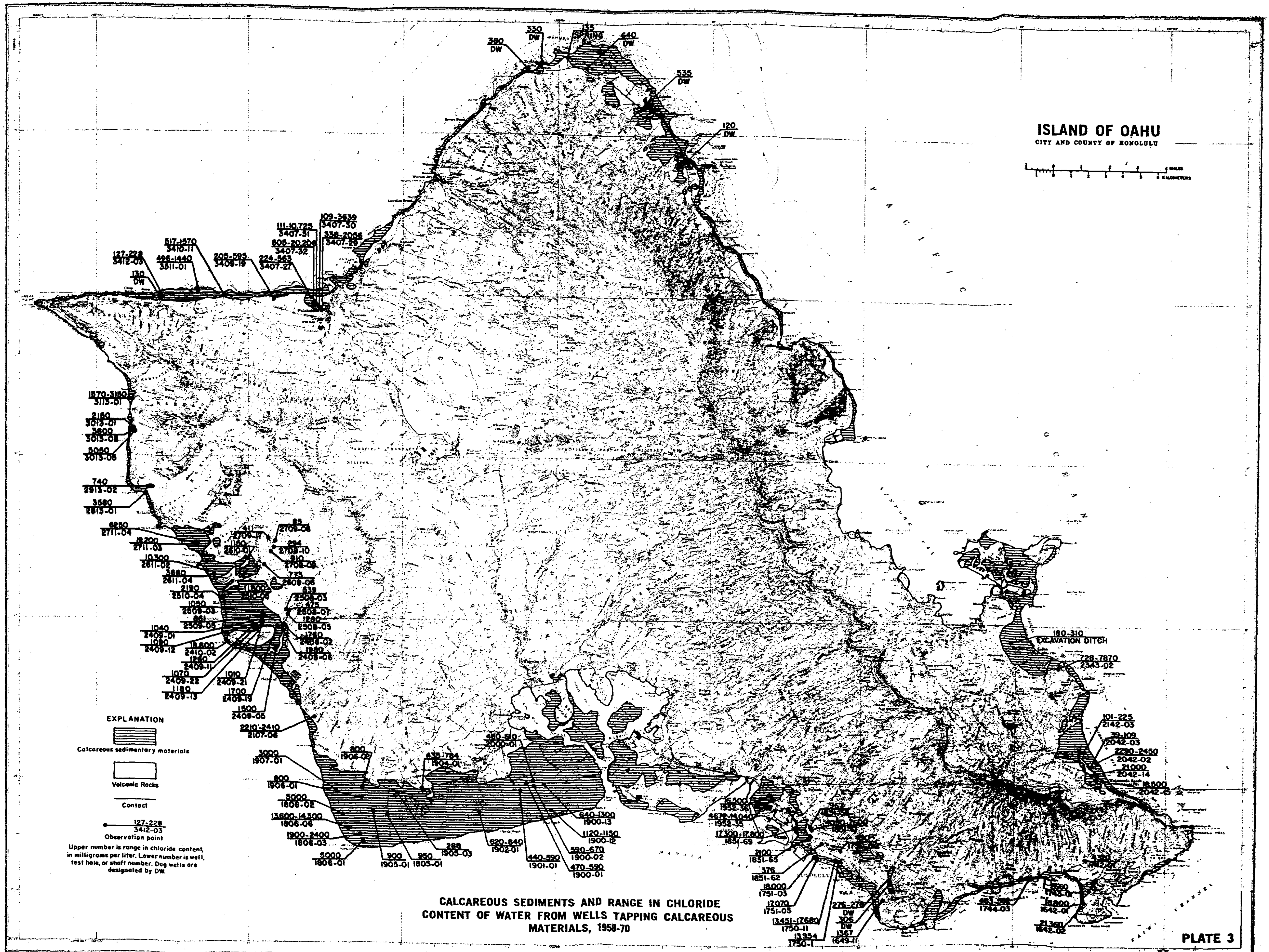
One distinctive characteristic common to all of these analyses is the high bicarbonate. Values range from 203 to 332 mg/l, which greatly exceeds that of sea water and indicates dissolution of the $CaCO_3$ rock.

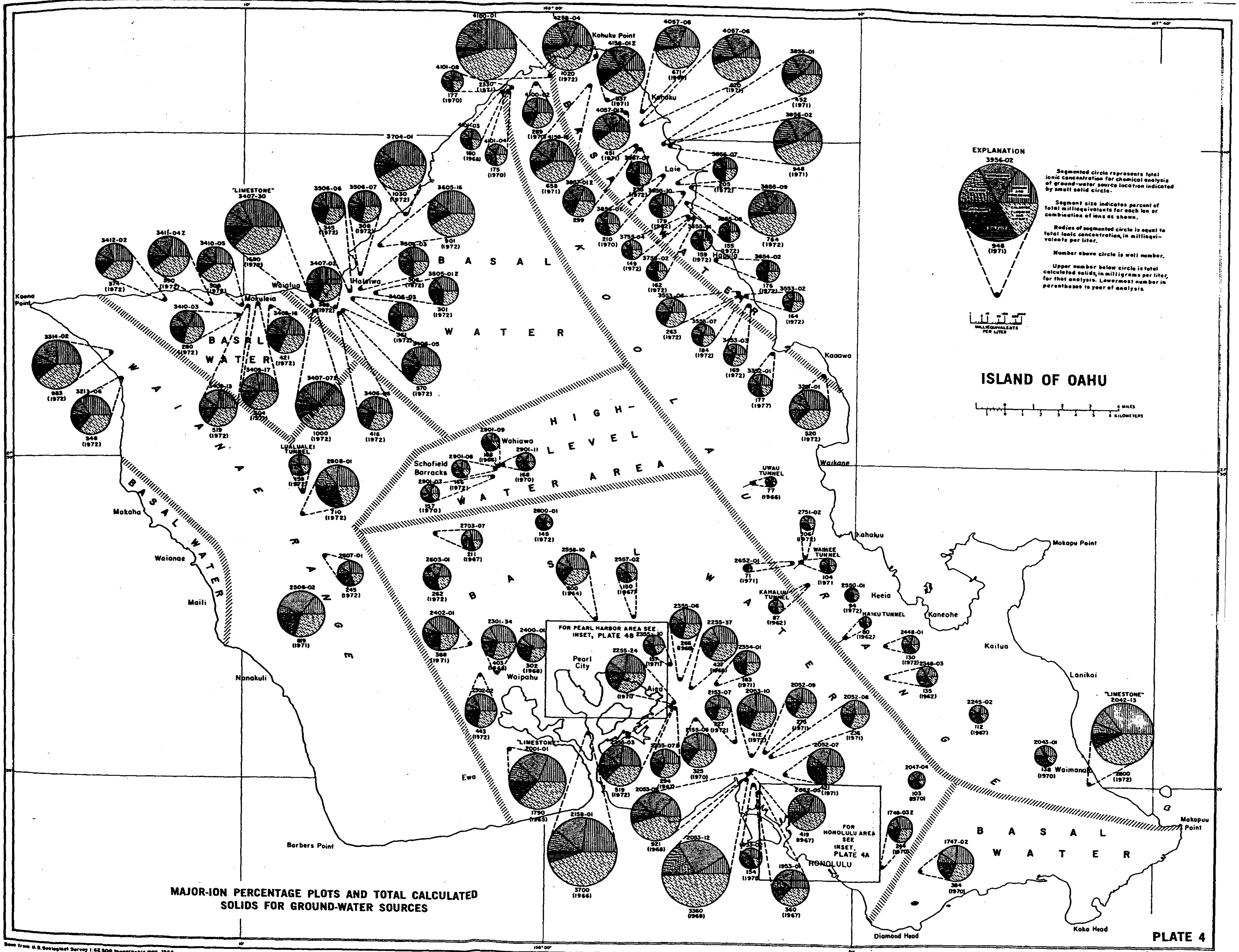
Water in the Volcanic Bedrock. The term "volcanic bedrock" for Oahu, as used in this report, applies only to rocks associated with the initial phase of mountain building, caldera collapse, and caldera filling. The rocks included are those of the Waianae, Kailua, and Koolau Volcanic Series, as described by Stearns and Vaksvik (1935). Rocks of the Honolulu Volcanic Series of the late Pleistocene and Holocene time constitute only a fraction of the total rock volume and are not included.

Most of Oahu's ground water occurs in the



NONCALCAREOUS SEDIMENTS AND RANGE IN CHLORIDE CONTENT OF WATER FROM WELLS TAPPING NONCALCAREOUS SEDIMENTARY MATERIALS, 1958-70

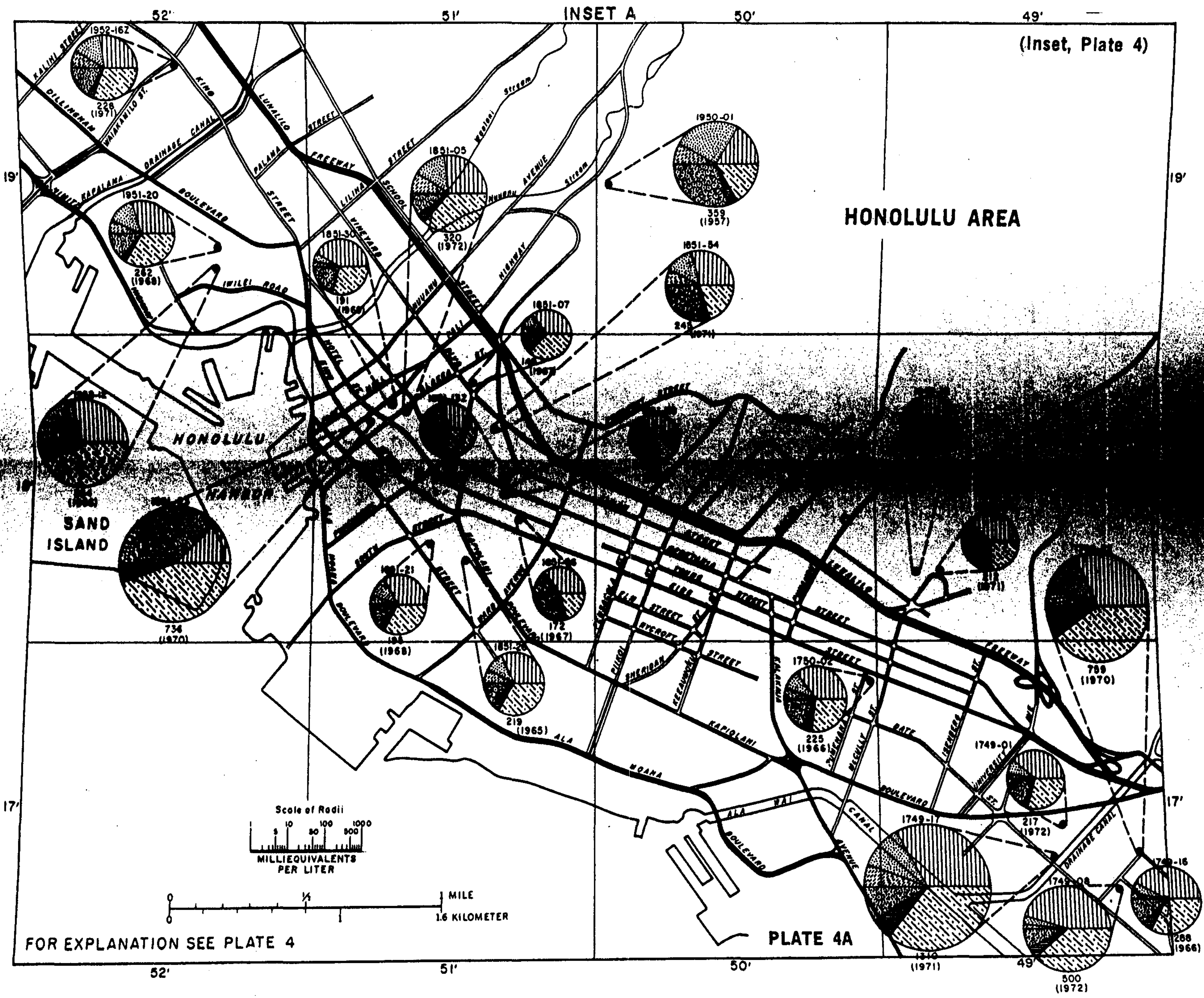

ISLAND OF OAHU
CITY AND COUNTY OF HONOLULU
EXPLANATION
Calcareous sedimentary materials
Volcanic Rocks
Contact
127-228
3412-03
Observation point
Upper number is range in chloride content, in milligrams per liter. Lower number is well, test hole, or shaft number. Dug wells are designated by DW.
180-310
EXCAVATION DITCH
CALCAREOUS SEDIMENTS AND RANGE IN CHLORIDE CONTENT OF WATER FROM WELLS TAPPING CALCAREOUS MATERIALS, 1958-70
PLATE 3
Base from U.S. Geological Survey base, 1954

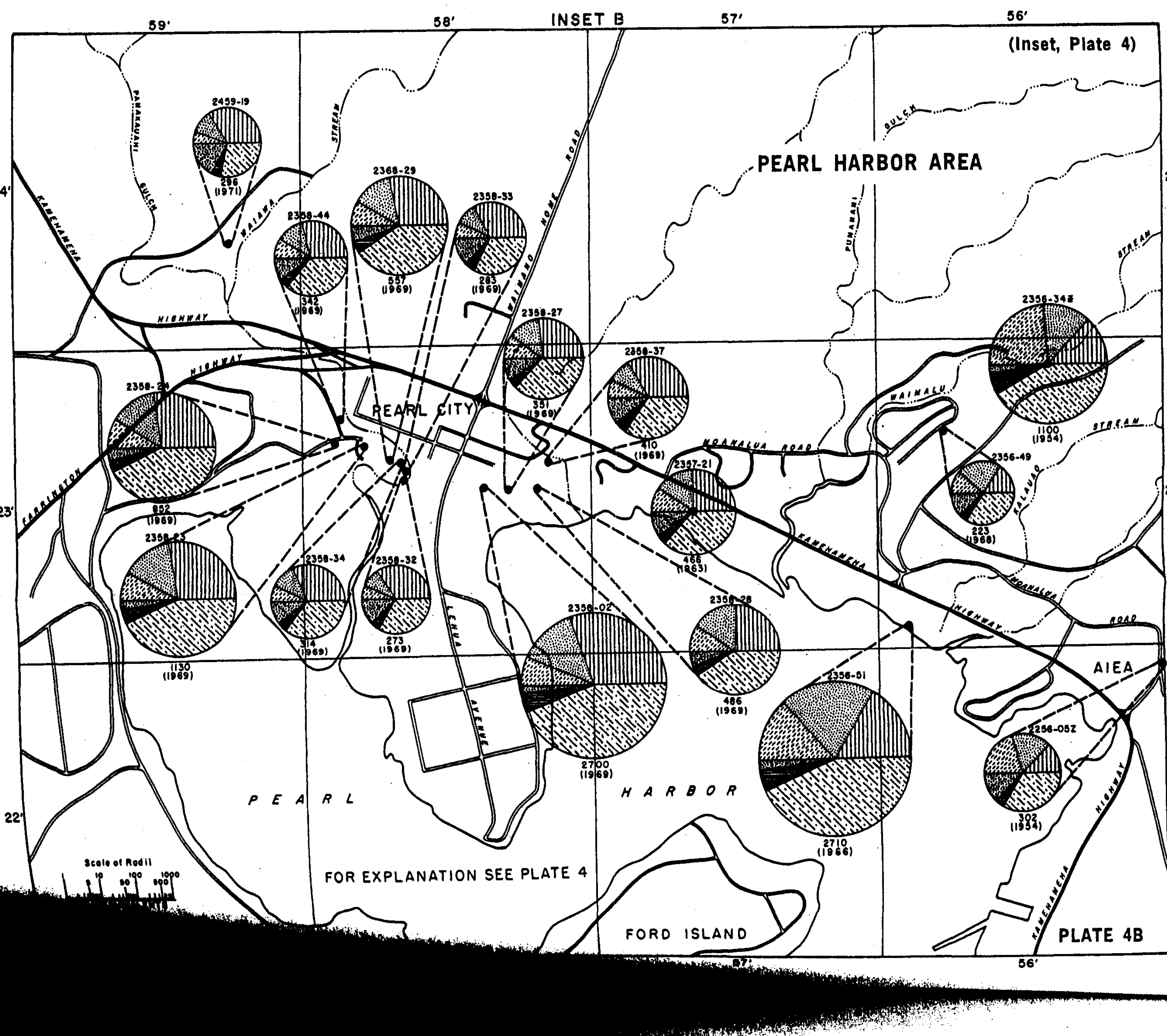


MAJOR-ION PERCENTAGE PLOTS AND TOTAL CALCULATED SOLIDS FOR GROUND-WATER SOURCES

PLATE 4

Compiled by L.A. Swain, 1973


INSET A
(Inset, Plate 4)
HONOLULU AREA
HONOLULU HARBOR
SAND ISLAND
Scale of Radii
MILLIEQUIVALENTS PER LITER
1 MILE
1.6 KILOMETER
FOR EXPLANATION SEE PLATE 4
PLATE 4A


INSET B
(Inset, Plate 4)
PEARL HARBOR AREA
PEARL CITY
AIEA
PEARL HARBOR
FORD ISLAND
Scale of Radii
FOR EXPLANATION SEE PLATE 4
PLATE 4B

volcanic bedrock as dike-impounded water in rift zones and as basal water outside the rift zones. Lava flows tend to be more thickly bedded and are dike-intruded within the rift zones, but outside the zones, lava flows are generally thin-bedded and dike-free.

Water-quality types of high-level water areas: As shown on plate 4, most of the water sources in Oahu's three high-level water areas (Koolau Range, Waianae Range, and the central plateau high-level water area) have quite similar chemical characteristics. Sea water is effectively barred from these areas by high fresh-water heads, by the dikes as impermeable boundaries, or by other impounding geologic structures. It appears that the chemical character of these waters is derived almost entirely from rainfall interacting only with the rocks within the areas. The water-quality type for all three areas is predominantly sodium magnesium bicarbonate, with very low concentrations of chloride and dissolved solids.

A few exceptions to these types exist on the northwestern edge of the Waianae Range, and in the northern coast of the Koolau Range. In these two areas, the water is affected by sea-water intrusion. The chemical character of the water in these areas is more like that of basal water than dike water.

One important area, with a water quality distinctively different from that of dike water, exists within the central portion of the Waianae Range. At two locations, wells 2508-02 and 2808-01, the water has a significantly greater dissolved-solid concentration than that of surrounding sources. The water for well 2508-02 is a sodium sulfate type, and that for well 2808-01 is a magnesium chloride type. These waters are markedly different from that found on any of the other islands. The anomalies may be related to a geothermal hot spot in this area. Water temperatures of 26.7°C for well 2808-01 at an elevation of 440 feet (134 meters) and 28.4°C for well 2508-02 at a lower elevation would tend to support this possibility.

Water-quality types of north-central basal-water area: The north-central area extends from the northeastern edge of the Waianae Range to the western edge of the Koolau Range north of the central plateau high-level water area. The basal water in this area can be subdivided into three subzones based on water levels and ground-water boundaries (Rosenau and others, 1971).

The westernmost third of the area has artesian water levels from 10 to 24 feet (3.0-7.3 meters) above mean sea level (msl), with a relatively thick caprock. The water in this area is either a sodium magnesium chloride type or a magnesium sodium chloride type. The dissolved-solids concentration ranges from 280-590 mg/l.

The middle subzone, with less caprock, has artesian water levels averaging about 11 to 13 feet (3.4-4.0 meters) above msl. The water in this area is a sodium chloride type. The sodium plus chloride concentrations in water in this subzone is between 50 and 75 percent of the total concentration of the major ions.

The subzone northeast of the valleyfill boundary has water-table conditions with water levels less than 5 feet (1.5 meters) above msl, and relatively little caprock. The two analyses for water in this subzone, shown on plate 4, have greater than 900 mg/l dissolved-solids concentrations. The water is also a sodium chloride type but the sodium plus chloride concentration is greater than 75 percent of the total ion concentration.

Water-quality types of the Kahuku basal-water area: The Kahuku basal-water area is located along the northeastern edge of the Koolau Range. Although there is no absolute ground-water boundary to separate them, two distinct water-quality types are evident.

The southernmost half of the area has artesian water levels from 18 to 22 feet (5.5-6.7 meters) above msl because of an alluvial caprock. The water in this area is primarily a sodium magnesium chloride type. The dissolved-solids concentration of these waters is less than 235 mg/l.

The northern half of the area has extensive calcareous deposits both in the upland recharge areas and intermixed with alluvial caprock. Ground water in this area has considerably greater dissolved-solids concentration than that in the southern section. The water here is mainly a magnesium calcium chloride type. There appears to be extensive cation exchange present. The high pumpage rates and varied geology of this area definitely affect the water quality.

Water-quality types of the southern Oahu basal-water area: The numerous analyses from greatly varying depths and hydrologic conditions make it difficult to generalize as to water-quality types in the southern Oahu area.

However, the dissolved-solids concentrations of water samples from the Honolulu area are less than in the Pearl Harbor area (insets, plates 4A and 4B). In addition, the ground water of the Honolulu area is primarily a sodium chloride type, while those waters of other areas show a greater variation in water types. Despite these variations, chloride is by far the major anion in all water analyses from these areas.

Mink (1961) pointed out that cation exchange is a very dominant process in the ground waters of the southern Oahu basal-water area. As shown in figure 1, the cation-exchange process in the Pearl Harbor area exhibits an interesting trend with depth. This trend is toward increased per-

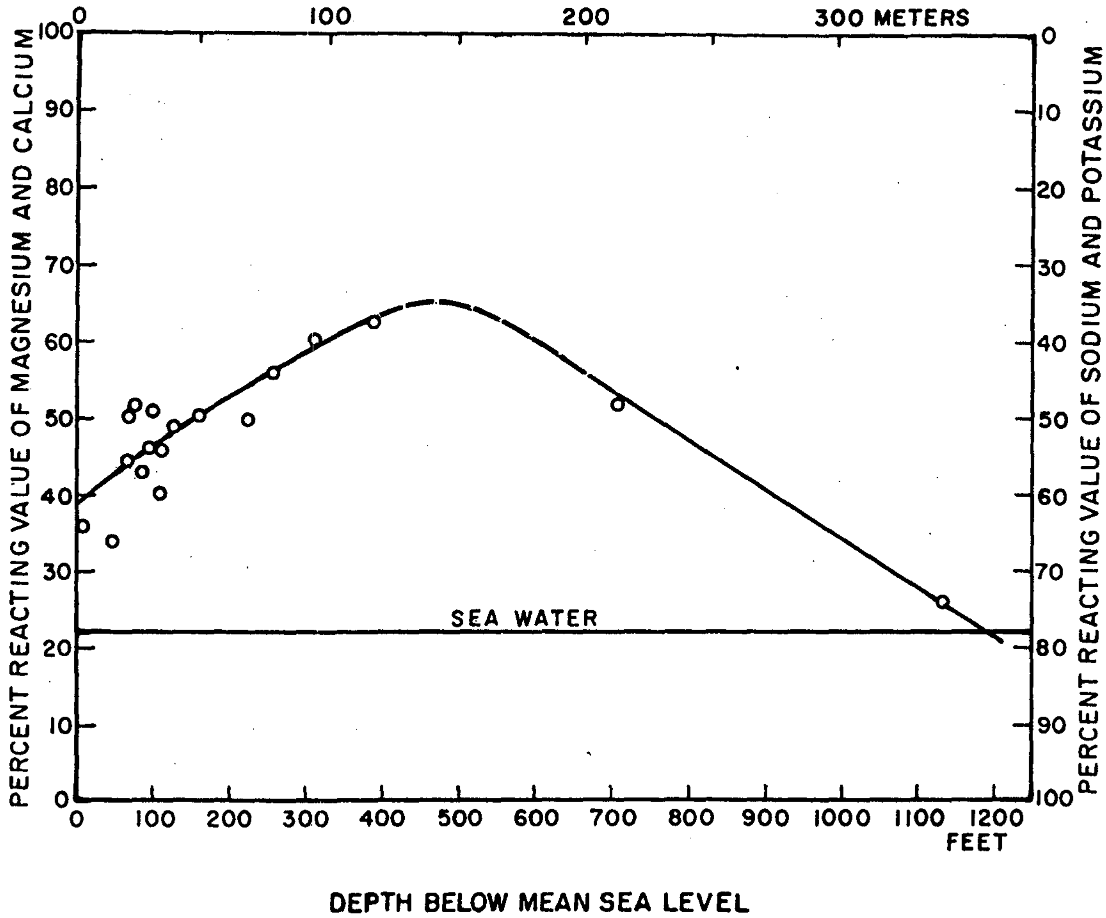


Figure 1. Depth and percent-reacting values for the Pearl Harbor area.

centages of calcium and magnesium down to a certain depth in the aquifer, where the trend reverses and the percentage of sodium then increases with depth.

Maximum and Minimum Chloride Levels in the Volcanic Bedrock Aquifer. Except where retarded by dikes, caprock, or artesian pressure, sea water freely intrudes Oahu's permeable lavas. The rate of sea-water intrusion is generally greatest in areas of significant ground-water development and heavy pumping.

Ground water is heavily developed from basal-water sources in the Honolulu, Pearl Harbor, and Waialua areas. Until the end of 1971 when sugarcane cultivation ceased, it was also heavily developed in the Kahuku area. Dike-impounded water is developed in windward Oahu, in the Schofield area, and in the Waianae area. Draft is steady in the Honolulu area during the normally wet months of October to March each year, increasing by about a third during the rest of the normally dry months. Draft in the Pearl Harbor area is heavy from about April to October each year during the sugarcane-irrigation period. The draft decreases by about 75 percent during the wet months of October to March, when sugarcane is not irrigated. In the predominantly agricultural areas of Kahuku (before 1972) and of Waialua, draft is reduced by more than 95 percent during the nonirrigation period.

Plate 5 shows minimum chloride levels for both the high-level and basal-water aquifers, mostly for the 1968-70 period. In a few instances where information was not available for this period, earlier data are included.

Plate 6 was prepared to depict areas where a significant change in chloride content of the water occurs as a result of sea-water intrusion induced by pumpage. This map shows the maximum chloride-content levels for the same sources and same period as shown on the map for the minimum chloride-content levels (plate 5). Inland movement of intruding sea water is shown by the changing position of the isochlors on the two maps. However, even though these data show great increases in chlorinity as a result of pumpage in agricultural areas, during periods of nonirrigation the water of the aquifers will be somewhat freshened on an annual cycle by recharge from rainfall.

Chloride Content by Depth Within the Volcanic Aquifer. The maximum and minimum chlorinity maps indicate that sea water intrudes laterally inland. However, water quality in a Ghyben-Herzberg lens is gradational from fresh to salt water in a vertical direction through a zone of transition. Thus, a knowledge of sampling depths is fundamental to understanding the mechanics and degree of sea-water intrusion in the artesian basal-water system. Although limited in precision and quantity, more depth information is available for Oahu than for the other islands. The data, where available, show where pumping has caused upconing and mixing of the higher-chloride waters in the areas of draft.

The map of plate 7 shows lines of equal depth to the 250-mg/l chloride-content level, developed from depth-salinity relations of water from deep wells. Where sufficient data are available, depth-salinity curves are shown for selected one-minute rectangles. The lines of equal depth and the depth-salinity curves show generally the areas where the fresh-water lens is thickest and where it has been reduced by upward movement of the transition zone.

The contours and curves shown on plate 7 are preliminary and are, in some areas, prepared from very limited data because, heretofore, depth-oriented sampling has been little stressed. The preliminary data may, however, facilitate planning of a network of observation wells needed to better define movement of the salt-water body into the aquifers.

As shown, the basal water beneath Honolulu has less than 250-mg/l chloride, and is more than 1,000 feet (305 meters) thick in areas where the water level is 28 feet (8.5 meters) or more above mean sea level. The effects of mixing by pumping and tidal fluctuation, causing upward movement of the salt-water body, are quite apparent in the Pearl Harbor area. Even though the water-level elevation is only about 10 feet (3.0 meters) less than that in Honolulu, water fresher than 250 mg/l is generally less than 250 feet (76 meters) thick. In the southern part of Pearl Harbor, and in areas of Kahuku, the entire ground-water body has a chlorinity greater than 250 mg/l.

The depth-salinity curve for the one-minute rectangle identified by 3406 in north-central Oahu shows a significant decrease in chlorinity with depth in the upper part of the basal lens. This phenomenon, although not as marked as in north-central Oahu, is also common in the Pearl Harbor and Kahuku areas. It results from irrigation with water higher in chlorinity than the underlying ground-water body. Infiltration of this water creates a reverse salinity gradient above the normal salinity gradient from underlying saline water.

Nitrate Levels. Nitrate concentrations above 1.1 mg/l indicate other than natural conditions. Study of the levels of nitrate in ground waters is, therefore, useful to delineate areas where man has affected water quality. Although sewage effluent may have a localized effect, the major source of widespread and significant levels of nitrate on Oahu is fertilizers in irrigation return water.

Figure 2 shows areas of Oahu where information on nitrate levels is available. The map shows that the areas of lowest nitrate concentrations exist where man has had little effect upon the landscape, such as in the steep Koolau Range. The areas of greatest nitrate concentrations correlate well with known areas of irrigation.

Nitrate concentrations are greatest at the land surface and decrease with depth below irrigated areas. Thus, the values shown on the map, which were from greatly varied depths, show only areas of relative concentration and the exact concentrations within any area may have great variation.

Although the "greater than 8.0 mg/l" class does not indicate an upper limit to the nitrate concentration, nearly all samples within this class range from 8 to 10 mg/l. However, two samples from shallow depths have high enough nitrate concentrations to warrant specific mention. One sample with a concentration of 19 mg/l was from calcareous deposits in the Ewa plain of southwestern Oahu. The other sample, also from calcareous deposits, was from a well in Waimanalo. This sample had a nitrate concentration of 26 mg/l.

Calcareous Deposits in Kahuku Area. As mentioned previously, the fundamental factors controlling the chemical character of basal waters in the Kahuku area are high draft rates and cation exchange. However, extensive exposures of calcareous deposits in upland and recharge areas also directly affect the quality of fresh water in the basal lens. This is shown by the ratios of calcium to chloride for those waters with less than 250-mg/l chloride, and by comparing the Kahuku values with other areas lacking these deposits in their recharge areas. Figure 3 shows that the ratios in the Kahuku area are significantly greater than in other areas.

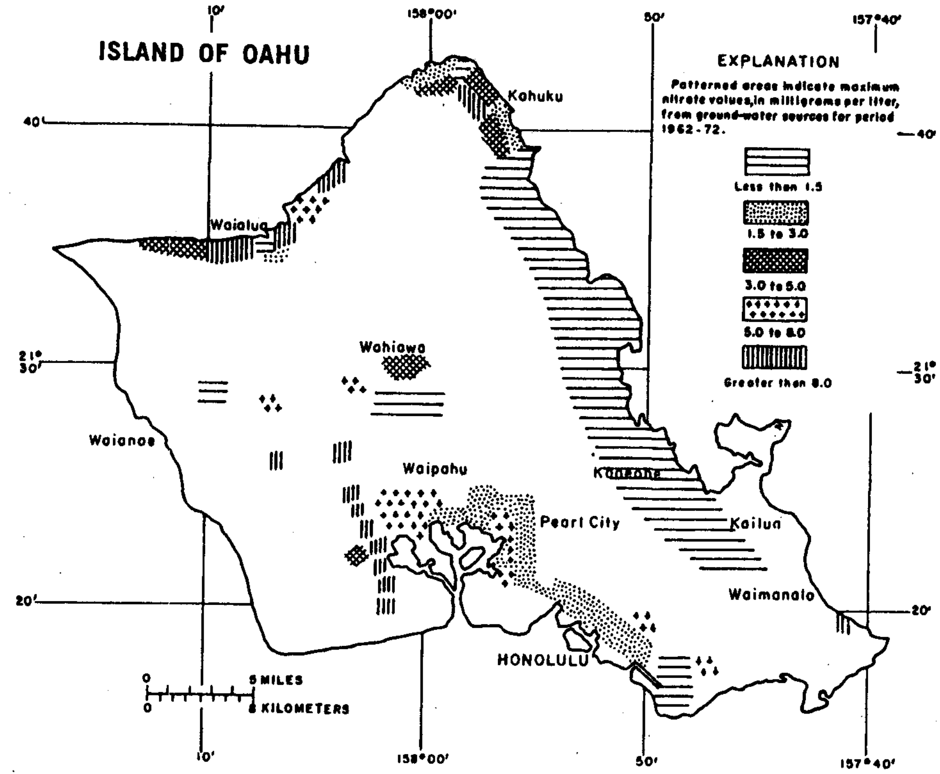


Figure 2. Maximum nitrate values for ground waters, 1962-72.

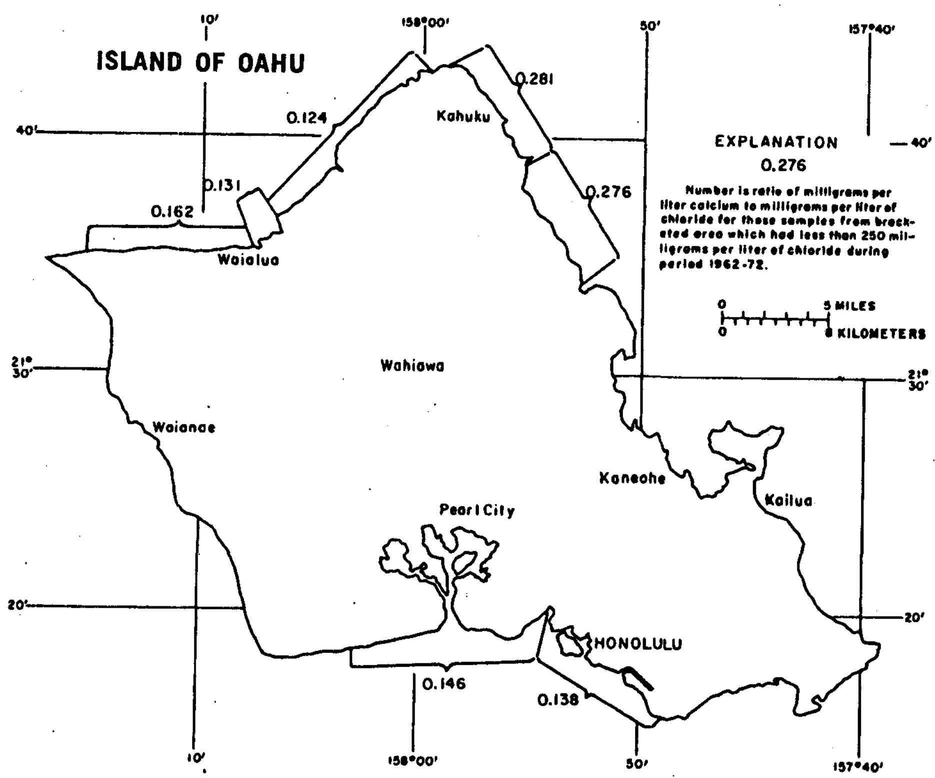
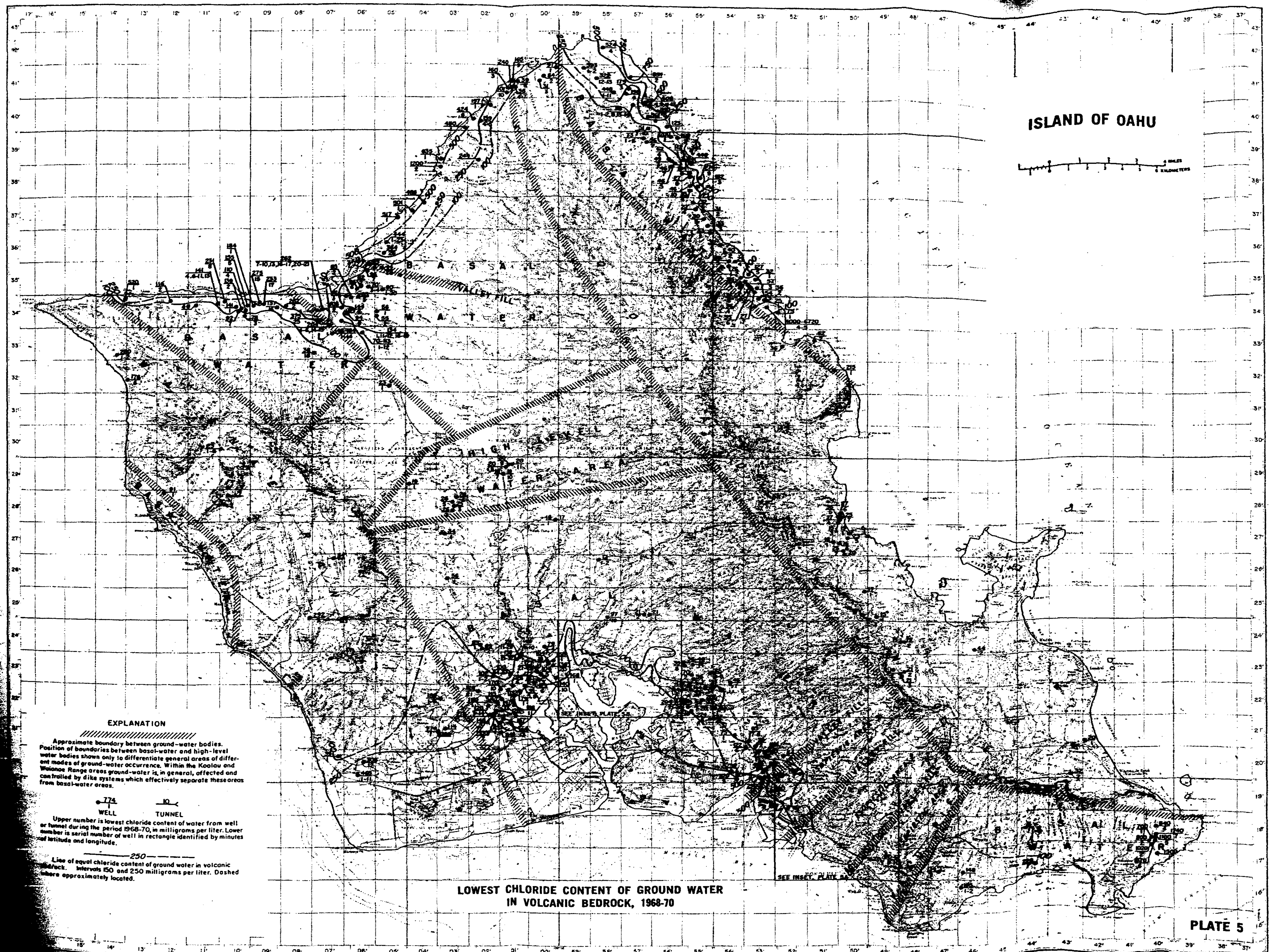
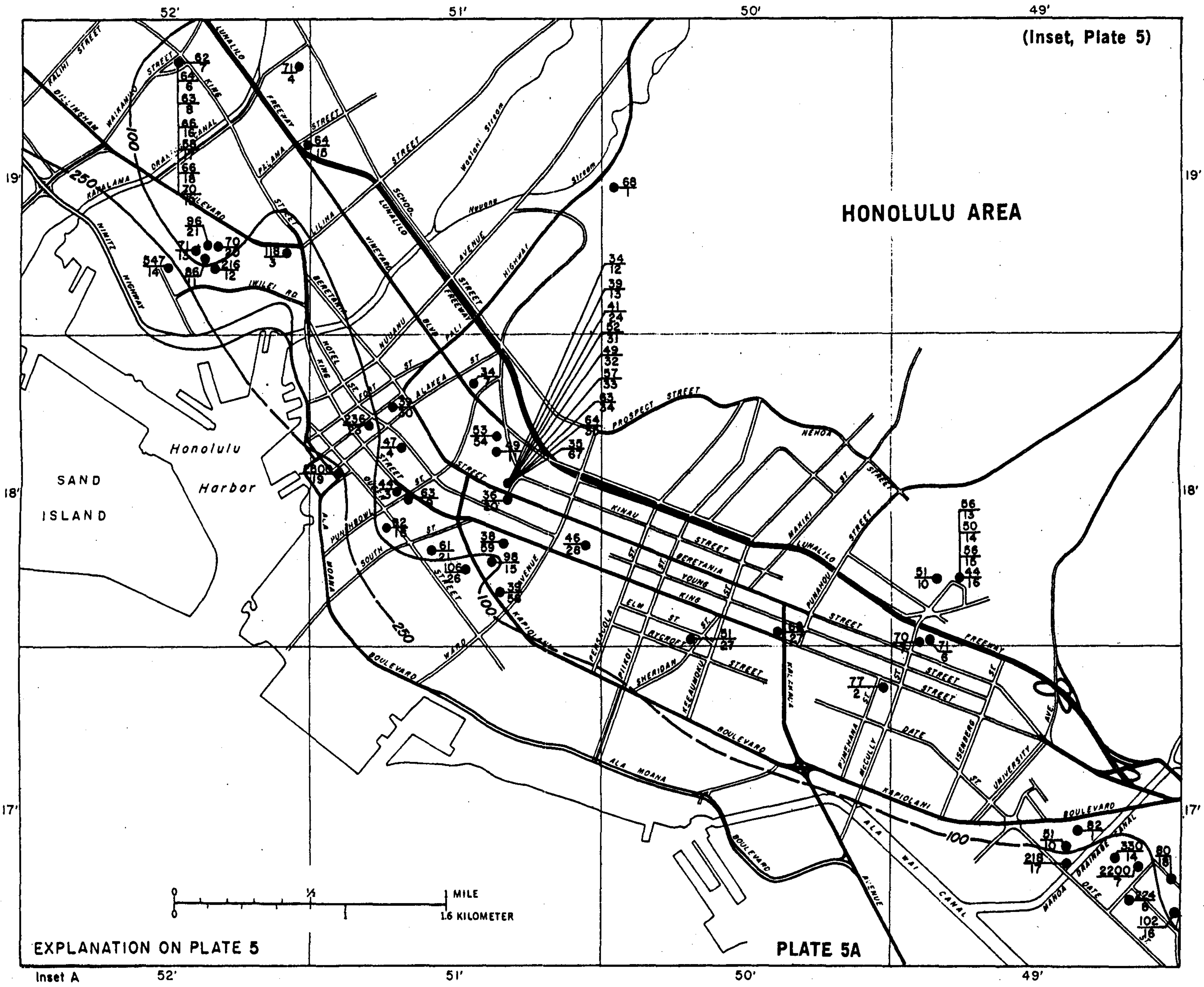


Figure 3. Average calcium to chloride ratios for fresh ground water 1962-72.

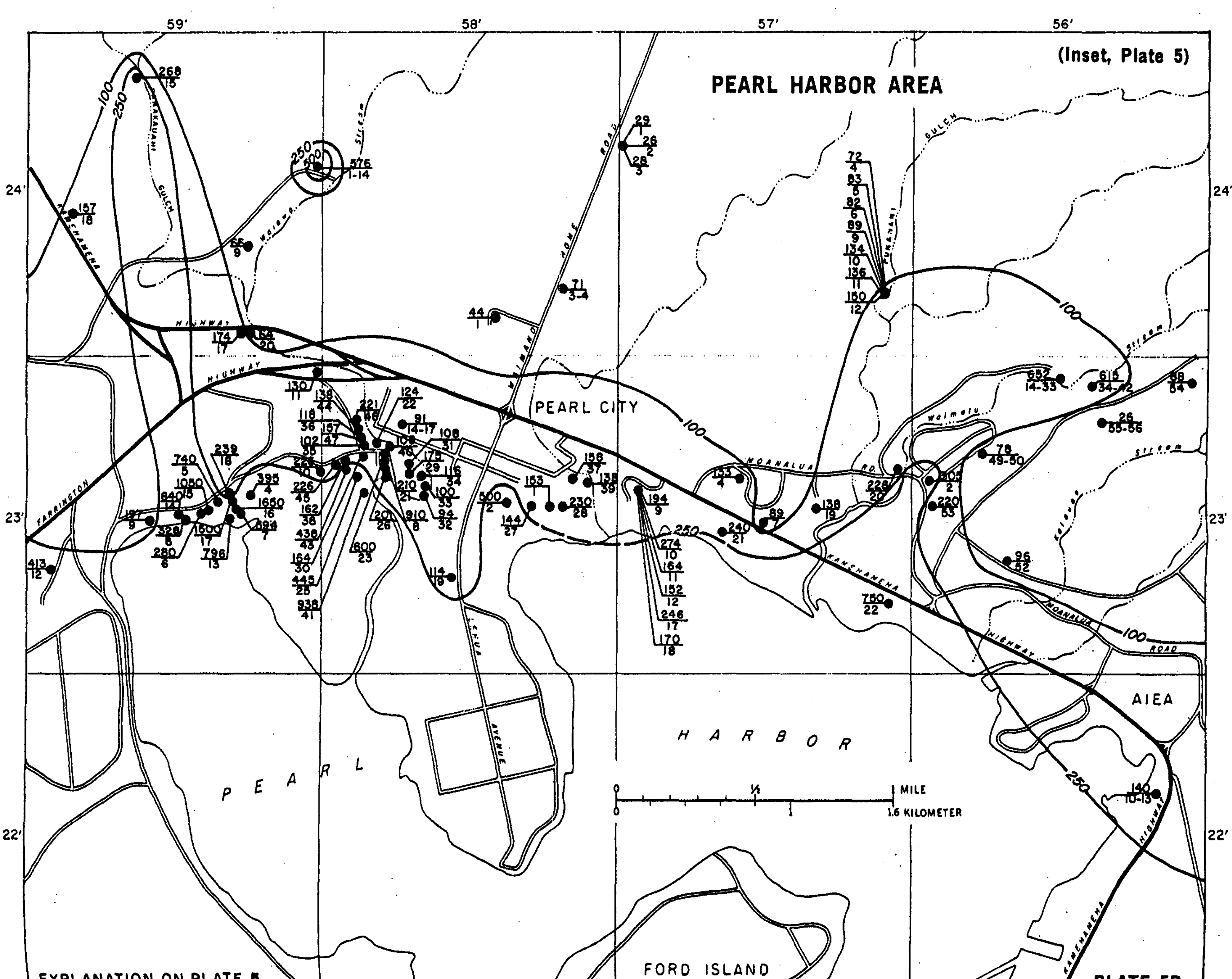


LOWEST CHLORIDE CONTENT OF GROUND WATER IN VOLCANIC BEDROCK, 1968-70

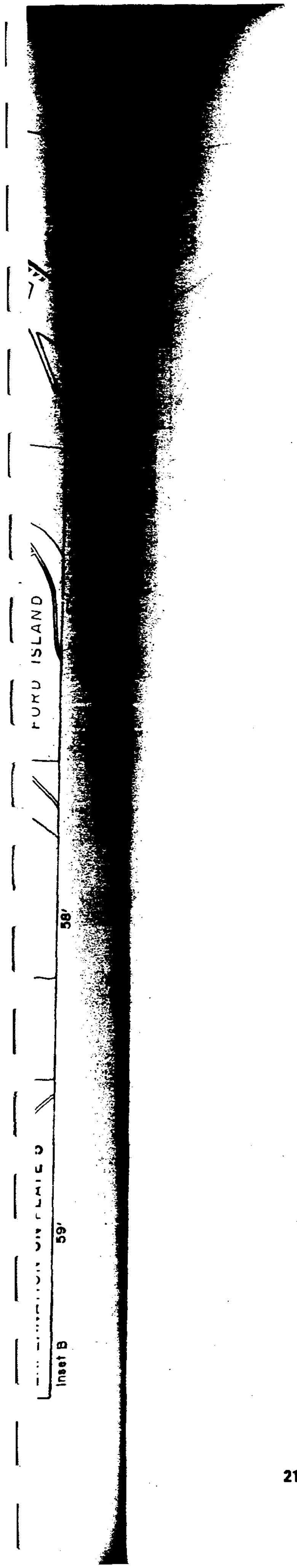
PLATE 5

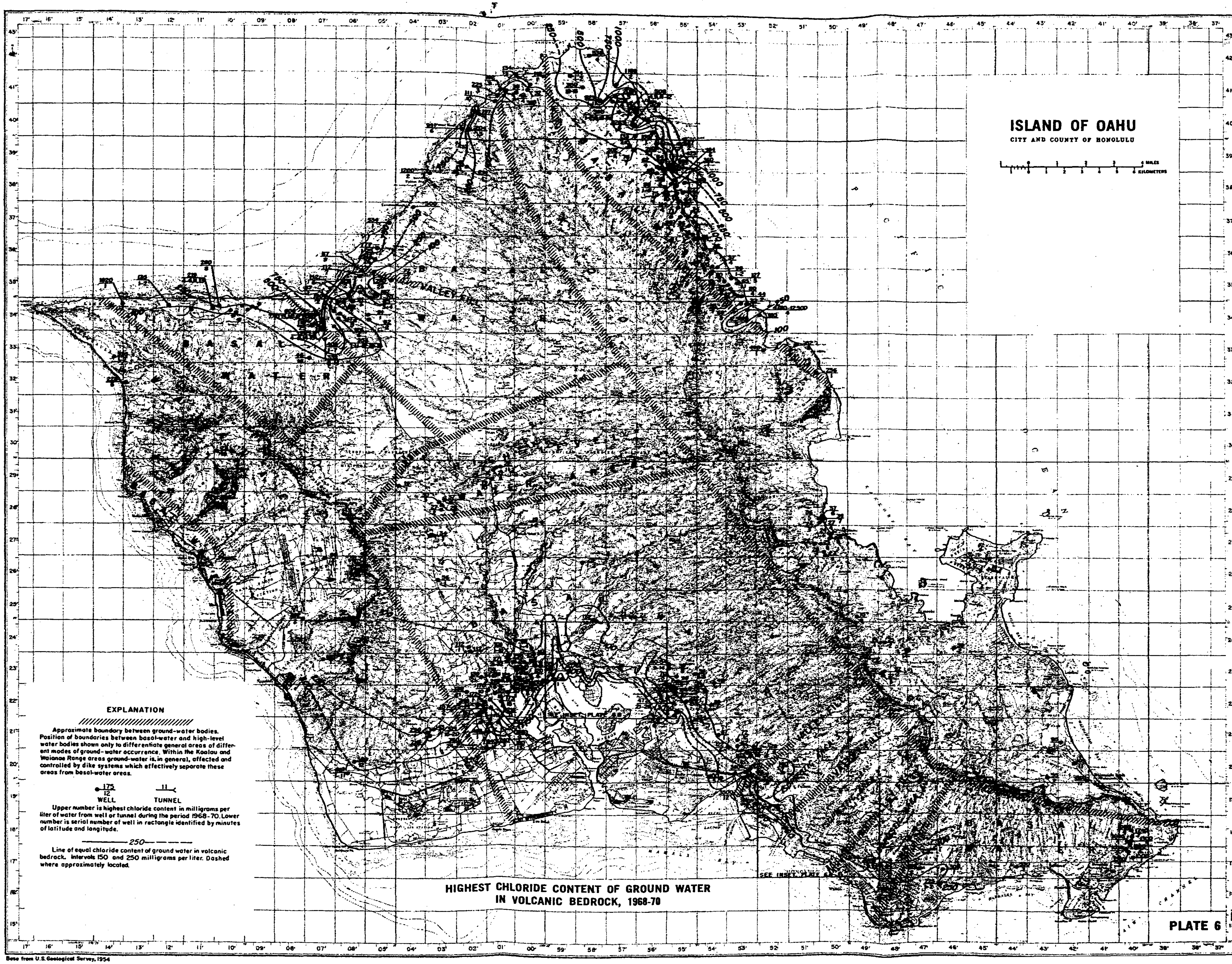


(Inset, Plate 5)
HONOLULU AREA
SAND ISLAND
Honolulu Harbor
PROSPECT STREET
KAPIOLANI
ALA MOANA
ALA WAI CANAL
FREEWAY
1 MILE
1.6 KILOMETER
EXPLANATION ON PLATE 5
PLATE 5A
Inset A
52'
51'
50'
49'
19'
18'
17'



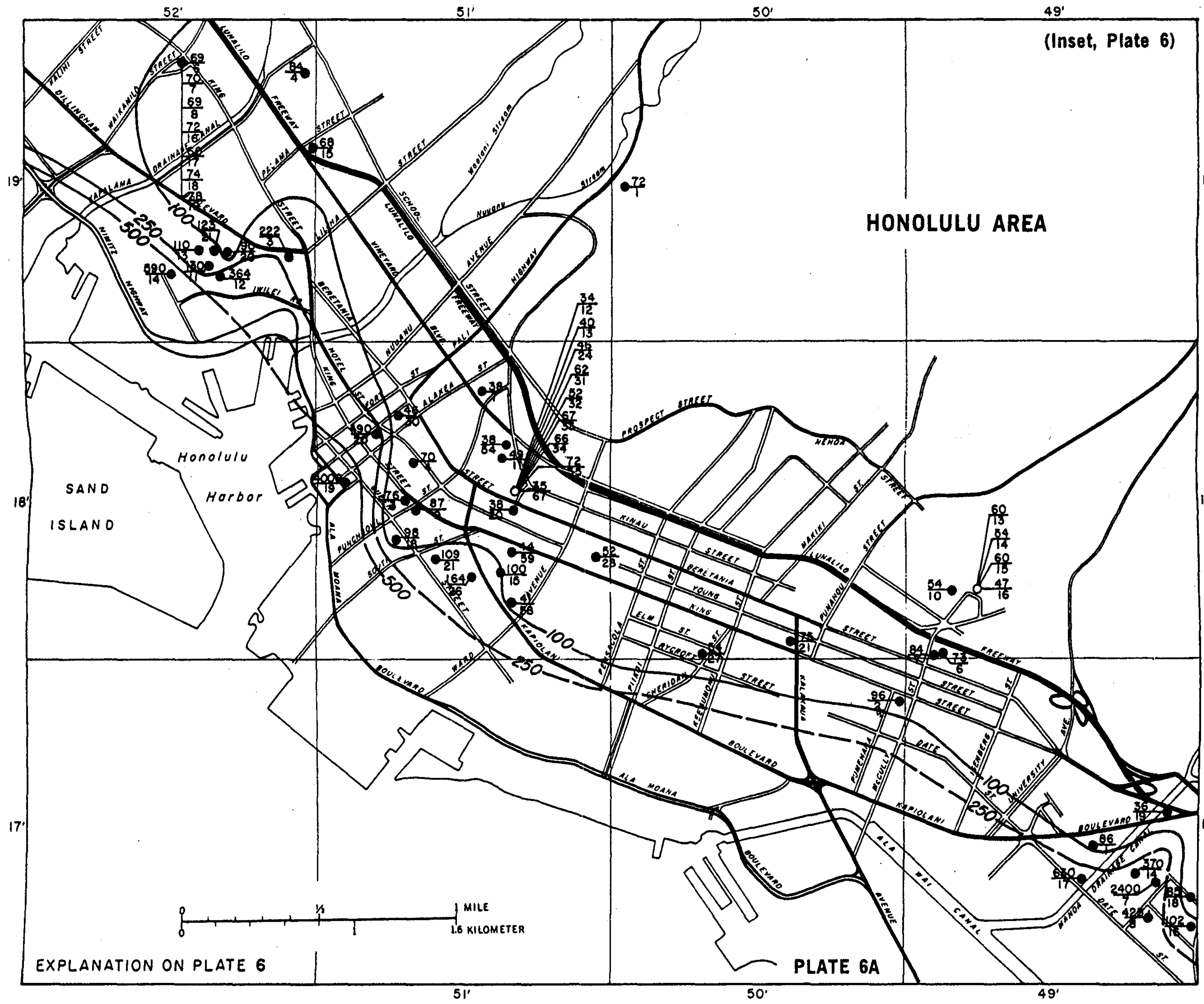
(Inset, Plate 5)
PEARL HARBOR AREA
PEARL CITY
AIEA
PEARL
HARBOR
FORD ISLAND
KAMEHAMEHA HIGHWAY
MOANALUA ROAD
1 MILE
1.6 KILOMETER
EXPLANATION ON PLATE 5
PLATE 5B
Inset B
59'
58'
57'
56'
24'
23'
22'

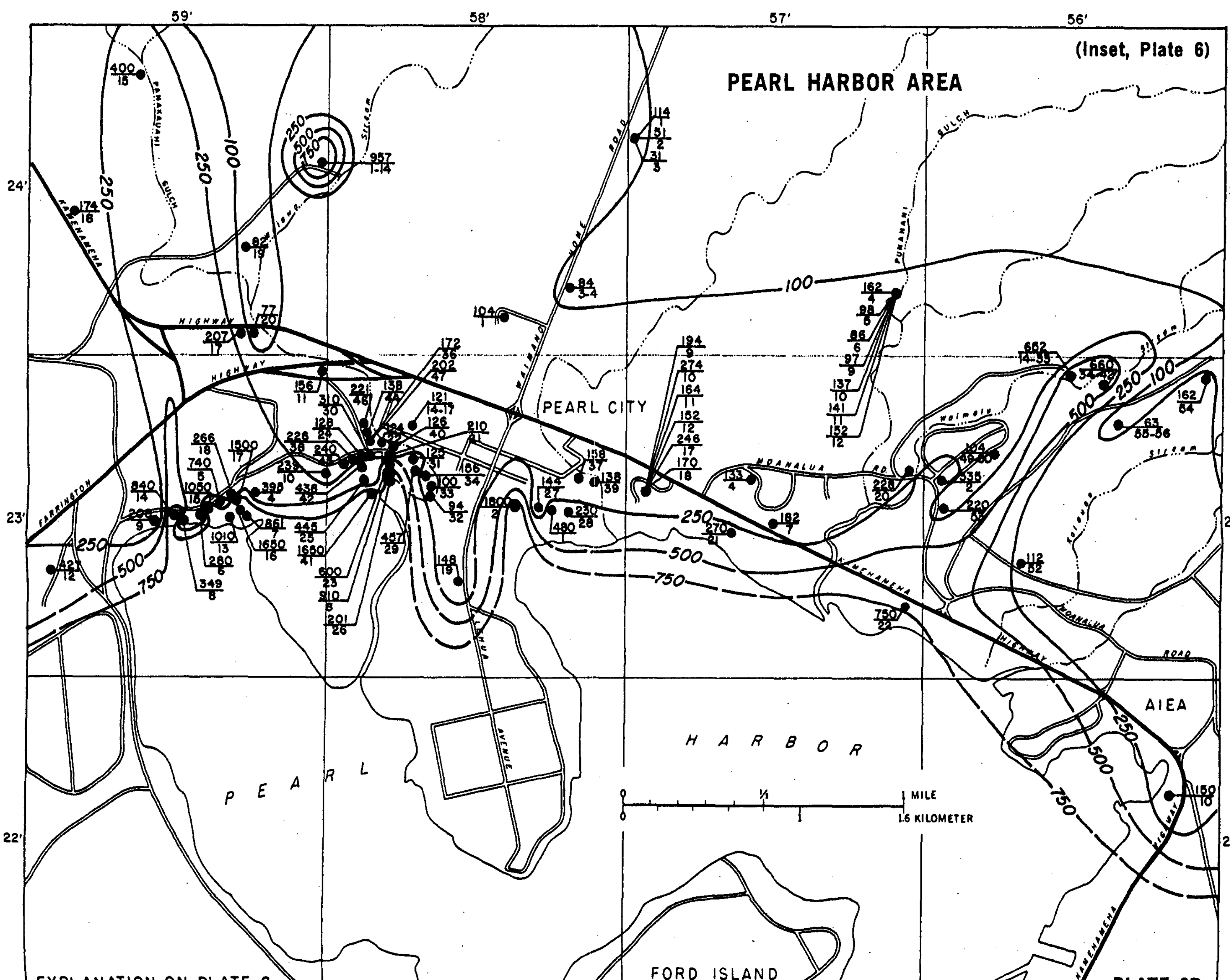


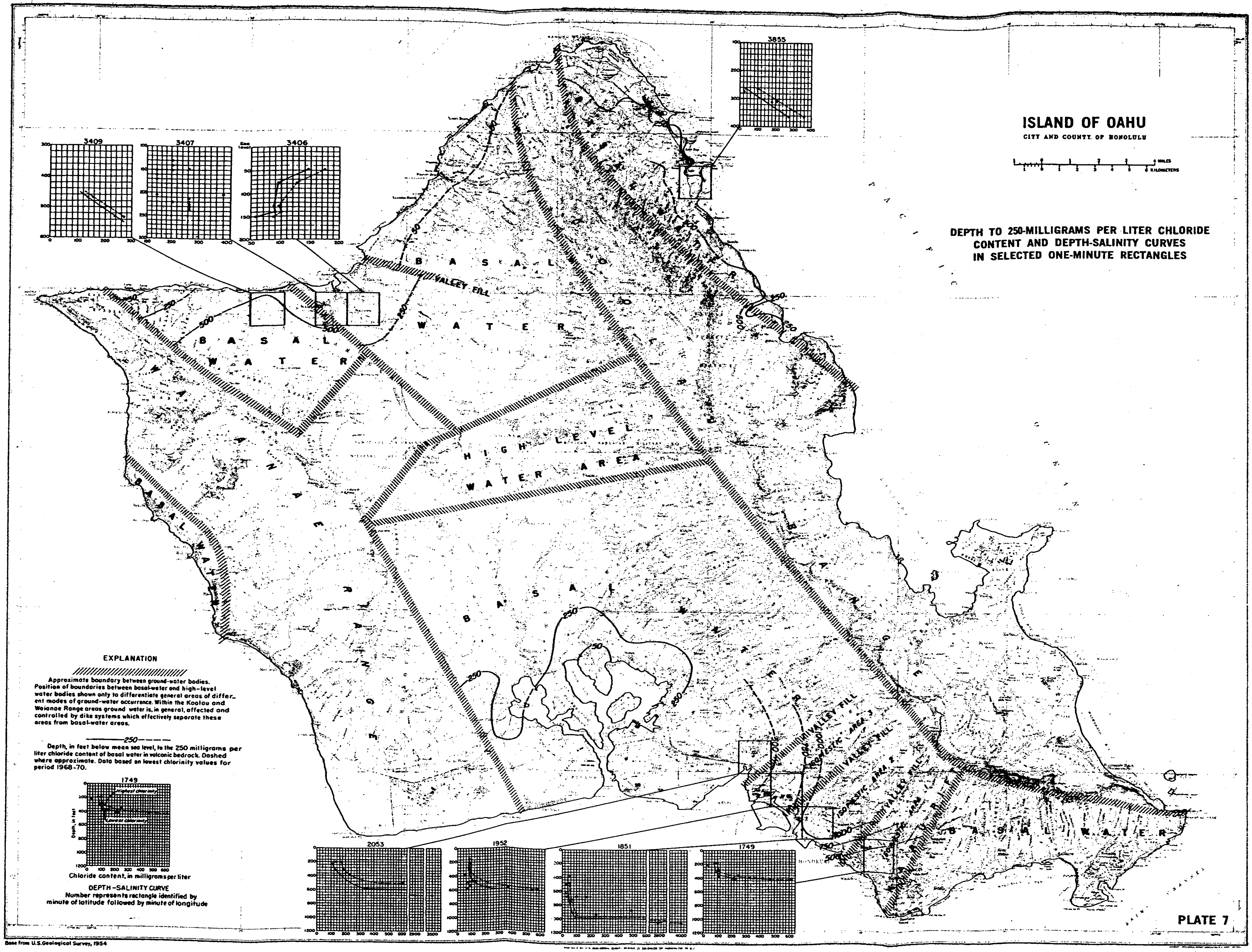


HIGHEST CHLORIDE CONTENT OF GROUND WATER IN VOLCANIC BEDROCK, 1968-70

PLATE 6


(Inset, Plate 6)
HONOLULU AREA
Honolulu Harbor
SAND ISLAND
0 ½ 1 MILE
0 1 1.6 KILOMETER
EXPLANATION ON PLATE 6
PLATE 6A


(Inset, Plate 6)
PEARL HARBOR AREA
PEARL CITY
AIEA
P E A R L
H A R B O R
FORD ISLAND
0 ½ 1 MILE
0 1 1.6 KILOMETER
EXPLANATION ON PLATE 6
PLATE 6B


ISLAND OF OAHU
CITY AND COUNTY OF HONOLULU
DEPTH TO 250-MILLIGRAMS PER LITER CHLORIDE CONTENT AND DEPTH-SALINITY CURVES IN SELECTED ONE-MINUTE RECTANGLES
PLATE 7
EXPLANATION
Approximate boundary between ground-water bodies. Position of boundaries between basal-water and high-level water bodies shown only to differentiate general areas of different modes of ground-water occurrence. Within the Koolau and Waianae Range areas ground water is, in general, affected and controlled by dike systems which effectively separate these areas from basal-water areas.
250
Depth, in feet below mean sea level, to the 250 milligrams per liter chloride content of basal water in volcanic bedrock. Dashed where approximate. Data based on lowest chlorinity values for period 1968-70.
1749
Depth, in feet
Chloride content, in milligrams per liter
DEPTH-SALINITY CURVE
Number represents rectangle identified by minute of latitude followed by minute of longitude
3409
3407
3406
3855
2053
1952
1851
1749
BASAL WATER
VALLEY FILL
HIGH-LEVEL WATER AREA
WAIANAE RANGE
KOOLAU RANGE
PACIFIC OCEAN
Base from U.S. Geological Survey, 1954

PLATEAU
FORD ISLAND
EXPLANATION ON PLATE 6

MOLOKAI

Molokai, smallest of the five major islands, is composed of two volcanic mountains interconnected by a central plateau. The lavas are principally basaltic with areas of eastern and central Molokai overlain by andesite and even some trachyte (Stearns and Macdonald, 1947). Annual rainfall has great areal variability, so that western and central Molokai receive from 15-30 inches (38-76 centimeters) annually, while eastern Molokai receives from 30-250 inches (76-635 centimeters) each year, depending upon elevation. As determined by geologic features, ground water occurs as perched, dike-impounded, or basal water.

Ground-Water Zones. Perched water occurs primarily on the western slope of eastern Molokai. Here, ground water is perched by nearly impermeable ash flows within the permeable volcanics. Discharge from springs and tunnels tapping this zone fluctuates greatly. Unfortunately, only limited chemical data are available for these water sources.

Dike-impounded waters occur principally in a zone approximately 2 miles (3.2 kilometers) wide located in the higher-elevation areas of eastern Molokai, as shown on plate 8. In this area, the nearly impermeable, almost vertical dikes form a honeycomb structure of subsurface reservoirs. At the peak of the mountain formed by this resistant rock unit, rainfall is greatest of anywhere on the island.

The basal-water zone underlies almost the entire island, except for possibly beneath the rift zones. Because of greater rainfall, the freshwater lens of eastern Molokai has developed a far greater thickness than in the western or central parts of the island. Low-permeability sedimentary caprock retards flow of fresh ground water to the sea in the southern parts of eastern Molokai, causing further thickening of the lens.

Numerous shallow drilled wells and shafts acquire water from the volcanic basal aquifer in the southern coastal area of eastern Molokai, and many shallow dug wells tap the sedimentary caprock for a water supply.

Water Quality by Area. Only seven complete chemical analyses of ground water on Molokai were available for this study. The water sampled was from varied sources over a great period of time, which makes it difficult to show meaningful areal or change-with-time comparisons among the data. However, numerous and more current chloride data supply a large amount of information for areas deficient in more detailed analyses.

In general, the ground water of the eastern section of the island is of good quality and is only slightly affected by sea-water intrusion in the southern basal aquifer. In contrast, the water of the western and central parts of Molokai shows a large increase in chloride and dissolved-solids concentration over that of the south, with a predominant influence of intruded sea water (see plate 8).

The one complete analysis of dike zone water shown on plate 8 is a sodium calcium bicarbonate type water. This water has a similar chemical composition to the dike waters of the other islands. One distinct difference is the sulfate concentration, which is three to six times greater than in other dike waters. This may be the result of a reducing environment in the swamps upgradient from the well, but the exact origin is not known.

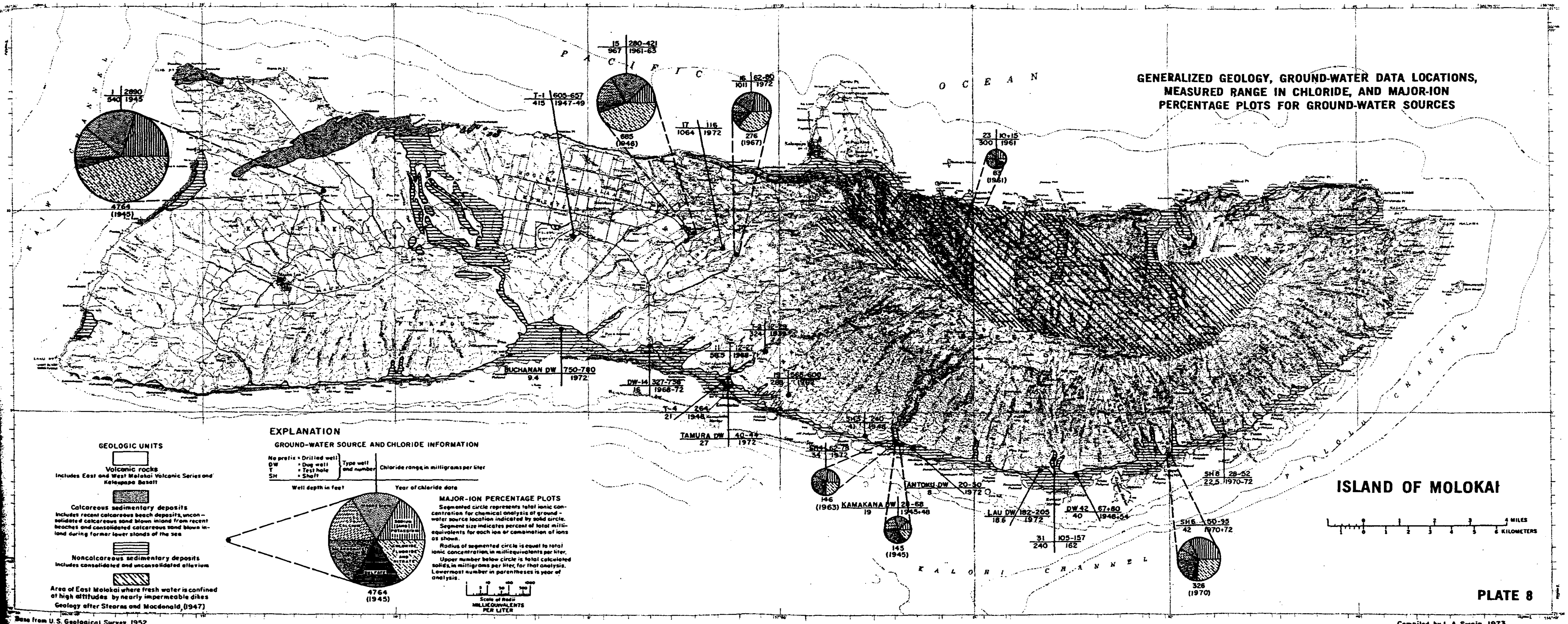
The basal water in the volcanic and sedimentary deposits in the southern coastal area of eastern Molokai has a relatively low chloride concentration. In addition, it does not exceed drinking water limitations for any chemical parameters measured. Waters in the volcanic aquifer from shafts 4 and 6 are sodium magnesium chloride bicarbonate and sodium chloride types, respectively. The variations in dissolved-solids concentrations and water-quality types for these sources may be a result of greater recharge to shaft 4 from streamflow infiltration from Kawela Stream.

The one chemical analysis from a shallow dug well in the sedimentary aquifer shows a dissolved-solids concentration similar to the water from shaft 4. The water from the dug well, however, is a calcium magnesium bicarbonate type.

The great increase of chloride concentrations from less than 100 mg/l in eastern Molokai to greater than 2,800 mg/l in western Molokai vividly shows the thinness of the fresh-water lens and the greater saline-water intrusion in the western and central sections of the island.

The three chemical analyses for western and central Molokai show the water to be of two types. They are either sodium magnesium chloride or magnesium calcium chloride types. Of these sources, only the water from well 16 has chloride and dissolved-solids concentration within the limits for drinking water.

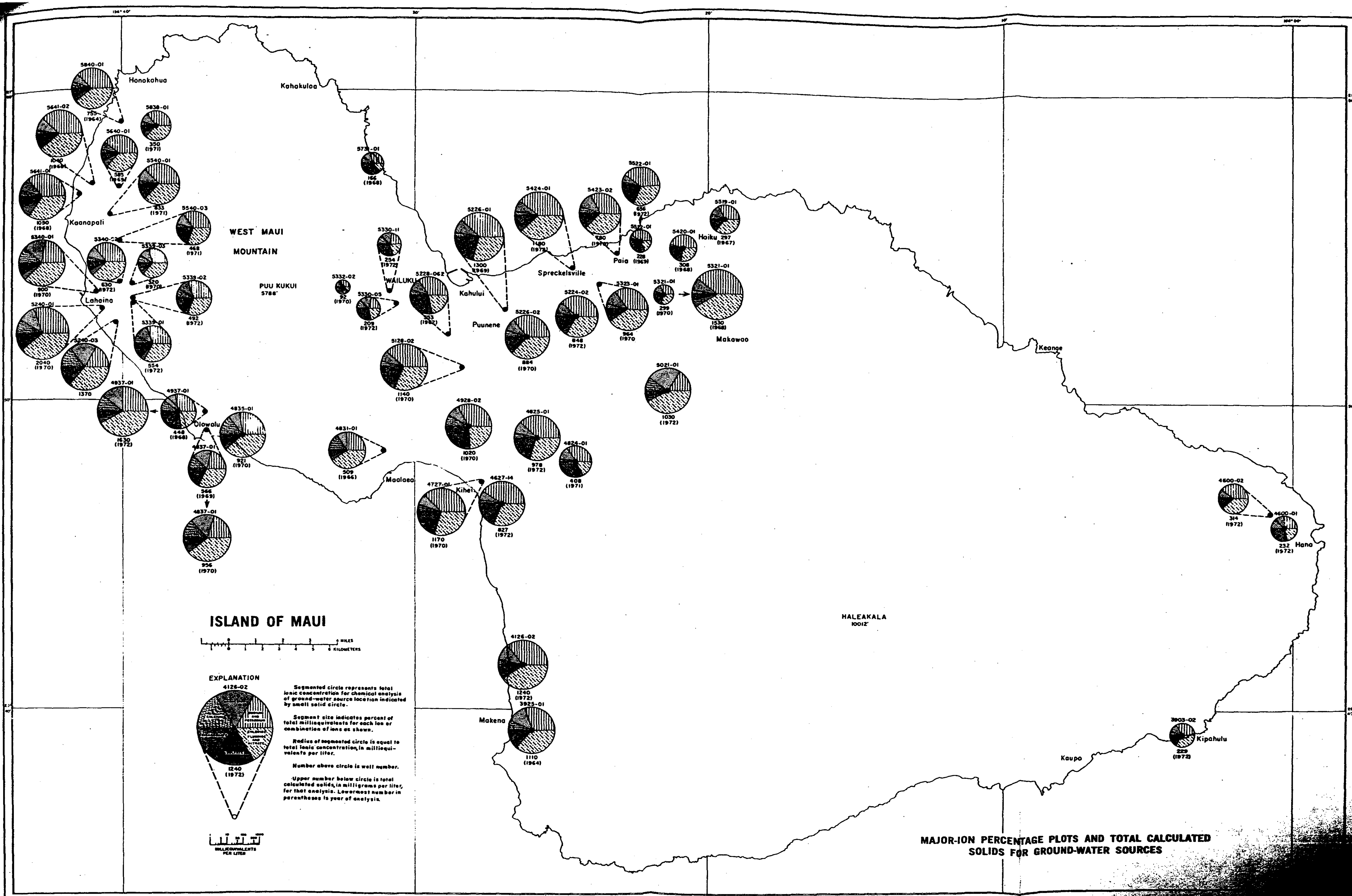
The analyses indicate that much of the intruded saline water beneath Molokai is chemically different from sea water. Comparisons of the analyses of samples from wells 1 and 15 with that of sea water diluted to the same respective chloride concentrations appear to indicate this difference is due to cation exchange (see table 2). Worthy of notice is the fact that the temperature of the water from well 1 was 93°F (34.0°C) when sampled. This suggests that some dissolved constituents may have been brought upward by volatiles or leached from rocks by rising gases (Stearns and Macdonald, 1947, p. 78).



GENERALIZED GEOLOGY, GROUND-WATER DATA LOCATIONS, MEASURED RANGE IN CHLORIDE, AND MAJOR-ION PERCENTAGE PLOTS FOR GROUND-WATER SOURCES
PACIFIC
OCEAN
ISLAND OF MOLOKAI
KALOHI CHANNEL
PAILOLO CHANNEL
EXPLANATION
GEOLOGIC UNITS
Volcanic rocks
Includes East and West Molokai Volcanic Series and Kalaupapa Basalt
Calcareous sedimentary deposits
Includes recent calcareous beach deposits, unconsolidated calcareous sand blown inland from recent beaches and consolidated calcareous sand blown inland during former lower stands of the sea
Noncalcareous sedimentary deposits
Includes consolidated and unconsolidated alluvium
Area of East Molokai where fresh water is confined at high altitudes by nearly impermeable dikes
Geology after Stearns and Macdonald, (1947)
GROUND-WATER SOURCE AND CHLORIDE INFORMATION
No prefix = Drilled well
DW = Dug well
T = Test hole
SH = Shaft
Type well and number
Chloride range, in milligrams per liter
Well depth in feet
Year of chloride data
4764
(1945)
MAJOR-ION PERCENTAGE PLOTS
Segmented circle represents total ionic concentration for chemical analysis of ground-water source location indicated by solid circle.
Segment size indicates percent of total milliequivalents for each ion or combination of ions as shown.
Radius of segmented circle is equal to total ionic concentration, in milliequivalents per liter.
Upper number below circle is total calculated solids, in milligrams per liter, for that analysis. Lowermost number in parentheses is year of analysis.
Scale of Radii
MILLIEQUIVALENTS PER LITER
BUCHANAN DW 750-780 9.4 1972
TAMURA DW 40-44 27 1972
KAMAKANA DW 28-68 19 1945-48
LAU DW 182-205 18.6 1972
SH6 50-95 42 1970-72
SH8 28-52 22.5 1970-72
4 MILES
6 KILOMETERS
PLATE 8
Base from U.S. Geological Survey, 1952
Compiled by L.A. Swain, 1973

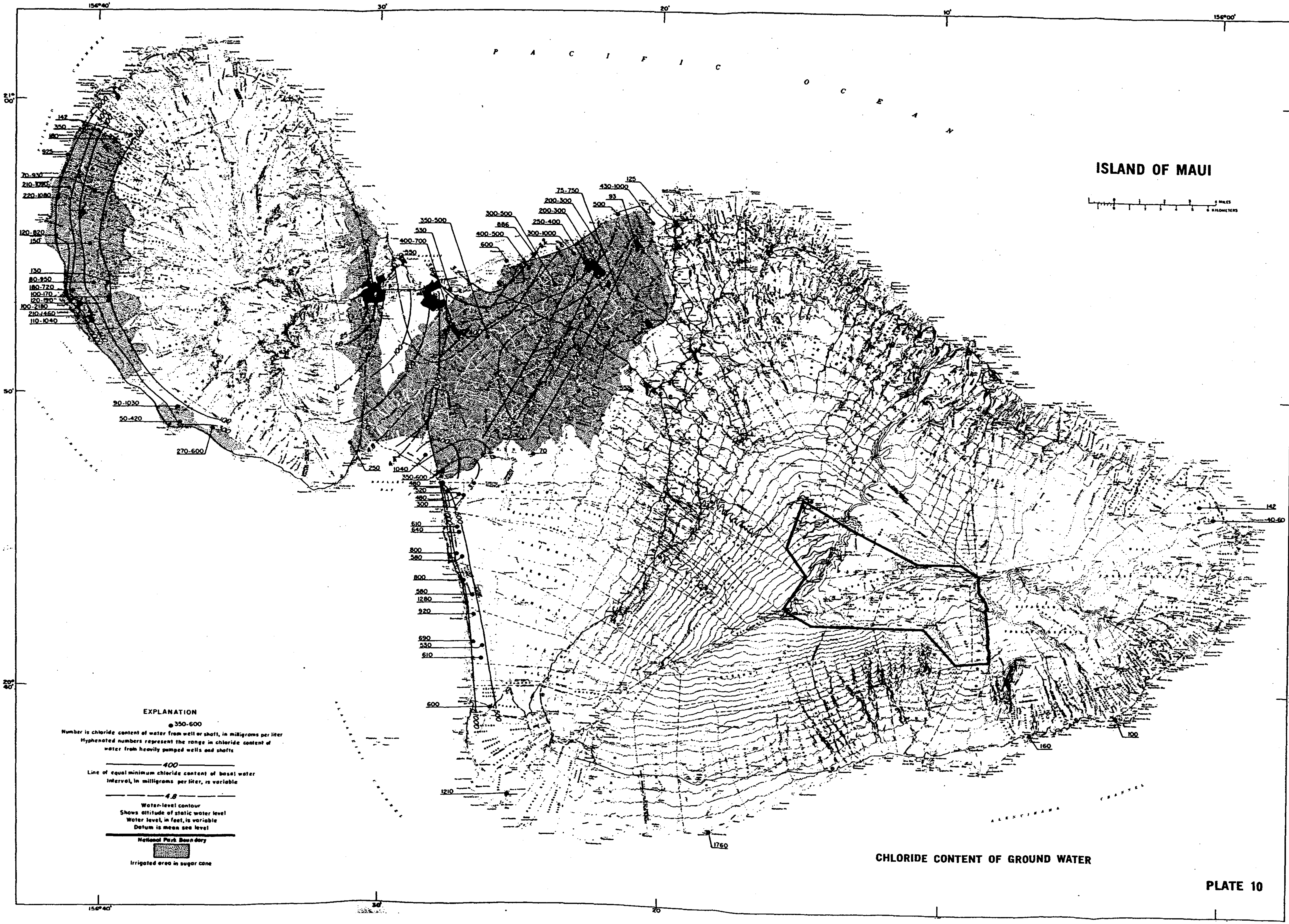
Table 2. Comparison of major cation and anion concentrations of water from well sources on Molokai with those of sea water diluted to the chloride content of the well water

Well No.	Chemical parameter	Concentration in meq/l	Diluted sea water in meq/l	Change
1	Ca	19.6	2.9	+ 16.7
	Mg	32.5	15.1	+ 17.4
	Na	35.7	66.1	- 30.4
	Subtotal cations	. . . .		+ 3.7
	HCO_3	.72	.33	+ .39
	SO_4	5.08	7.92	- 2.84
	Cl	81.5	81.5	0
	Subtotal anions	. . . .		- 2.45
15	Ca	4.14	.38	+ 3.76
	Mg	5.43	1.97	+ 3.46
	Na	2.87	8.63	- 5.76
	Subtotal cations	. . . .		+ 1.46
	HCO_3	.84	-.04	+ .80
	SO_4	.52	1.03	- .51
	Cl	10.50	10.50	9
	Subtotal anions	. . . .		+ .31



MAJOR-ION PERCENTAGE PLOTS AND TOTAL CALCULATED SOLIDS FOR GROUND-WATER SOURCES

Base from U. S. Geological Survey 1:62,500 topographic map, 1957



CHLORIDE CONTENT OF GROUND WATER

PLATE 10

MAUI

Maui, second largest of the islands, had its origin from two major volcanoes, Haleakala on the east and West Maui. The isthmus in the central portion of the island developed from the lava from Haleakala banking against West Maui Mountain (Stearns and Macdonald, 1942).

The principal aquifer is the volcanic rock, generally the highly permeable primitive basaltic lava flows, which make up the bulk of the island. In the isthmus and along the northern and southwestern shores of eastern Maui, the surface rocks are mainly calcareous dune sand. The sand is fairly permeable, and numerous wells have been drilled into it for home-lawn irrigation and for disposal of storm runoff. Consolidated sedimentary rocks are unimportant as aquifers because they are poorly permeable and generally lie above the water table.

Development and use of ground water and the importation of surface waters, especially for sugarcane irrigation, have affected the quality of the basal water in many areas of Maui. In general, the quality of basal water will be degraded where natural recharge has been decreased by development, and the quality will be improved where natural recharge has been increased. Streamflow diversions at high altitudes on the northern flanks of Haleakala and in the northeastern and northwestern parts of western Maui have significantly reduced natural recharge to the basal-water body in these areas. The recipient areas for the diverted water are those sections of Maui where sugarcane is irrigated. Here, recharge to the ground-water body is increased over natural conditions by the infiltrating irrigation water. Where streams are diverted at higher elevation and used for sugarcane irrigation at a lower elevation within the same drainage basin, net recharge to ground water may be reduced because of increased evapotranspiration.

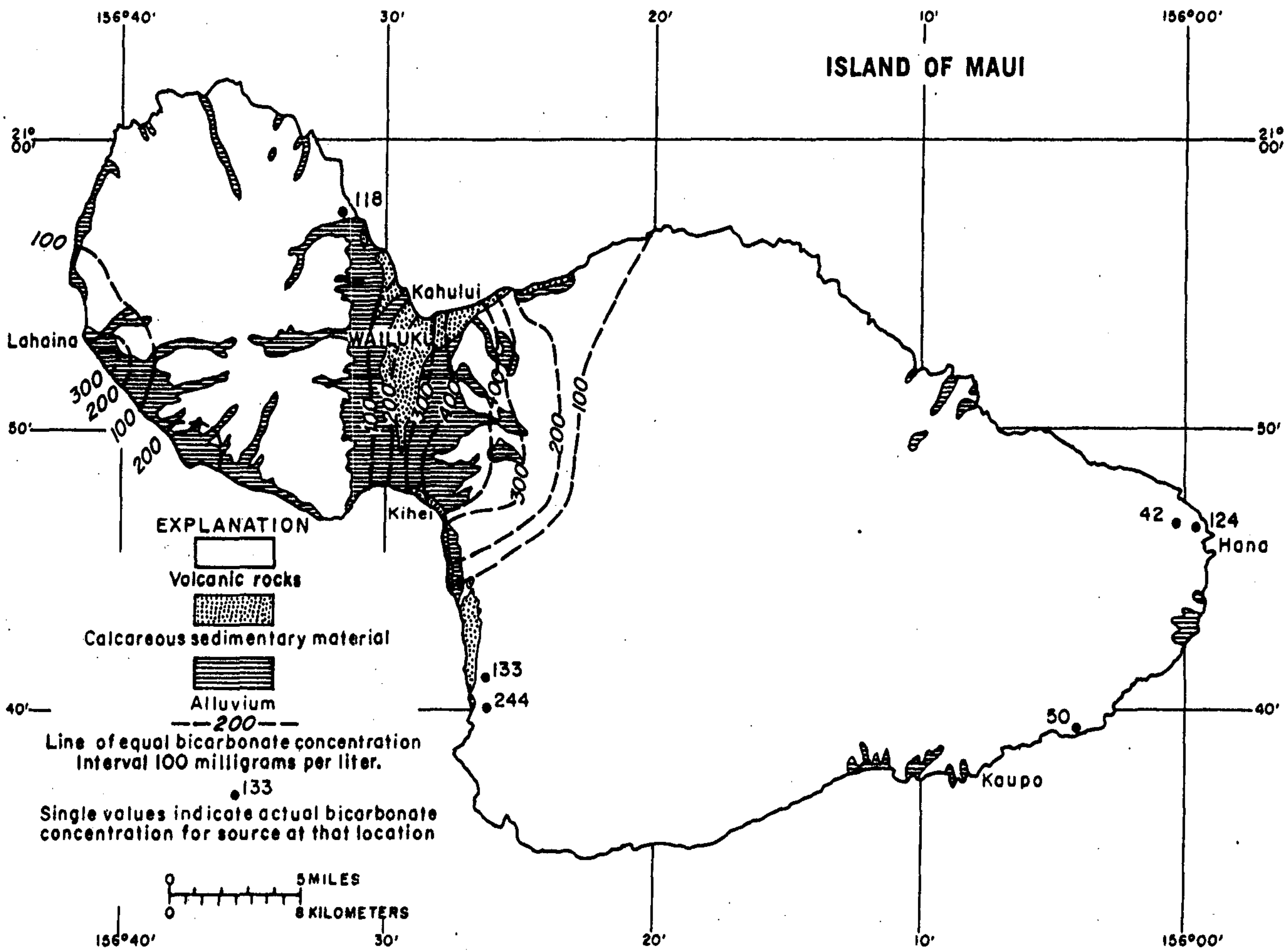


Figure 4. Maximum bicarbonate concentrations and generalized geology, 1962-72.

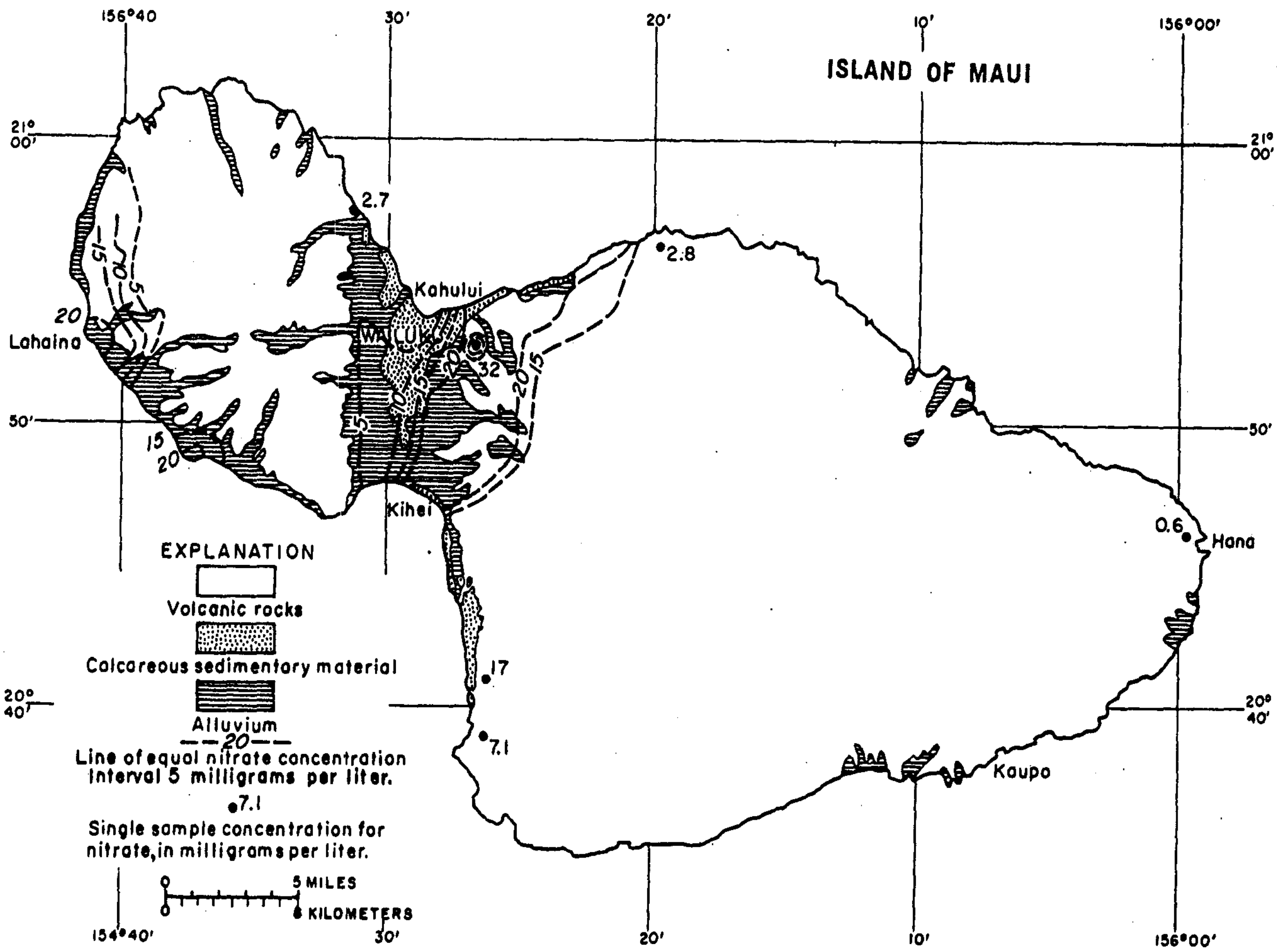


Figure 5. Maximum nitrate concentrations for ground-water sources, 1962-72.

Water-Quality Types. The generalized water-quality types for Maui's ground-water sources are depicted on plate 9. In cases where a significant variation in quality exists for a single source at different times, both water-quality types are shown.

Only one analysis of dike-impounded water is available for Maui. The sodium bicarbonate type water from this source (5332-02) is of excellent quality. The analysis showed very low concentrations of all chemical parameters.

The remaining samples are believed to be from the basal-water system. The water is generally of a lower quality than the dike water. In many cases chloride and dissolved-solids concentration exceeds the limits for drinking water. The water is predominantly a sodium chloride type, which results from the high permeability of the volcanic rock aquifers throughout the island These highly permeable aquifers, in free communication with the sea, allow the development of only a shallow fresh-water lens and permit extensive sea-water intrusion. Consequently, even though they are diluted by fresh water in some areas, the ground waters throughout most of the island are quite similar to sea water in chemical percentages. The high-pumpage rates for sugarcane irrigation from March to late summer further accelerates sea-water intrusion. This results in increased concentrations of all parameters associated with sea water, especially chloride. However, recharge from the imported surface water, and from rainfall during the nonpumping season freshens the water of the wells on a seasonal basis. Well 5321-01 is a good example of this freshening characteristic.

The few analyses of ground water along the southern and southwestern margins of western Maui that are sodium chloride types, appear to have their own distinctive characteristics. These waters contain much higher percentages of calcium and magnesium than other ground-water samples from Maui. A further characteristic common to each of these analyses is that each of them is from a source either beneath or inland of an extensive alluvial deposit. As on other islands, this chemical condition can be interpreted as the result of cation exchange. Because of the less extensive alluvial deposits on Maui, cation exchange is not as prominent as on Oahu.

One water-quality characteristic of particular significance on Maui is the high bicarbonate concentration shown in many ground-water analyses. The distribution of these high values is shown in figure 4. The concentrations greatly exceed the 140 mg/l bicarbonate concentration of pure sea water and are significantly higher than anywhere else in the State. These very high concentrations may be the result of continuous recycling of irrigation water through the vegetation root zone. However, the extensive calcareous deposits of the isthmus may be a major contributing factor.

Chloride Content of Ground Waters. The magnitude of sea-water intrusion induced by pumping for irrigation is reflected in the chloride concentrations shown on plate 10. Because high rates of pumping are maintained during the spring and summer months, these chloride concentrations may increase more than tenfold on an annual basis. The lines of equal chloride shown on the map represent low-chloride conditions during the winter months when little or no pumping occurs. The annual range in chlorinity from the winter to summer months is shown for the heavily pumped wells. The lines of equal chloride in the Kihei-Makena area outside the irrigated area of eastern Maui represents average conditions. Water-level contours in eastern Maui were drawn from measurements taken after 10 days of nearly complete pump shutdown. The contours, as drawn in the area of the isthmus, infer by their shape that flow of ground water is from the east and the west, and reflects, in part, the effect of recharge to the basal-water body by irrigation water return.

Nitrate Levels. The concentration of nitrate in the ground water of Maui is shown in figure 5, and is useful in delineating the extent of irrigation return water to the basal-water system. The map shows that no source exceeds the recommended domestic limit for nitrate of 45 mg/l.

HAWAII

Hawaii, the largest and southernmost of the islands, has an area of about 4,030 square miles (10,438 square kilometers). It was formed by the building and coalescence of five volcanoes: Kohala Mountains have long been extinct; Mauna Kea has had Holocene but no historic eruptions; Hualalai last erupted in 1801; Mauna Loa last erupted in 1950; and Kilauea is active today. The peaks of these volcanoes range in altitude from a few thousand to almost 13,800 feet (4,206 meters), resulting in about 80 percent of the island being above 1,000 feet (305 meters) in altitude.

The bulk of the island is composed of moderately to highly permeable basaltic lava flows, which comprise the principal aquifer. These basaltic flows are capped by andesite on much of Mauna Kea and by andesite and trachyte flows on part of Kohala Mountains (Stearns and Macdonald, 1946). Sedimentary deposits are generally thin and sparse.

Rainfall ranges from 10 to 300 inches (25-760 centimeters) annually, depending upon location and altitude. Island-wide average annual rainfall is 50 inches (130 centimeters), and because of the high permeability of the lavas a large part of the rainfall infiltrates to the water table. Some ground water is perched in the lava flows above sea level and some is impounded by dikes in rift zones. Most of the ground water, however, exists in the basal-water system. Unless evaporated, transpired, or intercepted for man's needs, it escapes to the sea as diffuse flow at or near the shore (Davis and Yamanaga, 1973).

Water-Quality Types. Of the water-quality analyses for the island of Hawaii depicted on plate 11, two are from samples of perched water. The water from tunnels 6 and 7 in Kohala Mountains is believed to be perched upon soil or weathered zones within the volcanics. They are sodium calcium bicarbonate and sodium magnesium bicarbonate waters of excellent quality, with low concentrations of all chemical parameters.

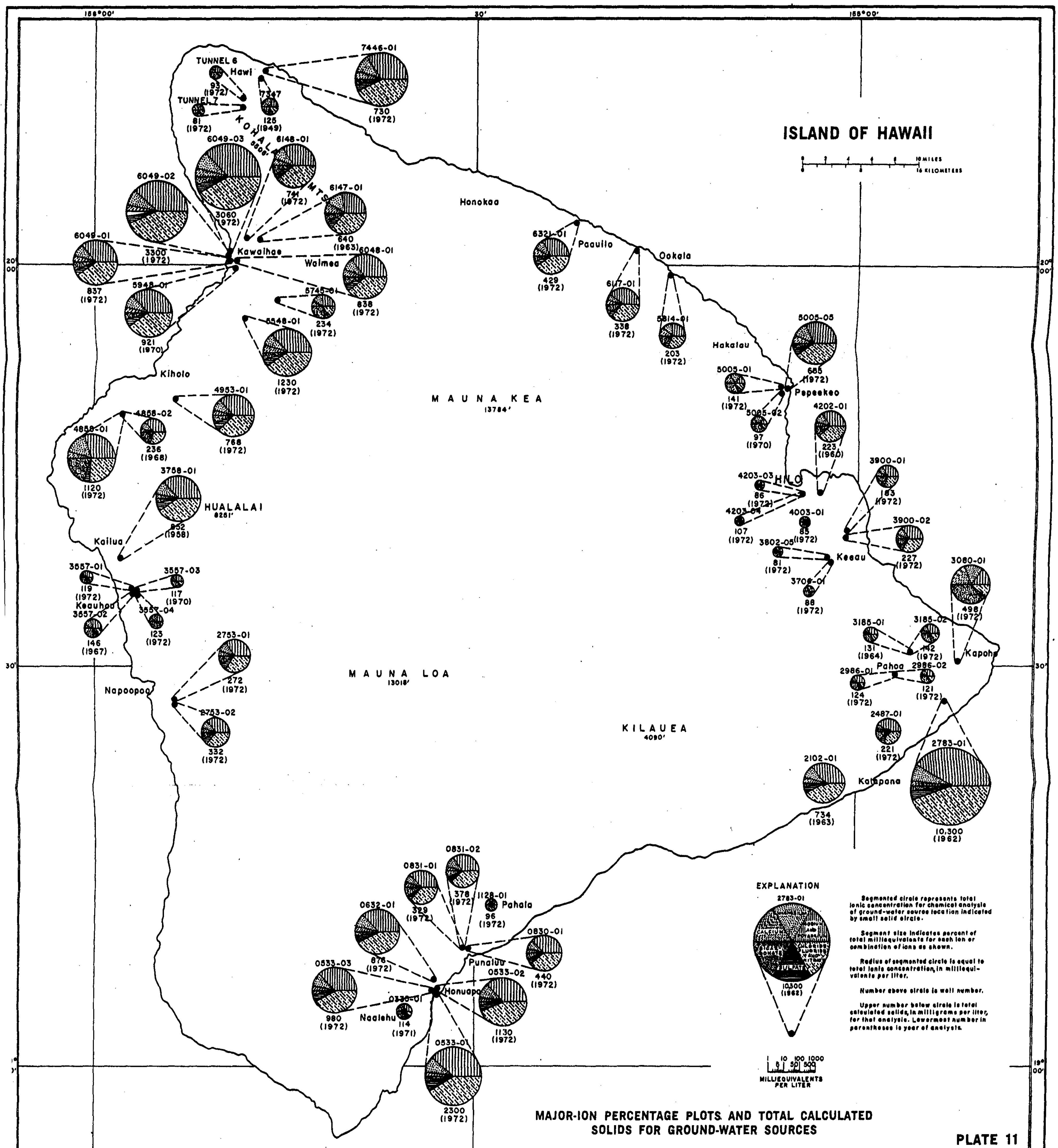
The numerous other analyses on plate 11 are of basal-water samples from sources within the permeable volcanics of the island. A great majority of these waters are sodium chloride types. In many of these analyses, the chloride and dissolved-solids concentration exceeds the limitations for domestic drinking water. These conditions are the result of widespread sea-water intrusion into the highly permeable volcanic rock aquifer. Water levels are frequently less than 5 feet (1.5 meters) above msl in the basal-water system, and there is no thick fresh-water lens. The areal extent of the sea-water effects in any specific area can be seen on plate 11 by comparing the circle sizes (total concentration of major ions) with their distance from shore; the lesser sea-water effect having the smaller circle.

Because the effect of sea-water intrusion is minimal in the basal-water sources farthest from the shore, water samples from these areas have greatly varied chemical compositions. The inland wells appear to tap only the uppermost layer of the fresh-water lens as recharged by infiltration. The waters from these wells have less than 150 mg/l dissolved-solids concentration, and the dominant anion is bicarbonate. The major cations may vary between different areas and within the same locale. In the Keauhou and Pahoa areas, these low-concentration waters are of sodium bicarbonate type but near Pepeekeo, the waters are of magnesium calcium bicarbonate type. However, in other areas, such as near Hilo and Honuapo, the cations vary greatly in percentages and no one cation is dominant for each place at all times.

Effects of Recent Volcanic Activity. Recent volcanic activity on the island of Hawaii appears to affect some ground water in and near the activity sites. One water analysis which exhibits these effects is from a well within Kapoho cone (3080-01), where the water is a calcium magnesium sodium bicarbonate type. The dissolved-solids concentration range is from 498 to 895 mg/l. The high bicarbonate concentration, which is believed to be indicative of volcanic gases at this location, ranges from 273 to 976 mg/l for three samples taken in 1968, 1970, and 1972.

Another well which appears to exhibit effects of volcanism is well 4858-01 in the Hualalai Volcanics. The sodium chloride type water from this well also has a relatively high bicarbonate concentration. The range of bicarbonate for three samples taken in 1960, 1965, and 1972 is from 260 to 439 mg/l. The possibility of volcanic gases entering this water source is further supported by fluoride concentrations of 2.0 and 2.2 mg/l from two analyses made in 1965 and 1972 by two different agencies. These fluoride concentrations are much greater than those of other water in Hawaii, which rarely exceed 0.4 mg/l of fluoride.

Chloride Levels. Because of the variations in recharge, pumping, and tidal effects within the permeable aquifers, the fresh water is readily mixed with the sea water. This results in brackish water at the coastline, even in some areas where ground-water flow is large. In dry areas where ground-water flow is small, the basal water may be brackish for more than a mile (1.6 kilometers) inland. Because of this, sodium chloride waters dominate the coastal areas, where chloride concentrations of the basal waters clearly show the inland extent of sea-water intrusion. The chloride contents of the basal-water system on Hawaii are shown on plate 12. Levels of equal chloride content are drawn wherever adequate data are available.

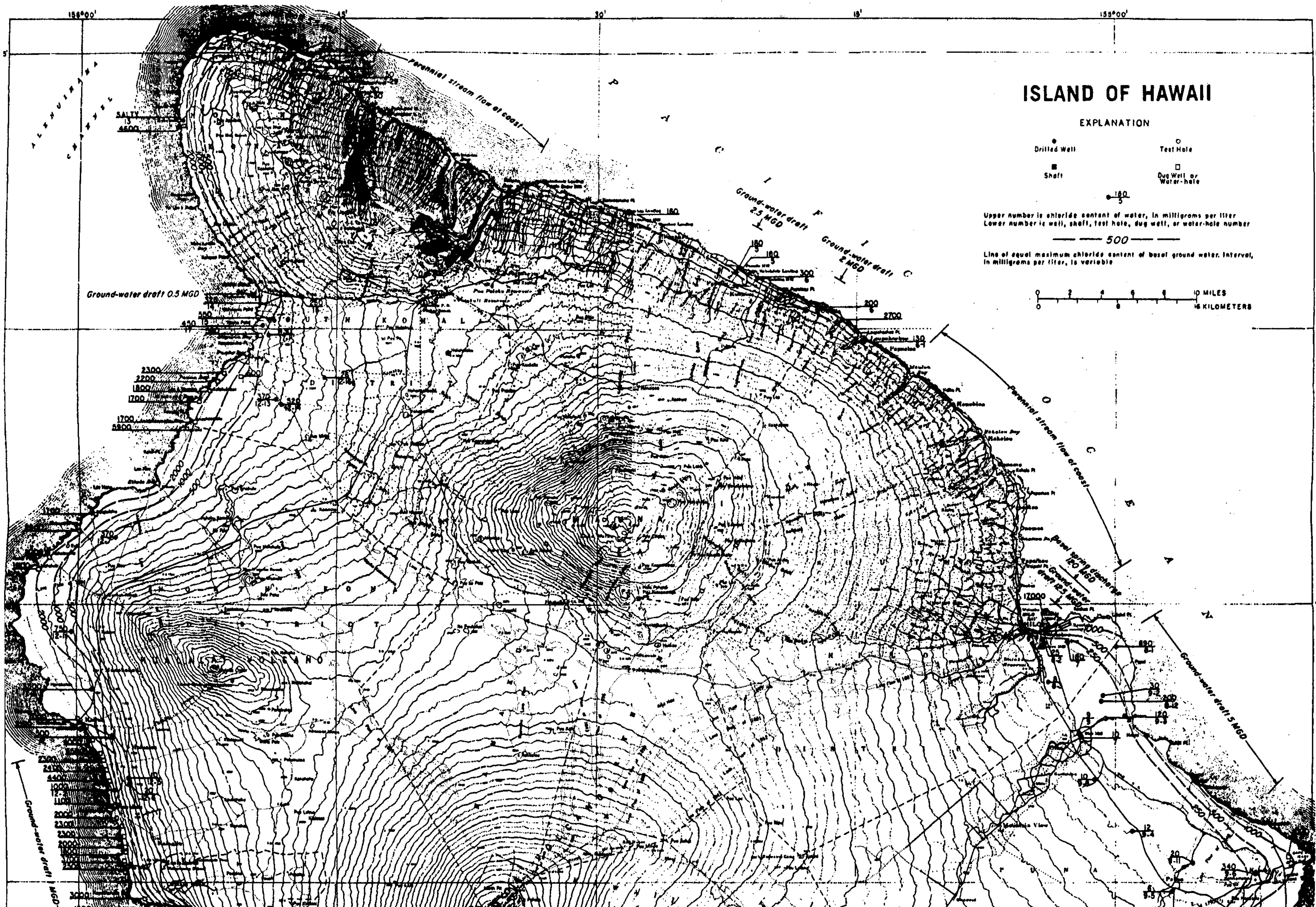


MAJOR-ION PERCENTAGE PLOTS AND TOTAL CALCULATED SOLIDS FOR GROUND-WATER SOURCES

PLATE 11

...from U.S. Geological Survey 1:125,000 topographic map, 1944

Compiled by L.A. Swain, 1973



Base from U.S. Geological Survey 1:125,000 topographic map, 1944

Data from Davis and Yamanaga (1973)

Conclusions

From collection and evaluation of all available data, the first synthesis of ground-water quality for the five major islands of Hawaii is now available.

In general, the water quality of each island is a function of the environment and of man's activities. The environmental factors are rainfall, geology, and sea-water intrusion. Man's activities that affect quality are agricultural pumping and return irrigation water, industrial wastes, and domestic wastes.

Heavy pumping significantly increases chloride concentrations by inducing sea-water intrusion. Fertilizer application adds soluble products to the soil, which are washed down with infiltrating irrigation and rainwater. Nitrate is the most definitive chemical identifiable from irrigation return water. No current detrimental effects of industrial wastes upon the ground-water bodies have been measured. Only limited information regarding the effects of solid and liquid domestic wastes is available. The principal or dominant factors affecting each island may vary greatly.

Kauai's ground-water quality is mainly a result of geologic effects. The few analyses available indicate calcium bicarbonate and magnesium sodium bicarbonate types of perched water. The dike-impounded water is also a magnesium sodium bicarbonate type water. Both of these types of water have low-chloride and dissolved-solids concentrations. The basal waters have higher concentrations of all chemical parameters. Bicarbonate is the principal major anion in the basal-water resource. The cations in these sources vary considerably. In a few analyses, the major anion is chloride. In these waters there appears to be significant cation exchange.

Water from Oahu's calcareous sedimentary aquifers is either a sodium chloride or sodium magnesium chloride type. All samples from calcareous materials have concentrations of chloride exceeding drinking water limits. In addition, all samples have bicarbonate concentrations greatly exceeding that of fresh or sea water, indicating solution of the calcareous rocks.

High-level water on Oahu is primarily a sodium magnesium bicarbonate type with low-chloride and dissolved-solids concentrations. Exceptions exist in coastal areas of both mountain ranges and a geothermal area in the Waianae Range.

Basal water in the three subzones of north-central Oahu is distinctive for each subzone. Depending upon its location, the water is either a sodium magnesium chloride type or a sodium chloride type with varying percentages of ions. Basal water in the Kahuku area is a sodium magnesium chloride type in the southern half of the area. In the northern half, where calcareous deposits and large draft are present, the water is a magnesium calcium chloride type. Basal-water quality of southern Oahu varies greatly but is primarily a sodium chloride type. There is significant cation exchange in the deeper, more concentrated water sampled.

Areal rainfall variation is a definite factor determining Molokai's ground-water quality. Water in eastern Molokai's dike zone is a sodium calcium bicarbonate type with a higher sulfate concentration than that of other island dike waters. The two basal-water samples in the volcanic aquifer of eastern Molokai are sodium magnesium chloride bicarbonate and sodium chloride types. One shallow dug-well sample in the noncalcareous sedimentary aquifer is a calcium magnesium bicarbonate type. There is a great increase in salinity of ground waters from eastern Molokai to western Molokai. Samples from western and central Molokai are sodium magnesium chloride or magnesium calcium chloride types. The chloride concentration in one sample from the westernmost source was 2,800 mg/l.

Dike water in Maui is a sodium bicarbonate type of low concentration for all parameters. Most basal-water samples on Maui are sodium chloride types as a result of sea-water intrusion. Where alluvial caprock exists, there is a cation exchange effect upon the intruded waters. In much of Maui's ground water, there are very high concentrations of bicarbonate compared to natural water. This results from continuous recycling of irrigation water through the vegetation root zone, and also from dissolution of the calcium carbonate rock through which it infiltrates. Nitrate concentrations show the areas of greatest amount of return irrigation water.

Perched water sources on the island of Hawaii are sodium calcium bicarbonate or sodium magnesium bicarbonate types. The basal-water samples are mostly sodium chloride types The dissolved-solids and chloride concentration often exceeds domestic usage limitations as a result of widespread sea-water intrusion. However, some areas inland and in the upper portion of the lens have good quality water with low-dissolved solids. The effects of recent volcanic activity are evident in two ground-water samples.

Need for Further Investigations

Although this study has established general baseline data for Hawaii's ground-water quality, it has also brought to light the many deficiencies in the data base that must be resolved in order to effectively understand and monitor changes in water quality.

Intensive study of the uncontaminated waters of high-level areas is severely limited by the scarcity of rainfall chemistry data. There is little information for the islands, which shows the effects of man's activities upon this rainfall chemistry. In addition, because of limited data, it cannot be determined what part of the chloride concentration in ground water is from rainfall and what part is from accumulated "dry rain" being washed from the surface and carried into the ground water.

To understand the variations in basal-water quality, the information must include depth from which the sample is taken. This depth information will help in the determination of the stratification of chloride concentration and its movement. In addition, depth information for complete chemical analyses will make it possible to determine where cation exchange is the most intense, and how water quality varies within aquifers. It is no longer acceptable to blindly compare analyses areally, when one sample may be from 20 feet (6.1 meters) below msl and another may be from 1,000 feet (305 meters) below msl.

If we are to adequately understand the ground-water systems and prevent contamination of our ground waters, measurements must be made for some parameters about which we presently have almost no information for the islands. Such parameters would include biochemical oxygen demand, hydrocarbons, minor metals, and organic compounds.

It would greatly enhance the value of all chemical analyses if pH and temperature were determined at the sample site. The prevalent practice of only determining these parameters in the laboratory severely limits usefulness of the data. The most reliable possible information is needed for the study and interpretations of chemical reaction which take place in the ground-water bodies.

This report only touches upon the numerous chemical characteristics and anomalies present in Hawaii's ground-water bodies. Far more intensive study of the water quality of each area, and the anomalies, will be necessary to determine the origin and causes of each specific water-quality condition.

The historical and current data obtained for this study will establish a broad water-quality data base for today's conditions. However, water quality is continuously undergoing change, and as waste disposal on land and by subsurface injection becomes more widespread, the effects upon future water quality may be significant. It is inevitable that Oahu's ground-water quality will undergo change as urban sprawl spreads from the "protective" caprock area of southern Oahu out over recharge areas for ground-water supplies. Thus, priorities and methods to meaningfully monitor change must be established if undesirable contamination of our present and future water supplies is to be prevented.

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APPENDIX A

Selected Chemical Analyses of Ground Water

The headings and the data included in the table columns on the following pages are:

Heading	Remarks
WELL NO.	--Number or name assigned each field source from which sample was obtained. First two digits are minutes of latitude, second two digits are minutes of longitude. Digits following the dash indicate a sequential number within the 1-minute rectangle. A "Z" following the sequence number indicates the sample was from a battery of wells or several sources with a common discharge.
DATE	--Day/month/year when sample obtained from source.
SIO_2	--Silicate.
CA	--Calcium.
MG	--Magnesium.
NA	--Sodium.
K	--Potassium.
HCO_3	--Bicarbonate.
CO_3	--Carbonate.
SO_4	--Sulphate
CL	--Chloride.
F	--Fluoride.
NO_3	--Nitrate.

Concentration, in milligrams per liter, of constituent as determined. A "0.0" in these columns indicates the constituent was determined to be present only in concentration less than 0.05 milligram per liter. Analyses made prior to 1963 generally included potassium with sodium, and the total concentration was reported as sodium.

Heading	Remarks
SOLIDS DET	--Dissolved solids concentration analytically determined, in milligrams per liter. Usually determined as residue on evaporation.
SOLIDS CALC	--Dissolved solids concentration calculated as the sum of determined constituents. Calculated as $HCO_3/2.03$ plus the sum of all other constituents.
CA, MG	--Carbonate hardness as $CaCO_3$ in milligrams per liter.
HARD NONC	--Noncarbonate hardness as $CaCO_3$ in milligrams per liter. Calculated as carbonate hardness minus alkalinity, both in milligrams per liter. Negative values reported as 0.
ALK CARB	--Alkalinity as $CaCO_3$ in milligrams per liter.
COND	--Electrical conductivity in micromhos.
PH	--Measure of hydrogen ion activity. Waters with pH greater than 7.0 are alkaline, less than 7.0 are acid.
TEMP C	--Temperature of water at time of sampling, in degrees Celcius.
LAB	--Laboratory performing the analysis.

1 = U.S. Geological Survey
3 = State of Hawaii, Department of Health
6 = Private laboratory
7 = University of Hawaii
8 = Honolulu Board of Water Supply

Blanks in any column indicate no value determined for that parameter.

The analyses given in the following table are as reported by the analyzing laboratory, except that where the analyzing laboratory failed to report calculated solids, hardness (Ca, Mg), noncarbonate hardness as carbonate alkalinity, these values were calculated and added by the author. With this exception, the accuracy of the reported analysis is solely the responsibility of the reporting laboratory.

CHEMICAL ANALYSES OF KAUAI GROUND WATER

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
0120-02	07/25/60	54	18	26	72		161	0	27	124	0.2	0.1	490	400	178	46	132		7.7		3
	09/22/67	51	66	79	110	13.0	155	0	63	375	0.0	2.7	1140	836	489	362	127		7.3		3
	10/13/67	74	6.1	6.9	70	12.0	171	0	20	28	0.3	5.3	310	306	44	0	140		7.4		3
0320-02	03/29/60	59	14	12	30		117	0	21	25	0.0	0.4	260	219	85	0	96		7.4		3
0421-01	04/21/72	83	18	21	24	1.0	142	0	7.5	41	0.2	4.6		270	132	16	116	360	7.7	24.5	1
0545-01	07/15/67	26	21	39	83	10.0	257	0	12	120	0.1	3.5	460	441	213	2	211		7.0		3
	07/23/67	30	23	40	77	9.1	229	0	13	116	0.1	4.5	480	425	222	34	188		7.0		3
0619-01	01/20/54	36	33	12	2.4		76	0	14	44	0.1	0.6	292	179	132	70	62		7.9		3
	12/04/56	25	16	18	20		85	0	12	45	0.2	4.0	198	182	115	45	70		7.5		3
	01/22/60	42	13	11	21	0.8	78	0	5.2	34	0.1	1.5		167	77	14	63	265	7.6		1
	05/06/65	0.0	13	12	35	2.0	130	0	22	29	0.0	2.5	212	179	81	0	107		7.5		3
0620-01	01/02/70	10	34	4.9	14	<0.2	99	0	<2.0	31	0.1	0.1	126	142	74	0	81		6.9		3
0623-01	08/17/62	23	6.5	7.2	9.4	1.6	58	0	1.2	13	0.0	1.6	102	92	46	0	47	135	7.2	19.1	1
0623-02	10/04/48	26	7.4	6.1	11		61	0	2.6	14	0.1	0.0	106	97	47	0	50		7.5		3
	08/17/62	26	7.1	6.9	9.0	1.9	59	0	1.6	13	0.0	1.2	88	95	46	0	48	130	7.4		1
0818-02	06/03/57	38	7.3	8.9	64		79	0	88	38	0.3	1.6	306	285	55	0	65		6.8		3
	01/02/70	28	24	3.5	22	<0.2	96	0	5.0	22	0.0	0.2	220	151	46	0	79		6.8		3
3318-03	06/03/57	14	17	21	30		74	0	69	44	0.1	1.2	276	232	157	96	61		7.1		3
1125-01	03/03/72	39	8.9	6.8	10	0.9	66	0	1.0	13	0.0	0.7		112	50	0	54	150	7.1	23.0	1
1126-01	11/06/69	33	26	2.5	6.0	<0.2	83	0	<2.0	17	0.1	0.1	148	125	60	0	69		6.7		3
1225-01	02/04/70	16	16	2.4	10	<2.0	45	0	<2.0	21	0.2	0.1		87	49	12	37		6.7		3
1333-01	11/12/65	21	10	10	15	4.1	93	0	4.0	22	0.2	0.5	120	132	67	0	76		7.4		3
5427-01	03/13/53	48	10	9.1	20		73	0	8.4	25	0.2	0.5	168	157	66	6	60		7.4		3
	08/04/54	63	9.6	12	19	0.5	85	0	8.1	24	0.1	0.5		178	73	4	69	233	7.1	22.8	1
	08/10/55	36	27	9.8	3.8		82	0	18	24	0.2	0.0	168	159	108	41	67		7.1		3
	05/08/56	45	10	9.2	21		77	0	7.9	26	0.2	1.2	192	158	66	3	63		6.8		3
5427-02	01/22/64	56	14	9.4	20	4.0	93	0	7.6	26	0.0	1.6	188	184	74	0	76		7.5		3
5529-03	04/19/55	8.0	21	7.3	19		52	0	21	42	0.1	0.2	164	144	83	40	43		7.2		3
5530-02	08/08/54	67	9.0	13	20	0.8	88	0	8.5	26	0.1	0.2		187	76	4	72	238	7.3	22.8	1
5534-02	01/18/50	29	12	14	16		72	0	8.7	47	0.1	0.4	221	162	99	40	59				3
	12/23/52	22	25	37	26	1.2	68	0	21	137	0.0	0.6		303	214	159	55	591	7.1		1
5534-03	03/04/66	30	6.3	8.6	70	6.1	132	0	21	44	0.3	15	260	266	42	0	108		7.2		3
	01/17/72	29	3.2	3.4	92	1.9	183	0	26	42	0.0	0.3	250	287	22	0	150				3
5822-02	05/12/70	15	13	10	25	2.0	60	0	27	32	0.1	7.8		161	74	25	49	271	6.7		1
5823-01	08/21/72	29	8.0	8.9	16	1.0	82	0	5.7	18	0.1	0.8	140	127	54	0	67		7.7		3
5843-01	08/09/54	82	13	19	50	1.8	164	0	15	50	0.1	2.0		313	111	0	134	444	7.4	23.6	1
5921-01	12/16/54	32	39	13	26		163	0	53	23	0.2	0.1	326	266	151	17	134		7.2		3

Lott Loy
40-28 47-03

CHEMICAL ANALYSES OF OAHU GROUND WATER

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
1747-02	09/21/49	39	26	25	56		89	0	19	138	0.1	1.4	415	348	167	94	73		7.8		8
	10/22/51	40	27	26	57	3.0	91	0	20	144	0.1	2.7	425	364	174	99	75		7.8		8
	10/12/53	41	27	27	58	2.8	92	0	21	148	0.1	3.3		373	178	103	75		7.8		8
	10/05/59	43	26	26	58	3.0	94	0	21	140	0.0	3.6		367	170	93	77	670	7.7		8
	10/30/62	44	28	27	62	3.0	98	0	24	151	0.0	4.5		391	183	103	80	695	7.6		8
	10/11/63	41	24	24	64	3.3	100	0	24	135	0.0	5.2		369	159	77	82	680	7.8		8
	10/12/64	43	27	26	63	3.2	99	0	23	146	0.0	5.3		385	175	94	81	702	7.7		8
	10/08/65	45	27	26	65	3.4	100	0	24	149	0.0	4.6		393	176	94	82	705	7.6		8
	10/24/66	44	27	26	66	3.4	101	0	24	151	0.0	4.5		395	175	92	83	735	7.8		8
	10/23/67	45	26	25	65	3.2	101	0	24	143	0.0	4.9		386	168	85	83	694	7.9		8
	10/18/68	48	28	27	70	2.3	102	0	24	155	0.0	5.8		410	178	94	84	736	7.8		8
	10/17/69	44	26	26	70	3.1	105	0	24	150	0.0	5.1		400	172	86	86	697	7.8		8
	10/19/70	44	24	24	69	3.2	106	0	22	141	0.0	5.2		384	158	71	87	673	7.8		8
1748-032	11/20/26	35	4.4	5.2	30	19	47	0	14	48			183	178	32	0	38				6
	12/ /28	34	5.0	5.5	47	4.8	73	0	13	48			195	193	35	0	59				6
	12/ /29	40	2.8	2.8	51	4.3	71	0	11	49			199	195	18	0	58				6
	09/20/49	36	6.7	8.3	49		83	0	9.8	55	0.1	1.1	205	207	51	0	68		8.2		8
	10/22/51	36	7.2	8.4	48	2.7	80	0	9.8	59	0.1	1.6	220	212	53	0	66		8.2		8
	10/13/53	35	7.5	8.8	49	2.2	78	0	10	62	0.0	1.5		214	55	0	64		8.2		8
	10/05/59	36	8.2	9.4	49	2.5	74	0	11	68	0.0	1.8		222	59	0	60	380	8.2		8
	08/29/62	39	5.9	6.6	64	2.9	81	0	14	76	0.0	0.7	251	249	42	0	66	388	6.7	22.5	1
	10/29/62	35	8.3	10	51	2.5	72	0	13	74	0.0	1.5		230	64	6	58	394	8.1		8
	10/11/63	36	7.9	9.6	50	2.4	73	0	12	70	0.0	1.6		225	59	0	60	381	8.2		8
	02/17/64	40	5.5	8.3	62	1.0	71	2	13	68	0.0	1.3	236	236	48	0	62		8.0		3
	10/09/64	36	7.9	9.8	51	2.5	73	0	12	70	0.0	1.3		226	60	0	60	388	8.1		8
	10/08/65	37	8.1	10	50	2.5	73	0	12	70	0.0	1.4		227	62	2	60	388	8.2		8
	10/21/66	38	8.6	11	50	2.5	73	0	13	73	0.0	1.4		233	66	6	60	400	8.1		8
	10/27/67	38	8.9	11	50	2.5	72	0	13	75	0.0	1.6		235	67	8	59	405	8.2		8
	11/08/67	33	7.8	10	52	6.5	66	2	10	78	0.1	2.0	240	233	63	5	58		7.8		3
	10/18/68	36	9.4	12	52	2.2	72	0	13	80	0.0	1.8		242	72	13	59	408	8.2		8
	10/17/69	37	8.7	11	53	2.5	77	0	13	76	0.0	1.6		240	67	4	63	402	8.1		8
	10/16/70	37	8.8	11	54	2.5	77	0	13	78	0.0	1.6		244	67	4	63	403	8.0		8
	10/22/71	38	8.8	11	56	2.6	77	0	13	80	0.0	1.7	288	249	67	4	63	424	8.2		8
1748-052	04/28/14	16	5.4	2.4	57		69	0	11	56			190	181	23	0	56				6
1749-01	04/24/72	35	4.1	5.5	58	2.1	61	0	13	70	0.1	0.0		217	33	0	50	366	7.4		1
1749-06	04/29/30	41	2.4	2.8	45	1.6	87	0	8.4	28		1.4	168	173	17	0	71				1
1749-08	03/22/72	55	3.6	4.4	160	3.7	60	0	36	208	0.1	0.0		500	27	0	49	834	7.3	22.0	1
1749-12	01/09/30	35	27	29	158	3.8	168	0	43	246			629	624	186	48	137				6
1749-16	02/ /66	33	4.4	5.1	81	2.7	71	0	17	102	0.1	0.2	279	280	32	0	58	470	7.9		1
1749-17	06/18/17	27	1.4	1.4	84		69	0	15	83			250	245	9	0	56				6
	04/22/25	0.0	16	17	180		106	0	61	247			582	573	110	23	86				6
	01/19/71	33	55	64	321	9.8	40	0	111	700	0.0	0.0		1310	400	367	33	2450	6.6	21.0	1
1749-18	02/13/28	67	4.0	1.4	64	2.4	63	12	18	50		0.6	252	250	16	0	71				1
1749-22	10/20/70	33	28	40	183	5.7	52	0	66	378	0.0	0.0		759	235	192	43	1440	6.1		1
1750-02	10/31/66	36	6.7	9.5	54	1.2	85	0	14	61	0.1	0.9	238	225	56	0	70		7.3		1
1849-10	03/15/28	48	7.6	6.7	48	6.5	104	3	12	38		0.9	231	221	46	0	90				1
	08/07/46	37	7.6	8.2	50		91	0	11	54		1.1	213	213	61	0	74		8.3		3
	01/05/55	24	20	7.5	41		73	0	30	61	0.1	1.2	238	220	80	20	60		8.0		3
	09/20/57	26	6.6	9.3	56		91	0	13	62	0.1	1.2	228	219	55	0	75		8.0		3
	10/27/67	36	6.0	7.2	52	7.8	87	0	7.5	56	0.1	3.0	210	218	42	0	71		7.8		3
	10/26/71	30	5.6	6.5	50	6.2	148	0	8.0	18	0.0	1.0	220	198	40	0	121		7.5		3
1849-11	11/20/26	26	4.0	5.2	30	21	47	0	12	51			178	172	31	0	38				6
	12/ /28	31	6.5	6.6	44	5.8	75	0	11	51			196	192	43	0	61				6
1849-15	10/11/63	34	6.3	8.6	53	5.2	86	0	11	64	0.0	2.8		227	51	0	70	389	8.3		8
	10/12/64	34	6.0	8.0	52	5.3	82	0	9.4	63	0.0	2.4		220	48	0	67	378	8.3		8
	10/08/65	35	5.9	7.3	51	5.5	80	0	10	60	0.0	2.2		216	45	0	66	364	8.4		8
	10/21/66	37	5.3	7.4	51	5.9	80	0	9.8	60	0.0	2.3		218	45	0	66	363	8.4		8
	10/20/67	33	5.3	7.0	52	5.1	80	0	9.7	59	0.0	2.6		213	42	0	65	363	8.4		8
	10/18/68	31	4.9	6.8	51	4.9	79	0	8.6	57	0.0	2.4		205	40	0	65	344	8.4		8
	10/17/69	34	6.0	6.5	50	5.7	83	0	9.3	56	0.0	2.2		210	42	0	68	342	8.4		8
	10/16/70	35	5.6	5.8	52	5.3	81	0	8.8	56	0.0	2.5		211	38	0	66	333	8.4		8
	10/22/71	31	4.6	6.5	53	6.4	82	0	11	57	0.0	2.1	254	212	38	0	67	342	8.4		8
1850-06	08/07/46	38	8.0	9.3	52		104	0	10	50		1.5	218	220	64	0	85		8.3		3
1850-27	01/25/26	26	29	4.8	57		91	0	21	85				267	92	17	75				6
1851-07	08/23/46	38	6.4	6.2	30		64	0	4.8	30		0.1	145	147	45	0	52		8.1		3
	10/11/67	30	5.2	7.4	28	7.5	54	2	4.5	37	0.0	1.2	148	149	44	0	48		8.0		3
	06/03/68	34	6.1	4.4	25	4.8	54	0	4.5	37	0.0	1.2	170	143	44	0	44		7.7		3
1851-11	06/18/46	35	11	11	43		108	0	13	47		1.1	223	214	78	0	89		8.3		3
	06/28/55	33	26	8.9	33		90	2	18	48	0.1	0.0	228	213	101	23	78		8.1		3
1851-132	11/20/26	12	7.3	6.4	26	18	53	0	14	46			161	155	44	0	43				6
	07/19/27	34	21	5.8	62		158	0	4.4	53			260	258	76	0	129				6
	12/ /28	36	7.5	7.7	36	3.8	71	0	15	44			189	184	50	0	58				6
	12/ /29	38	7.1	7.4	36	4.4	71	0	11	46			189	184	48	0	58				
	12/ /29	36	11	11	43	3.3	75	0	13	69			226	223	72	10	62				
	09/30/49	37	6.3	6.8	37	0.0	76	0	5.9	38	0.1	1.2	165	169	44	0	62		8.2		8
1849-132	10/22/51	37	6.3	6.7	34	3.4	76	0	5.3	38	0.1	1.6	170	169	43	0	62		8.2		8
1851-132	10/12/53	39	6.4	6.4	35	2.9	75	0	5.8	38	0.1	1.5		171	42	0	62		8.3		8
	10/05/59	38	7.2	7.4	35	3.3	76	0	6.6	40	0.0	2.1		177	48	0	62	280	8.2		8
	08/29/62	41	8.7	9.2	35	3.2	78	0	8.6	45	0.1	0.0	184	189	60	0	63	289	7.0	21.7	1
	10/29/62	36	7.5	8.4	36	3.0	76	0	7.7	46	0.0	2.0		184	53	0	62	304	8.2		8
	10/11/63	40	8.1	8.8	37	3.3	77	0	7.6	48	0.0	2.4		193	56	0	63	310	8.2		8
	10/09/64	39	8.2	8.9	37	3.8	78	0	7.8	49	0.0	2.0		194	57	0	64	318	8.2		8

Chemical Analyses of Oahu Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
1851-13Z	10/08/65	38	8.5	9.0	37	3.5	78	0	7.9	49	0.0	1.9		193	58	0	64	316	8.2		8
	10/18/65	32	5.9	6.2	32	4.0	73	0	1.5	39	0.1	2.6	180	159	40	0	60		7.0		3
	10/21/66	38	8.1	9.7	37	3.8	78	0	9.1	50	0.0	1.8		195	60	0	64	331	8.2		8
	10/20/67	35	9.4	10	37	3.4	76	0	9.4	55	0.0	1.8		198	66	4	62	336	8.3		8
	10/31/67	31	6.1	12	39	6.8	77	0	8.0	57	0.1	2.3	200	200	65	2	63		7.9		3
	10/18/68	35	9.4	11	40	3.6	77	0	9.0	59	0.0	2.1		207	67	4	63	347	8.2		8
	10/17/69	38	10	11	38	3.9	78	0	8.9	59	0.0	1.9		209	70	6	64	341	8.2		8
	10/16/70	39	11	11	40	3.8	79	0	9.2	63	0.0	2.2		218	73	8	65	352	8.2		8
	10/22/71	35	11	11	41	3.9	81	0	8.9	63	0.0	2.0	257	215	72	6	66	352	8.1		8
1851-18	12/30/07	26	13	11	70		110	0	16	89			298	281	78	0	90				6
1851-19	08/03/08	38	6.4	8.7	54		75	0	11	67			228	222	52	0	61				6
	06/09/25	16	37	19	94		203	0	4.2	144				414	170	3	166				6
1851-20	06/23/10	22	13	9.3	50		83	0	8.0	75			232	218	71	2	68				6
	04/25/12	28	13	9.5	46		85	0	9.1	66			220	213	71	1	70				6
	12/29/21	26	8.6	10	44		77	0	4.5	67				198	62	0	63				6
	06/18/46	34	8.0	7.9	33		83	0	12	37		1.1	185	173	57	0	68		8.4		3
	02/17/65	38	6.3	5.6	36	8.0	77	3	4.5	36	0.1	2.8	180	178	39	0	69		8.2		3
	07/05/67	29	5.2	6.9	38	5.8	73	2	4.5	38	0.1	3.0	160	168	41	0	63		7.4		3
	01/05/68	42	5.2	6.8	36	5.4	71	5	4.5	38	0.1	2.6	170	180	41	0	65		7.9		3
1851-21	07/10/46	40	5.4	7.9	34		72	0	7.5	41		0.9	188	172	48	0	59		8.3	22.2	3
	02/21/57	51	12	3.7	34		62	0	6.9	40	0.1	0.0	212	178	38	0	51		7.6		3
	10/27/67	36	6.1	8.4	42	6.8	49	2	6.5	63	0.1	1.6	180	196	50	6	44		7.8		3
	01/05/68	41	6.1	9.0	37	5.8	46	2	6.5	64	0.1	1.3	200	195	52	10	42		7.2		3
1851-23	06/18/17	17	7.1	8.5	56		97	0	8.2	62			208	206	53	0	79				6
	10/08/26	26	15	14	52		93	0	16	81			252	249	95	18	76				6
	05/28/62	44	7.8	8.7	35		86	0	23	16	0.0	3.5	232	180	56	0	72		8.1		3
	11/15/67	27	38	46	59	6.1	47	0	14	275	0.0	1.2	700	489	287	249	38		7.8		3
	12/08/70	37	72	72	74	7.3	48	0	26	425	0.0	0.0		736	476	436	39	1450	6.7		1
1851-26	05/13/10	28	15	14	69		114	0	15	95			304	292	95	1	93				6
	06/12/11	23	12	13	55		102	0	10	78			246	241	83	0	83				6
	04/20/21	23	13	16	55		91	0	15	95			266	261	98	23	75				6
	03/09/26	31	22	12	78		116	0	15	116			332	331	104	8	95				6
	02/18/27	20	21	14	60		138	0	11	81			277	274	110	0	113				6
	07/09/63	32	10	12	42	4.2	83	1	12	73	0.0	2.1	254	229	74	4	70		8.0		3
	11/02/64	35	10	12	41	5.0	63	2	7.5	78	0.1	2.4	254	224	77	21	56		7.9		3
	10/25/65	28	10	9.5	45	4.9	61	0	8.0	82	0.0	2.2	280	219	66	16	50		6.9		3
1851-27	06/09/11	9.8	8.7	7.0	37		59	0	5.6	55			158	152	50	1	48				6
	06/09/25	17	22	12	100		124	0	19	141				372	100	0	101				6
	12/29/30	31	9.9	7.8	72	7.7	122	0	12	78			284	278	57	0	100				6
1851-29	04/27/14	17	11	14	70		102	0	14	103			288	279	85	1	84				6
1851-30	11/15/67	36	3.4	5.2	28	5.1	56	0	4.5	39	0.1	1.2	160	150	30	0	46		8.0		3
	09/04/69	29	3.2	3.2	58	<0.2	68	0	0.0	63	0.2	0.3	201	190	82	26	56		7.C		3
1851-36	12/26/62	35	5.9	7.2	40	1.0	83	2	12	35	0.1	2.6	194	181	44	0	72		7.6		3
	11/02/64	33	6.7	5.3	33	3.0	63	7	3.7	34	0.0	3.2	176	159	39	0	64		8.0		3
	02/17/65	38	7.6	4.6	36	6.0	77	6	2.5	30	0.0	2.8	168	171	38	0	74		8.3		3
	07/05/67	29	5.2	6.3	38	6.0	76	5	5.0	37	0.1	3.0	164	172	39	0	69		8.1		3
1851-54	12/14/64	42	8.8	12	42	4.0	101	0	4.5	47	0.1	2.3	258	212	72	0	83		7.7		3
	11/17/65	26	7.7	11	30	1.4	61	2	7.0	51	0.2	3.5	160	169	64	10	54		7.8		3
	10/11/67	24	8.7	10	45	6.8	91	2	6.5	53	0.0	2.9	214	205	67	0	79		8.0		3
	06/03/68	34	9.5	12	45	5.4	99	0	7.0	55	0.1	3.2	220	219	72	0	81		7.8		3
	02/23/71	20	12	15	54	6.2	136	0	11	59	0.1	0.9	280	245	90	0	112		8.2		3
1950-01	08/23/46	51	23	25	60		215	0	14	60		1.3	334	340	165	0	176		7.1		3
	02/15/57	51	22	34	54		220	0	13	75	0.2	1.6	364	359	174	0	180		8.5		3
1952-03	01/29/09	21	42	31	61		73	0	42	187				419	230	170	60				6
	10/17/10	10	13	9.8	51		71	0	18	74			214	210	73	14	58				6
	05/18/26	20	20	8.9	50		89	0	12	78				232	86	13	73				6
	08/09/28	59	18	22	123	6.1	78	0	33	218	0.0	1.7	522	519	135	71	63				1
	01/07/47	37	10	14	98		71	0	22	142	0.4	0.1	378	358	83	25	58		8.2		3
1952-04	08/09/28	10	15	5.5	67	4.2	27	0	19	118		0.0	261	252	60	37	22				1
1952-11	04/28/14	9.1	16	15	126		75	0	30	200			440	433	101	39	62				6
	12/02/26	28	8.6	8.0	50	14.0	24	0	20	99			244	239	54	34	20				6
1952-12	09/03/63	31	40	50	145	6.7	67	0	49	378	0.0	0.8	974	733	306	251	55		7.4		3
	09/10/65	26	39	41	150	68.0	66	0	35	370	0.0	2.8	940	764	266	212	54		7.2		3
	05/23/68	33	28	32	111	8.2	46	0	27	290	0.1	2.3	760	554	202	164	38		7.4		3
1952-13	12/02/26	30	11	9.8	52	22.0	39	0	21	110			279	275	68	36	32				6
1952-14	12/10/23	17	26	18	157		85	0	33	266			564	558	139	69	70				6
	03/14/28	53	36	33	138	12.0	74	0	43	304	0.0	1.0	707	656	225	164	60				1
	01/20/47	36	55	50	183		65	0	45	410	0.7	0.4	1133	812	348	294	53		7.8		3
1952-16Z	11/20/26	24	11	9.4	25	16.0	34	0	15	71			193	188	66	38	28				6
	12/ /28	30	11	12	44	2.7	79	0	15	69			224	220	77	12	65				6
	09/20/49	35	10	11	37		71	0	8.7	58	0.1	1.0	200	195	70	12	58		8.2		8
	10/22/51	36	10	11	36	3.2	72	0	8.8	60	0.1	1.4	205	202	71	12	59		8.2		8
	10/12/53	34	10	11	36	2.3	70	0	9.0	60	0.0	1.7		198	70	12	58		8.2		8
	10/05/59	35	11	11	37	2.5	68	0	9.7	62	0.0	2.2		204	73	17	56	353	8.1		8
	10/29/62	36	11	12	36	2.5	68	0	9.8	64	0.0	1.8		206	76	20	56	351	8.0		8
	10/11/63	37	11	12	37	2.4	68	0	9.8	64	0.0	1.9		208	74	18	56	355	8.1		8
	10/09/64	36	11	12	37	2.5	68	0	9.8	56	0.0	1.6		209	77	21	56	362	8.2		8
	10/08/65	37	11	12	37	2.5	68	0	10	65	0.0	1.5		209	77	21	56	361	8.1		8
	10/21/66	37	11	12	35	2.7	68	0	9.9	64	0.0	1.6		206	78	22	56	360	8.1		8
	10/20/67	38	11	12	35	2.4	67	0	10	65	0.0	1.4		207	79	24	55	362	8.2		8
	10/31/67	33	10	14	37	7.5	68	0	10	71	0.1	2.0	230	218	83	27	56		7.7		3
	10/18/68	36	11	12	37	2.5	68	0	10	67	0.0	1.8		210	79	23	56	360	8.2		8
	10/17/69	37	12	14	36	2.6	71	0	11	69	0.0	1.9		218	83	25	58	365	8.2		8
	10/16/70	37	12	13	39	2.6	71	0	11	71	0.0	2.0		222	83	25	58	370	8.2		8
	10/22/71	34	13	14	40	2.7	72	0	11	77	0.0	1.6	265	228	90	31	59	302	8.0		8
1952-20	09/03/63	30	16	13	60	2.8	59	1	17	116	0.0	1.0	326	285	98	48	50		7.5		3

Chemical Analyses of Oahu Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
1952-20	10/20/67	36	11	14	52	6.8	51	5	12	101	0.0	1.7	290	264	87	37	50		7.9		3
	05/23/68	36	11	14	53	5.4	61	0	11	100	0.1	1.6	280	262	85	35	50		7.7		3
1953-01	08/07/14	16	18	19	61		63	0	17	130			296	292	123	71	52				6
	08/07/28	45	24	26	68	4.0	63	0	26	168		1.5	417	393	167	115	52				1
	01/07/47	30	30	24	84		65	0	29	188	0.4	0.4	614	417	175	121	53		8.1		3
	11/21/67	28	23	26	57	6.7	66	0	20	165	0.1	1.9	480	360	164	110	54		7.7		3
1953-02	09/09/46	41	76	39	81		67	0	34	285		0.8	871	589	353	298	55		8.0		3
	07/24/62	40	10	10	35		73	0	12	55	0.0	1.0	210	198	67	7	60		7.8		3
	05/01/68	38	9.5	10	30	6.8	68	0	5.5	47	0.1	2.2	160	182	65	9	56		7.3		3
	02/23/71	18	10	9.7	28	2.2	98	0	5.0	33	0.0	0.5	180	154	66	0	80		7.8		3
2001-01	08/16/65	21	145	142	270		332	0	128	896	0.8	19	2940	1790	949	677	272		7.1		3
2006-012	06/08/11	1.2	13	13	106		185	0	14	104			343	342	86	0	151				6
2042-13	04/26/72	24	126	93	772	28	203	0	196	1430	0.1	26		2800	698	531	166	5020	7.7	24.9	1
2043-01	04/16/70	22	14	2.8	28	1.1	84	0	5.4	24	0.1	0.1		138	47	0	69	218	7.3	30.0	1
2047-04	10/15/70	25	9.5	6.7	12	0.8	68	0	1.0	15	0.1	0.1		103	51	0	56	155	7.0		1
2047-05	12/04/70	29	10	6.5	11	1.0	70	0	2.6	14	0.0	0.0		108	52	0	57	156	6.9		1
2052-05	11/17/10	19	18	16	72		63	0	24	134			320	314	111	59	52				6
2052-07	10/13/47	40	18	16	56		104	0	19	87	0.1	1.3	309	288	111	25	85		8.0		3
	07/24/62	32	8.0	8.3	28		70	0	9.4	39	0.0	1.1	156	160	54	0	57		7.9		3
	06/16/67	23	26	42	90	2.2	133	0	42	190	0.1	5.4	600	486	239	130	109		7.6		3
	01/11/71	9.2	22	25	62	4.5	110	0	33	118	0.0	0.0	570	327	158	68	90		8.0		3
	10/26/71	20	29	36	70	5.0	191	0	37	130	0.0	1.2	512	421	198	41	157		6.9		3
2052-08	09/21/49	37	8.5	8.7	36		67	0	7.8	50	0.1	0.8	185	182	57	2	55		8.0		8
	10/22/51	37	8.9	9.2	36	2.4	67	0	7.9	53	0.1	1.3	185	189	60	5	55		8.0		8
	10/12/53	36	9.0	9.3	35	1.7	65	0	8.3	53	0.1	1.2		185	60	6	54		8.0		8
	10/05/59	39	10	9.9	34	1.9	62	0	9.3	57	0.0	1.3		193	66	15	51	325	8.0		8
	10/29/62	43	11	11	35	1.8	62	0	10	62	0.0	1.4		205	72	21	51	340	8.0		8
	10/11/63	40	11	11	36	2.0	62	0	11	66	0.0	1.4		209	74	23	51	358	8.0		8
	10/12/64	38	11	12	36	2.1	61	0	11	68	0.0	1.3		209	76	26	50	360	8.0		8
	10/08/65	39	12	12	37	2.1	63	0	11	69	0.0	1.2		214	80	28	52	360	8.0		8
	10/21/66	40	12	12	36	2.1	62	0	11	68	0.0	1.2		212	80	29	51	364	8.0		8
	10/20/67	40	12	12	36	2.0	62	0	12	68	0.0	1.4		214	80	29	51	364	8.1		8
	10/16/68	37	12	12	38	2.0	63	0	11	70	0.0	1.5		214	80	28	52	366	8.0		8
	10/17/69	39	13	13	39	2.2	65	0	13	74	0.0	1.5		226	86	33	53	378	8.0		8
	10/16/70	39	13	13	40	2.2	63	0	13	77	0.0	1.5		229	86	34	52	383	8.0		8
	10/19/71	40	13	14	41	2.2	65	0	13	80	0.0	1.5	270	236	90	37	53	403	8.0		8
2052-09	02/18/72	44	17	17	45	2.3	63	0	19	100	0.0	0.4	294	275	110	58	52	495	7.7		1
2053-05	04/27/09	15	6.6	1.4	80		75	0	13	85			240	237	22	0	61				6
	11/ /17	30	17	15	46		59	0	28	89			283	254	104	55	48				6
	12/11/57	58	22	35	41		61	0	38	136	0.1	0.2	506	360	199	149	50		6.8		3
	06/26/62	35	31	26	64		71	0	29	171	0.2	0.8	850	391	185	125	60		8.0		3
	09/01/65	25	39	33	65	4.2	63	0	21	205	0.0	1.9	700	425	234	182	52		7.9		3
	10/17/67	30	36	32	60	6.5	54	0	22	205	0.1	1.4	660	419	222	178	44		7.6		3
2053-09	08/23/47	25	50	36	104		61	0	33	280	0.1	0.4	843	558	274	224	50		7.9		3
	12/23/57	15	62	63	74		60	0	42	360	0.2	0.4	1140	646	418	369	49		7.3		3
	06/26/62	37	90	76	69		62	0	52	450	0.4	0.7	1430	805	536	485	51		7.7		3
	06/16/67	23	87	84	115	5.4	46	0	42	560	0.1	1.3	1340	940	565	527	38		6.8		3
	01/03/68	23	87	106	96	8.8	46	0	46	550	0.1	1.6	1590	941	652	614	38		7.5		3
	05/25/70	30	96	94	110	7.5	54	0	52	600	0.1	0.4	1690	1020	670	626	44		7.4		3
	02/23/71		115	52	123	9.2	80	0	61	515	0.0	0.4	2130	915	74	8	66		7.6		3
2053-10	06/12/68		24	18	76	3.2	62	0	37	147	0.2	4.0	363	339	134	83	51	677	7.9		1
	05/02/69	43	30	31	77	2.2	96	0	51	167	0.0	3.4	447	452	202	124	79	819			1
	05/05/70	44	24	25	69	3.0	87	0	39	145	0.5	3.3	410	395	163	92	71	710	7.9		1
	02/18/72	47	24	25	74	2.9	95	0	42	150	0.0	0.6	396	412	160	82	78	737	7.8		1
2053-11	02/ /66	36	18	16	43	2.1	65	0	18	99	0.4	0.0	294	264	110	57	53	451	7.1		1
	02/01/67	8	23	13	48	2.6	74	0	18	97	2.4	0.2	260	248	111	50	61	469	8.1		1
	05/05/70	39	17	17	44	2.2	64	0	17	98	0.1	2.1		267	112	60	52	479	8.2		1
2053-12	11/26/68	30	383	363	225	30.0	45	0	1.5	2300	0.3	1.4	2700	3360	2450	2410	37		7.3		3
2101-122	06/08/11	12	16	15	88		118	0	16	126			322	331	102	5	97				6
2102-022	06/08/11	2.6	52	55	94		41	0	52	334			615	609	356	322	34				6
2153-02	03/06/28	63	17	12	38	3.1	84	0	15	63		0.4	255	252	92	23	69				1
2153-03	03/02/09	22	9.7	10	42		69	0	11	64			198	192	65	8	57				6
2153-04	12/13/09	15	18	10	50		81	0	12	85			236	229	86	19	66				6
2153-05	02/13/13	7.0	13	11	47		79	0	14	70			212	200	78	13	65				6
	10/15/15	31	13	10	38		79	0	11	56				197	74	9	65				6
	04/ /20	35	14	12	43		69	0	12	79				228	84	27	57				6
	11/20/26	8.0	13	8.6	21	18	43	0	14	70			177	173	68	32	35				6
	12/ /28	36	8.5	13	41	2.5	85	0	11	67			224	220	74	4	70				6
	11/18/29	39	12	12	41	4.5	71	0	12	67			224	222	79	20	58				6
2153-06	01/05/55	30	48	16	32		55	0	40	103	0.1	0.2	392	296	186	141	45		7.3		3
2153-07	02/ /66	42	12	11	35	1.7	63	0	9.8	68	0.1	0.0	220	209	74	22	52	333	7.1		1
	02/01/67	36	12	11	34	2.2	62	0	10	66	0.1	1.4	220	204	75	24	51	343	7.8		1
	06/13/68	42	11	11	35	2.0	62	0	10	64	0.2	2.0	222	207	72	21	51	347	7.8		1
	04/30/69	40	12	10	34	1.8	57	0	9.4	62	0.1	1.4	205	198	71	24	47	514	7.1		1
	05/05/70	40	12	12	36	2.2	64	0	10	70	0.1	2.2	223	216	80	28	52	356	8.0		1
	02/03/72	44	13	12	38	2.0	62	0	12	76	0.0	0.4	200	227	82	31	51	381	7.6		1
2155-04	02/ /66	42	22	19	52	3.0	63	0	20	138	0.1	0.1	394	327	132	80	52	568	7.6		1
	02/01/67	42	22	20	57	3.6	62	0	20	134	0.2	1.6	342	331	138	86	51	592	7.8		1
	06/13/68	42	22	19	59	3.1	64	0	21	133	0.1	2.2	348	332	133	81	52	601	7.6		1
	05/05/70	42	20	20	57	3.1	66	0	18	131	0.1	2.5	356	325	132	80	52	585	8.0		1
	02/03/72	45	19	18	57	3.0	60	0	19	130	0.0	0.4	338	320	120	71	49	577	7.6		1

Chemical Analyses of Oahu Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
2153-01	11/07/66	41	297	254	690	14	51	0	264	2110	0.3	0.2	4720	3700	1790	1750	42	6380	6.9	22.9	1
2201-032	06/08/11	2.0	12	10	23		33	0	14	58			142	135	71	43	27				6
2201-05	06/08/11	4.2	42	40	70		47	0	43	241			468	463	269	230	38				6
2202-032	06/08/11	1.0	10	8.9	24		17	0	17	58			130	127	62	48	13				6
	05/12/55	68	54	21	49		73	6	76	150	0.2	1.2	496	461	223	163	60		8.0		3
2202-152	06/08/11		11	9.7	29		13	0	16	72			150	144	67	56	10				6
	06/08/54	72	101	33	101		63	0	72	365	0.1	1.2	928	776	391	339	52		7.6		3
2203-012	11/04/08	50	39	31	88		118	0	27	206			512	499	225	128	97				6
	10/26/11		23	27	88		75	0	25	194			398	393	168	106	62				6
	08/ /21	53	29	36	100		134	0	32	212			546	528	220	110	110				6
	09/ /29	25	31	21	106		136	0	29	181			467	459	164	52	112				6
2245-02	11/22/67	25	6.9	8.7	13	2.7	66	0	3.0	18	0.0	2.3	120	112	53	0	54		7.1		3
2255-03	02/08/72	46	38	34	85	4.1	88	0	37	230	0.1	1.6		519	235	163	72	957	7.2	22.0	1
2255-072	08/18/66	62	8.0	8.0	50	3.1	76	0	17	54	0.1	5.8	284	245	76	14	62		6.9	22.0	8
	06/21/67	64	13	14	50	2.8	63	0	18	96	0.2	5.1	358	294	112	60	52		7.2	21.7	8
2255-22	12/07/71		35	33	116	5.1	109	0	54	245		4.6		546	223	133	89		6.9		1
	12/07/71		43	40	96	5.2	82	0	59	260		1.9		545	272	204	67		7.0		1
	12/07/71		80	69	124	7.2	69	0	69	455		1.1		839	483	427	56		6.9		1
2255-23	12/07/71		36	34	108	5.3	120	0	55	220		4.2		521	229	131	98		7.2		1
	12/07/71		84	74	132	7.6	72	0	73	490		1.2		897	514	455	59		7.0		1
2255-24	11/29/71		37	35	98	5.6	121	0	53	212		4.9		505	236	137	99		7.3		1
2255-25	11/29/71		37	35	106	5.1	102	0	53	240		3.1		529	236	152	84		6.9		1
	11/29/71		51	46	92	5.7	76	0	54	295		1.0		582	316	254	62		6.8		1
2255-352	04/18/68	46	23	25	83	9.5	101	0	26	175	0.2	6.6	500	444	159	76	83		7.4		3
2255-37	03/07/68	51	18	19	96	4.5	92	0	29	158	0.1	6.3		427	120	45	75	758	7.1		8
2256-052	02/11/54	32	45	16	32		77	0	16	122	0.1	1.2	460	302	178	115	63		7.6		3
2256-10	02/27/23	16	28	21	71		102	0	33	138			362	357	156	72	84				6
2300-072	11/ /21	28	20	17	80		53	0	30	155			360	356	120	76	43				6
	06/17/54	41	43	16	75		51	0	56	150	0.1	0.6	504	406	172	130	42		8.1		3
2300-18	12/02/47	62	20	16	81		87	0	40	132	0.1	5.3	411	399	117	45	71		7.4		3
2300-19	08/14/58	46	21	24	44		65	0	41	122	0.2	0.2	456	330	153	100	53		8.1		3
2301-012	11/04/08	44	26	17	55		61	0	25	127			328	324	135	84	50				6
	05/ /20	74	21	11	52		4	0	42	113			396	314	98	94	3				6
	09/ /29	16	24	1.4	76		73	0	30	99			286	282	66	6	60				6
2301-112	11/04/08	50	24	19	51		57	0	21	129			328	322	138	91	47				6
	09/ /29	30	57	43	282		59	0	89	559			1090	1090	319	270	48				6
2301-212	11/04/08	36	23	19	52		55	0	24	127			322	308	135	89	45				6
	09/ /29	24	35	22	127		85	0	52	234			539	535	178	108	70				6
2301-272	09/ /29	23	38	28	138		61	0	49	284			598	590	210	159	50				6
2301-34	09/24/59	71	15	15	104	4.1	91	0	49	137	0.2	12		459	100	26	74	745	7.0		8
	10/15/64	76	14	15	91	3.8	90	0	41	122	0.2	10		418	96	25	71	652	7.0		8
	02/28/68	71	14	16	86	3.8	89	0	39	120	0.2	9.2		403	100	28	72	665	7.0		8
2302-01	08/18/58	66	18	20	84		110	0	54	126	0.1	4.0	436	426	129	39	90		8.0		3
	08/05/59	74	17	17	85	3.7	106	0	48	112	0.2	10		419	114	28	86	665	7.1		8
	10/15/64	73	14	15	80	3.4	106	0	39	98	0.2	11		386	96	9	87	597	6.8		8
	11/04/66	76	14	15	78	0.7	109	0	39	98	0.3	3.3	392	377	97	8	89	587	7.2	21.8	1
	02/28/68	73	14	16	80	3.6	107	0	37	103	0.2	8.4		388	101	13	88	622	7.1		8
2302-02	08/05/59	73	17	17	101	3.7	111	0	51	130	0.2	11		459	115	24	91	750	7.1		8
	05/26/72	75	16	17	96	3.9	108	0	39	135	0.2	8.0		443	110	21	89	699	7.7	22.4	1
2349-03	09/18/62	34	13	6.5	17	1.5	76	0	3.6	22	0.0	0.4		135	59	0	62	205	7.8		8
2354-01	09/21/49	39	8.3	7.3	25		66	0	5.1	32	0.1	1.0	150	150	51	0	54		8.0		8
	10/22/51	41	7.8	7.0	24	2.0	66	0	4.6	30	0.0	1.3	150	150	48	0	54		8.0		8
	10/12/53	42	8.0	7.1	24	1.7	65	0	5.1	31	0.1	1.6		152	49	0	53		8.0		8
	10/05/59	38	10	8.6	26	1.8	64	0	6.7	41	0.0	1.9		165	60	8	52	264	8.0		8
	10/29/62	40	11	9.1	26	1.9	64	0	7.4	44	0.0	1.4		172	64	12	52	272	7.9		8
	10/11/63	40	11	9.5	28	1.9	64	0	7.6	47	0.0	1.4		178	66	13	53	285	8.0		8
	10/12/64	40	11	9.1	27	2.0	64	0	7.4	45	0.0	1.1		174	64	12	52	273	7.8		8
	10/08/65	40	11	9.4	27	2.1	64	0	7.7	47	0.0	1.2		177	67	15	52	281	8.0		8
	10/21/66	43	11	9.9	26	2.1	64	0	7.7	47	0.0	1.0		179	69	17	52	288	7.9		8
	10/20/67	42	11	9.8	26	1.9	62	0	7.6	47	0.0	1.4		177	68	17	51	286	8.0		8
	10/16/68	37	11	9.3	26	1.9	63	0	7.1	46	0.0	1.5		171	66	14	52	276	8.0		8
	10/17/69	41	11	10	26	2.1	66	0	7.5	46	0.0	1.5		177	69	15	54	273	8.0		8
	10/16/70	41	11	9.4	27	2.0	66	0	7.4	46	0.0	1.6		178	66	12	54	276	8.0		8
	10/19/71	41	12	9.9	28	2.0	66	0	7.9	49	0.0	1.3	217	183	71	17	54	285	8.0		8
2355-05	04/20/58	38	5.9	20	20		77	0	17	38	0.1	0.3	174	177	100	37	63		6.9		3
2355-06	03/08/68	41	14	14	51	2.6	86	0	15	81	0.1	5.0		266	90	20	70	455	7.6		8
2355-10	05/25/65	45	12	12	34	2.3	78	0	9.6	54	0.0	1.6		209	76	12	64	315	7.9		8
	10/21/66	43	9.3	8.0	25	2.0	72	0	4.9	33	0.1	1.7		162	56	0	59	247	7.8		8
	10/25/67	44	9.6	8.5	23	1.8	72	0	4.6	32	0.0	1.2		160	58	0	59	243	7.9		8
	10/16/68	43	9.4	8.4	25	1.8	72	0	5.1	34	0.0	2.9		165	58	0	59	246	7.8		8
	10/17/69	44	9.2	8.4	25	1.8	73	0	5.1	33	0.0	1.7		164	57	0	60	235	7.9		8
	10/16/70	43	8.9	7.8	25	1.7	73	0	4.6	31	0.0	2.0		160	54	0	60	235	7.8		8
	10/19/71	43	8.7	7.9	24	1.7	74	0	4.4	29	0.0	1.7	195	157	54	0	61	224	7.7		8
2356-02	10/25/49	45	46	34	70		55	0	32	240	0.1	0.4	624	494	264	219	45				3

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Chemical Analyses of Oahu Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
2356-13	10/13/47	34	16	12	33		65	0	11	64	0.1	1.3	254	203	87	33	53		8.1		3
2356-34Z	07/01/54	25	196	65	126		45	0	105	565	0.1	0.2	1780	1100	760	723	37		7.8		3
2356-49	03/07/68	37	18	17	27	2.4	56	0	11	82	0.0	1.5		223	113	67	46	405	7.9		8
2356-51	02/11/58	45	310	312	538	15	59	0	263	2100	0.0	1.3	4250	3620	2120	2070	48	6220	7.6		1
	02/11/58	39	736	757	2070	35	65	0	843	6310	0.0	0.0	12800	10800	5040	4990	53	16700	7.2		1
	11/07/66	41	265	233	375	10	52	0	232	1530	0.2	0.3	3560	2710	1620	1580	43	4700	6.8	23.7	1
2357-09	04/26/38	45	15	12	72		65	0	27	122			362	325	90	36	53		7.4		3
2357-21	05/16/63	38	31	28	86	2.0	83	0	32	206	0.0	3.1	722	466	194	126	68		7.2		3
2358-02	12/15/69	39	136	145	635	15	52	0	204	1500	0.0	0.4		2700	936	894	42	4940	7.8	20.5	1
2358-03Z	01/29/09	21	42	31	61		73	0	42	187			430	419	232	172	60				6
	11/17/10	16	37	29	60		57	0	38	180			389	388	211	164	47				6
2358-08	12/15/69	41	87	100	370	9.5	44	0	120	910	0.0	0.1		1660	628	592	36	3100	7.5	20.5	1
2358-13	05/18/26	25	31	18	98		73	0	32	192				431	151	91	60				6
2358-21	12/15/69	45	31	27	87	3.3	60	0	31	210	0.1	0.6		464	188	140	49	854	7.7	21.0	1
2358-22	12/15/69	47	16	15	69	2.6	68	0	26	124	0.1	1.9		335	102	46	56	565	7.9	21.0	1
2358-23	12/15/69	43	63	72	235	7.9	50	0	81	600	0.0	0.8		1130	453	412	41	2160	7.3	20.5	1
2358-24	12/15/69	43	48	52	174	6.2	52	0	58	445	0.0	1.1		852	334	292	42	1630	7.6	20.5	1
2358-26	12/15/69	46	28	26	84	3.3	59	0	30	201	0.0	1.5		448	177	145	48	820	7.5	21.0	1
2358-27	12/15/69	43	21	19	68	3.1	64	0	20	144	0.0	2.1		351	130	78	52	632	7.7	21.0	1
2358-28	12/15/69	41	33	31	86	4.2	55	0	33	230	0.0	1.3		486	210	165	45	912	7.5	20.5	1
2358-29	12/15/69	44	32	34	108	4.3	56	0	38	268	0.0	1.2		557	220	174	46	1050	7.8	21.0	1
2358-32	12/15/69	44	11	9.3	63	2.2	65	0	16	94	0.1	1.4	273	273	66	12	53	452	7.7	21.0	1
2358-33	12/15/69	44	12	11	63	2.5	63	0	18	100	0.0	2.3		283	75	24	51	474	8.0	21.0	1
2358-34	12/15/69	46	15	13	68	2.6	64	0	20	116	0.2	2.0	314	314	91	38	52	535	7.9	21.0	1
2358-37	12/15/69	51	18	16	96	3.4	82	0	23	158	0.1	4.7	410	410	111	44	67	710	7.9	22.0	1
2358-42	12/15/69	44	54	60	152	6.7	50	0		438	0.0	0.9		780	382	340	41	1620	7.8	20.5	1
2358-44	12/15/69	50	18	18	66	2.6	57	0	20	138	0.0	2.2		342	119	72	47	597	7.5	21.0	1
2359-05	12/15/69	66	70	74	138	7.4	64	0		465	0.1	7.2		859	479	426	52	1750	8.0	22.5	1
2359-06	12/15/69	66	39	38	106	5.0	72	0		280	0.1	5.4		574	254	195	59	1130	7.9	22.5	1
2359-14	12/15/69	66	124	130	220	11	56	0		840	0.0	5.4		1420	844	798	46	2850	7.6		1
2359-15	12/15/69	64	136	150	320	14	60	0		1050	0.0	4.1		1770	956	908	49	3520	7.9	22.0	1
2359-16	12/15/69	62	210	240	480	21	53	0		1650	0.1	4.0		2690	1510	1470	43	5320	7.7	22.0	1
2359-17	12/15/69	65	156	175	295	14	56	0		1110	0.0	5.4		1850	1110	1060	46	3680	7.9	22.0	1
2400-01	05/12/55	50	25	9.8	63		82	0	38	94	0.2	1.6	376	321	108	41	67		7.8		3
	02/28/68	57	8.4	7.9	73	2.6	89	0	21	80	0.4	7.6		302	53	0	72	485	7.4		8
2432-01	05/21/71	71	13	18	79	3.5	106	0	37	105	0.3	8.3		388	106	19	87	601	7.2		8
2448-01	09/02/66	25	8.6	7.7	20	4.8	78	0	3.0	21	0.0	0.7	120	129	53	0	64		7.2		3
	02/16/68	32	9.5	7.9	17	5.4	71	0	2.5	21	0.1	0.5	120	130	56	0	58		6.9		3
	04/ /72	32	11	7.0	17	1.4	76	0	4.0	20	0.1	1.0		130	57	0	62	187	8.1	20.5	1
2458-01	10/30/47	52	9.4	7.7	99		79	0	24	134	0.1	1.8	373	366	55	0	65		7.2		3
2459-01Z	11/04/08	34	46	47	231		53	0	59	501			954	944	308	264	43				6
	09/ /29	4.3	35	28	161		53	0	48	326			643	628	202	158	43				6
2459-06Z	09/ /29	33	54	43	254		55	0	83	519			1030	1010	312	266	45				6
2459-19	05/21/71	60	10	11	63	2.5	81	0	19	82	0.2	8.2		296	70	4	66	453	7.2		8
2501-01	05/18/26	56	27	31	76		234	0	4.5	121				430	195	3	192				6
2538-02	08/08/39	88	49	130	94		400	0	30	360			1150	948	655	327	328		7.4		3
	02/27/39	87	40	111	68		402	0	27	250			1230	781	540	210	330		7.4		3
	10/06/71	92	36	102	92	7.9	338	0	22	292	0.2	8.5		819	510	233	277	1420	7.8	29.0	1
	10/06/71	89	41	108	126	9.6	313	0	25	382	0.2	8.7		943	547	290	257	1670	7.7	29.0	1
2550-01	04/26/72	28	5.7	4.2	14	0.6	40	0	4.0	18	0.1	0.0		94	32	0	33	128	7.5	22.8	1
2557-01	10/30/47	50	9.2	6.3	22		74	0	6.2	26	0.1	1.3	155	157	49	0	61		7.8		3
2557-02	11/29/67	43	6.9	7.4	22	6.5	71	0	4.5	23	0.1	2.3	160	150	48	0	58		7.4		3
2558-10	05/17/62	61	12	11	57	2.3	63	0	14	91	0.2	2.8	299	282	74	22	52	454	7.1		1
	04/24/63	58	12	12	61	2.7	64	0	15	103	0.2	6.4	317	303	80	28	52	489	7.1		1
	05/01/63	58	12	12	59	2.4	63	0	14	102	0.7	6.1	315	297	80	29	51	483	7.1		1
	09/30/64	54	13	12	62	2.8	62	0	14	107	0.2	4.5	311	301	84	32	51	497	7.1		1
2600-02	12/10/57	12	10	16	26		87	0	24	28	0.1	0.5	138	159	94	23	71		6.6		3
2603-01	11/01/66	75	17	15	26	0.9	83	0	23	48	0.2	3.8	269	249	104	36	68	349	6.6	22.8	1
	05/26/72	75	17	16	28	2.2	84	0	20	53	0.1	9.6		262	109	40	69	357	7.6	22.0	1
2607-01	02/16/72	65	13	12	38	2.8	113	0	8.5	46	0.3	4.3		245	82	0	93	350	7.5	24.3	1

Chemical Analyses of Oahu Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
2632-01	08/11/71	24	4.2	3.0	8.5	0.9	27	0	2.4	14	0.1	1.2		71	23	0	22		7.3	19.5	1
2733-01	12/06/49	17	50	8.1	11		170	0	13	23	0.1	1.3	222	207	162	22	139				3
	11/28/67	61	9.5	10	30	10	85	0	12	36	0.2	0.8	230	211	65	0	70		6.9		3
2751-02	03/10/72	34	8.0	5.0	12	1.0	55	0	2.6	17	0.1	0.1		106	41	0	45	143	7.1	19.5	1
2800-01	05/21/71	64	7.6	6.6	15	1.4	56	0	6.9	18	0.1	1.3		148	46	0	46	163	7.3		8
	05/26/72	63	7.7	6.3	14	1.4	58	0	6.5	17	0.1	0.9		145	45	0	47	160	7.4	21.8	1
2803-01	02/16/72	63	66	28	120	3.4	97	0	222	160	0.3	0.3		710	2800	2000	80	1260	7.8	26.7	1
2901-07	05/15/62	74	9.5	6.2	15	1.2	53	0	5.8	18	0.2	1.1	169	161	49	2	48	175	6.7	20.0	1
	05/15/62	74	9.5	6.3	15	1.3	59	0	5.6	18	1.1	1.0	173	161	50	1	48	177	6.9	20.0	1
	04/24/63	66	9.0	7.3	14	1.7	62	0	4.0	19	0.9	0.9	160	153	52	2	51	185	7.0		1
	04/24/63	66	9.5	6.9	13	1.1	63	0	4.2	18	0.1	1.2	155	151	52	0	52	171	7.0	21.1	1
	05/ /65	55	8.7	7.1	15	1.0	68	0	6.8	20	0.1	2.2	176	149	52	0	56		7.4		8
	01/19/65	68	8.0	7.0	14	1.3	60	0	5.4	18	0.2	1.2	160	153	48	0	49	170	7.3		1
	05/26/72	69	8.8	7.2	14	1.2	64	0	5.3	19	0.1	1.6		157	52	0	52	174	7.6	21.6	1
2901-08	01/17/49	79	10	7.4	15		67	0	8.7	22	0.1	0.9	193	176	65	10	55				3
	05/26/72	72	8.8	6.4	17	1.3	64	0	7.3	19	0.1	2.8		166	49	0	52	183	7.3	22.7	1
2901-09	11/02/49	41	5.9	3.3	29		72	0	4.0	21	0.1	0.1	180	139	31	0	59				3
	06/25/58	82	10	18	6.2		80	0	11	21	0.8	0.4	212	188	71	5	66		7.5		3
	11/04/66	75	10	7.8	15	1.0	66	0	7.2	20	0.1	0.0	165	168	57	3	54	182	6.5	21.3	1
2901-11	11/13/64	30	9.2	7.7	17	1.5	64	0	6.1	21	0.1	3.5		128	54	1	53	203	6.7		8
	05/26/72	74	9.2	7.0	16	1.3	66	0	5.9	19	0.1	3.8		168	52	0	54	187	7.5	21.5	1
3213-06	02/17/72	61	17	20	132	3.0	106	0	36	225	0.2	2.4		547	125	38	87	970	7.4	24.7	1
3251-01	04/26/72	43	24	21	118	5.4	85	0	34	232	0.1	1.0		520	147	77	70	931	7.8	22.5	1
3307-01Z	11/12/47	70	44	55	240		93	0	90	520	0.2	0.9	1230	1060	334	258	76		7.1		3
3314-01	02/17/72	65	50	73	224	7.2	135	0	81	510	0.3	8.0		1090	425	315	111	2010	7.5		1
3314-02	02/17/72	78	45	70	188	6.0	135	0	55	470	0.0	4.6		983	401	290	111	1780	7.7	25.7	1
3332-01	04/21/72	39	13	8.8	28	1.4	85	0	6.9	38	0.1	0.5		177	69	0	69	269	7.6	22.7	1
3405-02	04/09/57	76	8.1	15	65		104	0	24	86	0.2	1.2	350	326	84	0	85		7.1		3
3405-03	04/27/72	74	11	11	80	3.0	104	0	24	98	0.2	8.9		361	73	0	85	546	7.7	22.3	1
3405-05	04/28/72	79	22	21	116	4.2	97	0	51	145	0.1	84		570	142	62	80	863	7.5	23.4	1
3405-06	04/28/72	75	13	15	92	4.4	104	0	30	126	0.2	9.6		416	94	9	85	642	8.0	22.8	1
3407-02	04/28/72	72	13	14	80	4.6	98	0	27	112	0.2	9.6		380	90	9	80	587	7.7	22.3	1
3407-07Z	12/13/63	75	10	21	117	6.5	102	0	39	190	0.0	4.4	516	513	112	28	84		6.8		3
	12/05/67	60	14	20	83	14	112	0	24	135	0.2	10	440	415	115	23	92		7.0		3
	04/28/72	69	20	38	268	14	104	0	74	460	0.2	6.2		1000	207	122	85	1800	7.6	22.0	1
3407-30	04/28/72	36	108	57	420	18	323	0	121	745	0.1	8.8		1670	505	235	269	3000	7.8	24.7	1
3409-09	05/08/57	46	30	33	71		56	14	27	180	0.2	1.6	630	430	210	140	70		8.6		3
3409-13	05/19/72	56	38	32	86	4.9	114	0	32	205	0.1	9.0		519	227	133	93	908	7.5	22.4	1
3409-16	04/28/72	57	32	32	56	4.5	120	0	23	150	0.1	7.8		421	212	113	98	715	7.9	22.0	1
3409-17	10/07/71	41	25	32	102	8.0	125	0	33	202	0.0	0.1		504	194	92	102	906	7.9		1
3410-03	05/19/72	16	27	24	35	3.2	106	0	17	100	0.2	5.4		280	166	79	87	532	7.6	21.9	1
3410-05	05/19/72	1.8	29	18	58	4.0	56	0	9.5	160	0.0	0.2		308	147	101	46	628	7.5	23.5	1
3411-04Z	08/06/14	29	56	51	82		61	0	46	304			606	597	349	298	50				6
	12/29/21	30	32	29	70		81	0	24	185				409	199	132	66				6
	05/19/72	52	43	42	94	6.2	90	0	41	265	0.0	3.4		590	280	206	74	1090	7.6	21.0	1
3412-02	09/28/64	47	20	19	66	4.8	78	0	20	134	0.2	3.3	382	352	127	63	64	617	7.5		1
	10/09/64	47	18	19	67	5.2	77	0	19	134	0.2	2.8	376	350	124	61	63	617	7.4	21.0	1
	01/19/65	47	18	19	66	4.6	78	0	22	135	0.2	1.6	372	352	125	61	64	611	7.7		1
	06/30/72	51	18	17	78	4.4	80	0	22	143	0.1	2.0		374	115	50	65	633	7.4		1
3453-01	01/24/38	35	8.5	11	46		71	0	8.6	75			246	219	70	11	58		7.6		3
	09/16/54	26	30	10	31		56	0	30	88	0.0	0.6	272	243	118	72	46		7.8		3
3453-03	04/21/72	32	13	10	24	1.6	54	0	7.9	54	0.2	0.0		169	74	29	44	280	7.3	20.1	1
3503-01Z	12/30/21	56	13	10	63		102	0	22	74				288	74	0	84				6
	04/27/72	71	8.8	9.1	64	3.0	92	0	21	73	0.2	6.0		301	60	0	75	432	7.5	22.0	1
3505-03	04/27/72	72	11	10	62	3.1	111	0	21	70	0.2	7.4		306	69	0	82	438	7.8	22.0	1
3505-05	10/14/53	62	23	16	71		55	0	30	137	0.2	1.2	608	367	125	80	45		7.1		3
3505-06	04/27/72	71	13	13	70	3.8	104	0	23	92	0.2	8.1		345	86	1	85	519	7.7	22.1	1
3505-07	04/13/72	50	11	11	68	3.5	98	0	23	85	0.2	9.0		308	73	0	80	491	7.9	22.3	1
3553-01	06/17/40	36	15	11	41		63	0	14	74			248	222	76	24	52		7.8		3
3553-02	10/27/71	19	13	7.8	24	1.0	73	0	7.2	44	0.0	0.3	202	152	60	0	60		6.9		3
	04/21/72	36	12	8.2	25	1.3	54	0	7.5	48	0.1	0.0		164	64	19	44	255	7.4	20.8	1
3553-05	07/18/69	1.4	16	14	55	2.7	48	0	0.0	127	0.1	0.0	233	239	98	58	39	497	7.9	23.0	1
3553-06	10/27/71	15	24	23	37	3.0	134	0	14	100	0.0	0.2	460	267	140	55	85		7.0		3
	04/21/72	44	20	17	37	1.9	76	0	12	94	0.2	0.0		263	120	58	62	448	7.5	21.5	1
3553-07	05/15/67	45	9.5	7.0	23	1.5	73	0	4.7	27	0.0	0.6		154	52	0	60	218	8.0		8

Chemical Analyses of Oahu Ground Water (continued)

WELL NO	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
3553-07	10/27/71	24	18	11	25	1.0	94	0	7.3	48	0.0	0.2	246	180	80	3	77		6.9		3
	04/21/72	42	14	11	24	1.4	66	0	7.9	52	0.1	0.0		184	80	26	54	287	7.3	21.8	1
3535-01	12/30/21	34	16	7.2	113		83	0	30	152				393	70	1	68				6
3635-03	03/30/72	64	18	33	328	13	74	0	82	545	0.2	4.0		1120	181	120	61	2050	7.8	21.3	1
3503-15	03/30/72	64	14	24	228	9.1	78	0	60	370	0.2	6.0		813	134	70	64	1460	7.6	21.6	1
3535-16	03/30/72	64	17	28	252	9.8	79	0	66	420	0.2	5.6		901	158	93	65	1610	7.9	21.5	1
3605-23	03/30/72	65	14	22	212	8.4	80	0	54	335	0.2	5.6	755	755	126	60	66	1320	8.0	21.6	1
3654-02	04/20/72	35	13	9.5	27	1.5	74	0	5.9	48	0.1	0.0		176	72	11	61	283	7.8	21.2	1
3553-01	04/20/72	36	9.7	8.4	26	1.1	82	0	5.0	33	0.1	0.0		159	59	0	67	239	7.7	21.3	1
3704-01	01/16/57	51	19	46	275		30	0	80	495	0.2	1.2	1200	1010	240	174	66		7.1		3
	12/12/67	76	7.8	8.4	68	10	94	0	18	70	0.2	8.2	330	312	54	0	77		6.9		3
	04/05/72	64	15	35	292	12	78	0	74	490	0.1	4.6		1030	182	118	64	1880	7.5	21.8	1
3753-02	04/20/72	36	11	8.0	26	1.1	77	0	5.9	36	0.1	0.1		162	61	0	63	244	7.5	22.8	1
3753-04	04/20/72	36	8.2	7.5	25	1.1	74	0	5.0	30	0.2	0.0		149	52	0	60	214	7.8	21.0	1
3955-05	04/20/72	43	8.1	7.1	25	0.8	62	0	5.9	35	0.1	0.2		155	49	0	50	220	7.5	21.5	1
3955-07	11/28/60	41	22	13	31		77	0	20	74	0.2	0.2	314	239	109	46	63		7.6		3
	10/28/69	36	50	7.2	18	<0.2	84	0	4.0	76	0.0	0.0	250	232	104	35	69		7.1		3
	01/12/72	45	16	8.4	33	1.1	78	0	8.9	54	0.1	0.8		205	75	11	64	321	7.2		1
3355-09	04/20/72	36	130	64	71	2.6	45	0	44	425	0.1	0.0		764	513	476	37	1510	7.6		1
3855-10	03/22/62	33	12	10	31		74	0	9.1	47	0.1	0.5	208	179	70	8	62		8.0		3
3834-07	02/06/69	47	12	13	32	1.0	102	0	10	48	0.4	3.0		217	85	1	84		7.5	24.0	7
	05/01/69	56	12	13	35	1.0	92	0	9.0	50	0.0	1.2		224	84	9	75		7.5	22.5	7
	08/12/69	84	13	11	31	0.8	88	0	15	38	0.1	1.8		238	78	6	72		7.6	22.5	7
	11/13/69	36	11	13	33	9.0	92	0	22	49	0.3	0.8		220	80	6	75		7.7	22.5	7
	01/20/70	51	19	7.9	31	1.1	92	0	11	40	0.3	3.1		210	80	5	75		7.3	23.0	7
3932-01	10/21/47	56	18	25	140		77	0	36	250	0.1	1.3	616	564	145	82	63		7.3		3
3955-01	09/27/51	28	101	71	52		44	0	50	405	0.0	0.1	1350	728	544	508	36		7.5		3
	09/16/54	27	37	11	18		35	0	36	72	0.0	0.4	270	218	139	110	29		7.3		3
3355-01	02/23/68	34	46	35	50	5.4	63	0	19	220	0.0	1.5	640	441	261	209	52		7.6		3
	09/04/68	40	55	47	50	2.8	63	0	24	242	0.6	0.4		496	330	279	52		7.8	25.0	7
	10/31/68	42	52	35	51	2.9	60	0	23	230	0.0	1.1		468	272	225	49		7.5	25.0	7
	01/30/69	45	48	39	44	2.5	65	0	24	208	0.3	1.4		444	282	227	53		7.2	22.0	7
	05/01/69	42	51	35	53	3.3	65	0	23	208	0.0	0.9		450	270	217	53		7.5	22.0	7
	08/12/69	59	53	33	45	4.1	64	0	23	200	0.0	1.8		452	266	220	52		7.7	22.0	7
	11/13/69	31	48	37	48	3.0	64	0	22	214	0.2	1.4		438	270	218	52		7.8	22.5	7
	01/20/70	42	60	29	44	3.2	66	0	21	205	0.2	2.8		442	270	215	54		7.7	22.0	7
	07/30/71	26	55	36	51	2.9	58	0	24	228	0.2	0.8		452	285	238	48	883	6.8		1
3356-02	07/30/71	39	130	84	78	4.3	49	0	53	535	0.1	0.6		948	671	631	40	1880	6.8		1
3955-03	09/04/68	46	17	14	30	1.1	93	0	13	52	1.5	2.0		223	100	24	76		7.7	23.0	7
	10/31/68	50	16	13	32	1.3	91	0	13	50	1.0	3.4		225	94	19	75		7.5	22.5	7
	01/30/69	43	17	13	29	1.3	91	0	13	58	1.3	3.0		224	95	21	75		7.0	22.0	7
	05/01/69	52	17	14	30	1.7	91	0	12	49	0.0	2.3		224	98	23	75		7.5	22.0	7
	08/12/69	74	16	15	26	1.5	92	0	12	49	0.1	1.4		241	100	26	75		7.5	22.2	7
	11/13/69	35	17	14	31	1.2	90	0	11	54	0.2	3.8		212	98	24	74		7.7	22.0	7
3936-04	04/13/72	41	14	11	35	1.4	90	0	9.9	52	0.1	1.5		210	80	6	74	330	8.0		1
3936-05	09/04/68	46	17	17	28	1.2	96	0	13	50	0.8	2.3		226	112	34	78		7.6	22.0	7
	10/31/68	50	18	11	31	1.3	88	0	13	51	0.1	2.8		222	90	18	72		7.4	22.0	7
	01/30/69	44	16	14	28	1.2	92	0	13	58	0.8	3.2		225	98	23	75		6.8	22.0	7
	05/01/69	50	17	12	30	1.2	92	0	12	46	0.1	2.8		217	92	17	75		7.6	22.0	7
	08/12/69	72	16	11	30	1.0	92	0	13	48	0.1	3.0		239	85	10	75		7.6	22.0	7
	11/13/69	35	25	7.2	30	1.1	90	0	11	54	0.2	3.0		211	92	18	74		7.7	22.0	7
	01/20/70	48	20	12	27	1.2	92	0	12	49	0.2	4.8		220	100	23	75		7.5	22.0	7
3957-012	02/07/68	43	21	22	53	6.5	66	0	16	145	0.1	2.0	420	341	141	87	54		7.5		3
	10/31/68	54	40	24	42	1.9	85	0	19	140	0.1	1.1		364	200	128	71		7.3	23.0	7
	02/06/69	13	29	9.6	25	3.5	56	0	12	73	0.7	0.6		200	112	58	54		8.3	23.0	7
	05/01/69	56	30	26	43	1.7	98	0	18	124	0.0	3.4		347	180	110	72		7.4	22.0	7
	08/12/69	72	34	26	42	1.5	90	0	29	128	0.1	3.2		383	190	118	74		7.4	24.0	7
	11/13/69	36	41	35	43	1.8	86	0	40	166	0.5	4.2		411	246	226	70		7.6	23.5	7
	01/20/70	25	22	15	29	3.2	62	0	13	86	0.2	1.2		227	118	66	51		7.4	23.0	7
	07/30/71	39	27	21	41	2.1	93	0	15	107	0.2	1.0		299	154	78	76	525	7.3		.
3957-07	02/06/69	61	14	13	51	1.0	106	0	16	58	0.9	5.0		273	88	2	87		7.4	25.0	7
	05/01/69	61	14	11	40	1.2	86	0	12	57	0.1	3.4		243	80	9	70		7.4	22.5	7
	08/12/69	96	16	15	39	1.1	96	0	19	61	0.1	4.2		294	106	31	70		7.4	23.6	7
	11/13/69	40	15	16	45	1.2	88	0	29	68	0.7	4.8		265	102	31	72		7.6	23.0	7
	01/20/70	47	19	12	41	1.6	102	0	13	56	0.4	4.4		246	97	13	84		7.5	23.0	7
	07/30/71	52	13	11	37	1.2	86	0	11	52	0.2	3.6		223	78	7	71	341	7.1		1
	04/12/72	53	12	9.7	44	1.3	97	0	11	52	0.1	3.7		235	70	0	81	350	7.7	22.1	1
4355-01	09/04/68	40	32	28	46	2.6	68	0	19	155	0.6	1.2		370	194	138	56		7.9	21.5	7
	10/31/68	42	34	21	47	3.1	68	0	17	148	0.1	2.1		351	170	116	56		7.4	21.5	7
	01/30/69	47	27	19	40	2.4	72	0	16	123	0.3	1.6		312	145	87	59		6.7	22.0	7
	05/01/69	42	30	26	42	3.2	70	0	18	140	0.1	1.2		338	184	125	57		7.7	21.5	7
	08/12/69	58	23	29	40	3.1	72	0	28	141	0.1	0.0		368	200	143	59		7.7	22.0	7
	11/13/69	30	34	26	41	3.0	70	0	11	150	0.2	1.7		332	194	136	57		7.8	21.8	7
	01/20/70	41	40	22	40	3.0	68	0	19	150	0.2	2.8		353	190	135	56		7.7	22.0	7
	07/30/71	39	34	24	47	3.0	57	0	17	152	0.2	0.9		350	184	129	55	642	6.9		1
4037-012	03/22/62	46	27	19	57		99	0	19	112	0.2	2.4	426	331	146	65	81		7.8		3
	03/27/68	47	30	22	47	7.5	32	0	5.5	130	0.1	4.2	460	333	165	98	67		7.4		3
	10/31/68	44	46	34	48	1.8	72	0	22	195	0.0	4.8		431	254	194	59		7.4	2.6	7
	01/30/69	25	29	25	38	1.4	87	0	17	123	0.5	2.7		304	173	101	71		6.8	20.5	7
	02/06/69	47	29	24	44	1.3	86	0	16	118	0.7	5.6		328	171	100	70		7.3	22.0	7

Chemical Analyses of Oahu Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
4057-012	05/01/69	56	34	26	40	1.7	83	0	18	132	0.2	4.0		368	194	125	68		7.5	22.0	7
	08/12/69	87	39	22	70	1.9	86	0	59	155	0.1	0.7		478	188	117	70		7.4	22.0	7
	01/20/70	50	36	24	33	1.2	84	0	19	123	0.3	8.0		342	190	121	68		7.6	22.0	7
	07/30/71	47	50	36	47	1.8	71	0	23	208	0.2	3.2		451	273	215	58	805	7.5		1
	09/25/72	16	30	21	38	1.4	91	0	18	120	0.1	1.2	480	290	170	95	75		7.2		3
4057-05	09/04/68	3.0	78	50	98	3.4	26	0	1.0	455	0.2	0.0		707	400	378	21		8.0	26.0	7
	10/31/68	2.5	76	61	96	4.0	25	0	0.0	452	0.0	1.1		706	440	419	20		6.9	26.0	7
	01/30/69	1.5	76	75	84	3.4	27	0	1.0	428	0.2	0.0		682	500	477	22		6.5	21.0	7
	05/01/69	2.0	71	64	92	4.0	22	0	1.0	425	0.0	0.0		678	442	423	18		8.2	23.0	7
	08/12/69	2.5	70	51	96	3.7	22	0	0.5	408	0.0	3.2		649	384	365	18		7.9	25.0	7
	11/13/69	1.0	69	55	100	4.0	24	0	11	418	0.1	0.4		671	400	380	19		8.2	22.5	7
	01/20/70	2.5	90	41	82	3.8	24	0	3.0	407	0.2	0.0		645	394	374	19		7.6	22.0	7
4037-06	02/06/69	9.5	85	67	65	2.5	46	0	30	363	0.5	0.0		645	490	452	37		7.3	25.0	7
	05/01/69	45	25	277	165	8.0	63	0	85	1030	0.0	1.2		1680	1200	1150	37		7.5	22.0	7
4157-03	10/31/68	0.0	56	19	37	0.5	10	0	1.0	198	0.1	0.4		317	220	211	8		7.2		7
	01/30/69	0.0	56	19	32	1.2	13	0	0.0	193	0.8	0.0		309	217	206	10		6.5	22.0	7
	05/01/69	1.0	54	15	38	1.4	12	0	0.0	184	0.1	0.0		306	198	188	9		7.6	24.5	7
	08/12/69	2.5	53	14	38	0.9	11	0	0.8	179	0.1	3.8		298	188	178	9		7.7	25.5	7
	11/13/69	1.0	52	20	35	1.3	10	0	5.0	188	0.3	0.0		308	210	201	8		7.1	24.0	7
	01/20/70	1.5	64	9.7	32	1.4	10	0	3.0	188	0.2	0.0		307	200	191	8		7.4	23.5	7
4057-06	08/02/69	59	80	361	66	6.8	63	0	74	1185	0.4	2.2		1800	1680	1630	52		7.5	22.0	7
	11/13/69	32	83	71	70	2.7	70	0	30	380	0.4	2.0		708	500	440	57		7.6	22.5	7
	01/20/70	42	107	42	58	2.8	55	0	31	361	0.2	2.6		677	442	395	45		7.5	23.0	7
	07/30/71	20	106	80	69	2.8	42	0	44	478	0.1	0.0		820	594	560	34	1640	6.8		1
4057-07	04/12/72	46	18	11	37	1.0	99	0	11	53	0.1	2.5		228	90	9	81	356	8.2	22.1	1
4057-10	04/12/72	42	17	11	36	1.5	99	0	9.	55	0.1	1.1		222	88	7	81	350	7.9	22.0	1
4100-01	09/04/68	49	19	19	48	2.5	64	0	17	118	0.5	1.6		309	126	73	52		7.8	25.0	7
	01/30/69	45	19	20	43	2.6	66	0	17	118	0.6	2.0		301	132	78	54		7.3	22.0	7
	05/01/69	52	17	16	45	2.8	66	0	15	97	0.1	1.7		281	110	56	54		7.7	22.0	7
	08/12/69	77	17	16	50	2.8	66	0	21	99	0.5	1.8		319	110	54	54		7.6	22.0	7
	11/13/69	36	18	27	43	2.7	66	0	25	104	0.2	2.1		311	162	103	54		7.8	22.5	7
	07/29/71	46	116	107	265	8.0	79	0	113	802	0.1	0.0		1490	730	666	65	2840	6.8		1
	08/27/71	54	144	153	462	11	68	0	179	1300	0.1	2.8		2340	985	934	56	4310	6.7		1
4100-02	09/21/68	52	12	20	46	1.3	64	0	17	92	0.5	2.3		276	114	60	52		7.3	23.0	7
	10/31/68	51	15	15	51	1.7	68	0	16	98	0.3	1.8		284	100	43	56		7.2	23.0	7
	05/01/69	54	15	17	49	1.6	66	0	13	94	0.0	1.5		283	106	52	54		7.2	22.0	7
	08/12/69	77	15	13	44	1.9	66	0	20	84	0.0	1.5		291	92	37	54		7.4	22.5	7
	11/13/69	36	23	25	55	1.8	84	0	17	134	0.5	2.4		337	160	91	69		7.1	22.0	7
	01/20/70	50	18	15	50	1.6	70	0	18	98	0.1	3.4		291	106	49	57		7.2	22.0	7
4101-03	09/04/68	45	10	8.5	27	1.4	61	0	7.0	43	0.4	1.6		174	60	10	50		6.9	22.0	7
	10/31/68	51	10	8.5	26	1.5	62	0	7.2	43	0.1	2.9		180	60	9	50		6.0	21.5	7
4101-04	09/12/38	47	17	20	102		85	0	30	195			565	452	110	40	70		7.3		3
	05/01/69	54	11	9.8	26	1.4	64	0	7.0	43	0.4	1.5		187	68	16	52		7.5	20.0	7
	08/12/69	77	10	8.5	26	1.9	64	0	11	37	0.5	1.5		206	60	8	52		7.6	20.5	7
	11/13/69	35	15	6.0	24	1.3	64	0	7.0	42	0.2	1.6		164	62	10	52		7.6	22.0	7
	01/20/70	49	12	10	20	1.4	68	0	7.0	38	0.2	3.4		175	72	16	56		7.7	23.0	7
4101-08	06/10/70	48	8.7	8.6	29	1.3	68	0	7.5	39	0.1	1.8		177	57	1	56	257	7.6		8
4157-03	09/04/68	1.0	56	17	35	1.2	10	0	1.0	208	0.5	0.0		327	210	202	8		8.0	26.0	7
4137-04	09/04/68	52	59	44	58	1.8	76	0	25	255	0.5	3.7		538	328	266	62		7.4	21.5	7
	10/31/68	51	54	33	60	2.2	78	0	23	220	0.2	4.1		486	370	207	63		7.2	21.5	7
	02/06/69	47	54	39	63	1.8	110	0	26	208	0.6	0.0		493	296	206	90		7.1	24.0	7
	08/12/69	72	56	34	60	2.3	81	0	34	218	0.0	4.3		525	280	210	66		7.4	21.5	7
	11/13/69	32	53	37	73	2.3	96	0	41	224	1.0	7.1		518	286	207	79		6.8	23.5	7
	01/20/70	49	66	23	54	2.0	102	0	22	198	0.3	10		476	260	175	84		7.7	23.0	7
	08/27/71	54	53	33	60	2.0	86	0	22	222	0.1	4.2		492	268	197	71	901	6.9		1
4158-012	10/31/68	46	129	105	160	7.0	119	0	65	688	0.1	0.8		1260	750	657	98		6.0	25.0	7
	01/30/69	44	157	166	242	5.8	74	0	89	923	0.8	3.2		1670	1080	1020	61		6.8	22.0	7
	08/12/69	67	98	58	110	6.3	110	0	32	448	0.1	0.0		878	485	390	90		7.5	25.0	7
	01/20/70	20	273	56	124	4.0	204	0	47	700	0.4	13.0		1350	912	745	167		7.3	22.0	7
	07/29/71	46	109	69	86	6.4	166	0	21	418	0.2	0.1		838	557	420	136	1620	6.8		1
4153-12	06/12/56	44	47	52	93		85	0	34	340	0.0	4.0	1010	655	332	262	70		6.9		3
	09/04/68	54	52	52	96	1.2	83	0	27	342	0.6	5.5		676	342	276	68		7.3	23.0	7
	10/31/68	54	54	62	102	2.6	84	0	28	342	0.1	4.6		692	390	321	69		7.2	23.5	7
	01/30/69	61	52	59	86	2.4	86	0	30	333	0.5	5.8		682	410	340	70		6.5	22.5	7
	05/01/69	56	52	53	120	2.9	32	0	27	350	0.4	5.4		710	348	280	67		7.4	22.5	7
	08/12/69	87	52	54	96	4.2	84	0	41	328	0.1	1.4		706	352	280	69		7.4	22.5	7
	11/13/69	40	52	60	95	2.7	86	0	50	322	0.2	5.6		672	376	300	70		7.2	22.5	7
	01/20/70	50	65	53	92	2.6	86	0	25	323	0.2	8.8		665	380	310	70		7.4	22.0	7
	07/29/71	49	55	53	97	2.6	84	0	25	332	0.1	3.3		658	355	286	69	1260	7.0		1
4133-01	07/29/71	49	57	56	99	3.2	78	0	29	350	0.1	5.0		686	373	309	64	1320	6.7		1
4253-04	06/12/56	32	94	61	112		56	0	37	480	0.0	0.4	1390	843	484	438	46		7.0		3
	07/29/71	50	116	76	117	4.6	56	0	41	550	0.1	1.2		983	603	557	46	1930	6.7		1
	03/30/72	48	121	74	130	4.3	60	0	43	570	0.1	0.0		1020	607	558	49	1960	7.4	22.5	1
WAIHEE TUNNEL	03/18/58	31	11	4.9	13	0.6	61	0	6.1	17	0.0	0.4			48		50	159	7.3	19.8	1
	12/02/58	31	9.2	5.7	13		59	0	11	17	0.3	0.0	132		49		48		7.4		3
	09/19/62	28	8.1	5.2	13	1.3	53	0	2.8	18	0.0	0.3	130		42		44	157	7.9		8
	05/01/63	30	9.5	4.5	12	1.2	55	0	3.2	16	0.1	0.6	105	104	42	0	45	147	8.0	21.1	1
	10/07/64	28	8.0	4.9	12	1.1	53	0	2.6	15	0.0	0.4	99	98	40	0	43	142	7.8		1
	08/11/71	26	8.7	5.0	13	1.2	57	0	3.0	17	0.1	1.8		104	42	0	48	148	7.6	19.5	1
KAHALUU TUNNEL	11/17/54	30	15	5.1	5.4		39	0	9.3	18	0.0	0.1	212		60		32		7.6		3
	09/19/62	23	7.2	4.3	11	0.9	44	0	2.4	15	0.0	0.3	108	87	36		36	128	8.2		8
HAIKU TUNNEL	11/16/48	23	5.7	2.4	12		39	0	3.3	14	0.1	0.4	86		28		32				3
	11/19/62	21	6.2	3.9	11	0.8	40	0	2.5	14	0.0	0.3	100	80	32		32	121	8.2		8
UWAU TUNNEL	11/08/66	29	5.8	3.7	7.1	0.4	36	0	3.2	10	0.0	0.0	75	77	30	0	30	95	7.8	18.1	1

Chemical Analyses of Oahu Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
NOA TUNNEL	11/09/66	25	8.2	5.2	10	0.6	52	0	4.8	13	0.0	0.0	89	93	42	0	43	135	7.1	19.7	1
KAKILO TUNNEL	02/09/54	83	23	72	420	12	101	0	249	640		37	1640	1590	350		82		7.4		8
LUALEI TUNNEL	02/17/72	49	11	7.4	19	3.1	75	0	3.6	26	0.1	2.5		157	58	0	62		7.7		1

CHEMICAL ANALYSES OF MOLOKAI GROUND WATER

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
0449-01	10/20/70	43	16	12	73	5.0	122		18	95	0.1	3.5		326	90	0	531		7.4		1
0456-01	11/15/45	25	21	9.4	11		86	0	7.7	28		0.1	190	145	127	57	70		6.6		3
0457-01	11/19/63	26	10	12	24	1.0	59		6.9	37		0.1	126	146	77	29	48		6.8		3
0801-01	05/09/67	20	15	24	47	6.1	51	0	18	119	0.2	1.5	440	276	135	93	42		7.0		3
0855-02	04/06/61	9.6	6.8	3.1	13		44	0	18	10	0.1	0.1	80	83	24	0	36		7.2		3
0802-01	11/21/46	41	83	66	66		51	0	25	375	0.6	4.0	1000	685	484	453	41		8.1		3
1011-01	12/09/45		393	395	820		44	0	244	2890				4764							6

CHEMICAL ANALYSES OF MAUI GROUND WATER

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
3903-01	03/16/72	26	9.3	11	58	3.7	49	0	16	106	0.1	0.0		254	68	28	40	452	7.1	19.0	1
3903-02	03/16/72	25	8.7	9.6	53	3.4	50	0	15	90	0.1	0.0		229	61	20	41	408	7.3	19.0	1
3925-01	08/18/64	41	50	64	255	23	244	0	50	500	0.1	7.1	1310	1110	388	188	200		7.4		3
4125-02	03/16/72	45	33	53	325	21	133	0	93	590	0.1	17		1240	301	192	109	2290	7.5		1
4600-01	11/30/50	5.2	12	14	48		100	0	16	75	0.0	1.3	248	220	84	2	82		7.3		3
	03/16/55	8.0	32	12	34		131	0	19	58	0.2	0.1	270	213	128	45	83		7.2		3
	07/15/68	25	8.7	11	42	0.2	105	0	5.6	40	0.1	0.0	180	184	67	0	86		7.1		3
	03/10/71	24	9.6	13	37	3.0	113	0	8.0	42	0.1	0.6		192	78	0	92	326	6.7		1
	03/15/72	42	14	19	46	3.8	119	0	15	78	0.2	0.0		276	113	15	97	447	7.9	20.0	1
	06/02/72	21	13	16	44	3.6	124	0	11	62	0.0	0.6		232	99	0	101	417	7.0		1
4600-02	06/02/72	19	4.6	9.3	92	4.8	42	0	22	142	0.1	0.0		314	50	16	34	586	6.9	19.0	1
4527-14	03/16/72	60	13	21	240	20	240	0	47	295	0.5	13		827	124	0	196	1430	8.1		1
4727-01	06/18/68	45	36	39	343	20	452	0	75	460	2.8	21		1290	250	0	370		7.0	25.0	7
	04/08/69	48	21	37	260	18	286	0	50	340	0.9	16		934	204	0	234		8.1	24.0	7
	08/07/69	29	40	45	384	10	440	0	72	483	0.6	18		1310	284	0	360		7.5	24.5	7
	01/13/70	50	46	52	300	20	360	0	44	455	3.3	15		1170	328	34	295		7.5	24.3	7
4824-01	03/19/71	57	11	18	95	11	232	0	16	73	0.8	12		408	102	0	190	612	7.7	24.0	1
4825-01	06/18/68	52	20	37	260	20	305	0	58	335	1.7	23		976	203	0	250		7.2	23.5	7
	01/20/69	62	19	34	208	15	300	0	42	262	0.7	16		815	188	0	245		7.7	24.0	7
	04/08/69	66	20	41	250	20	312	0	50	315	0.9	17		937	220	0	255		7.7	24.0	7
	08/07/69	33	22	34	260	21	316	0	64	328	0.6	17		955	194	0	259		7.7	23.5	7
	10/30/69	59	21	41	260	8.6	320	0	55	340	2.2	14		961	220	0	262		7.5	23.5	7
	01/13/70	54	24	43	205	19	300	0	34	273	2.8	13		818	230	0	245		7.5	23.0	7
	04/14/72	58	21	35	275	19	333	0	53	335	0.8	18		978	197	0	273	1670	8.0		1
4831-01	05/27/66	18	55	19	100	6.1	61	0	26	250		5.0		509	102	52	50		7.0		3
4835-01	07/01/68	66	38	23	210	19	50	0	42	420	2.6	9.0		858	190	149	41		9.0		7
	01/22/69	71	68	24	205	16	111	0	40	400	0.3	14		928	270	178	91		7.3	33.0	7
	04/09/69	71	68	21	240	17	124	0	47	432	0.1	13		999	256	155	101		7.7	34.0	7
	08/11/69	58	60	17	198	36	132	0	66	373	0.1	10		886	220	112	108		7.5		7
	10/31/69	59	53	15	200	10	147	0	21	354	1.2	5.5		792	194	74	120		7.5	33.0	7
	02/13/70	60	85	29	180	15	130	0	50	400	1.2	11		921	330	223	108		7.5		7
4837-01	07/01/68	53	74	59	118	7.2	222	0	45	305	1.1	20		794	430	246	182		7.3		7
	01/22/69	57	69	48	115	5.8	196	0	42	270	0.1	16		742	370	209	161		6.4	25.5	7
	04/09/69	45	49	34	92	4.0	150	0	35	208	0.1	14		566	263	139	123		7.2	25.0	7
	08/11/69	58	51	35	93	5.0	140	0	57	223	0.1	10		602	270	157	115		7.2		7
	10/31/69	47	67	24	156	3.0	137	0	29	303	0.9	10		708	364	252	112		7.2	25.5	7
	02/13/70	45	90	67	150	5.0	120	0	70	460	0.2	5.9		956	500	401	98		7.6		7
4929-02	01/22/70	45	64	41	248	11	474	0	56	298	0.2	23	1000	1020	328	0	388	1740	7.5		1
4937-01	04/22/68	53	30	18	93	4.5	198	0	30	112	0.8	8.5		448	149	0	162		7.0		7
	07/01/68	46	45	29	146	5.7	172	0	41	275	1.6	5.6		698	230	91	141		8.4		7
	01/22/69	54	29	24	91	3.5	202	0	28	110	0.2	10		476	170	6	166		6.9	23.0	7
	04/09/69	54	37	31	127	4.8	220	0	38	191	0.2	12		679	220	40	180		7.3	25.0	7
	08/11/69	66	61	49	148	7.9	160	0	66	338	0.2	8.1		825	354	223	131		7.3		7
	10/31/69	52	135	84	228	8.8	77	0	21	780	0.5	3.8		1350	682	620	63		7.2	21.0	7
	02/13/70	45	70	62	170	6.0	120	0	40	480	0.4	7.7		952	380	281	98		7.8		7
	03/24/72	51	132	91	320	12	148	0	96	845	0.2	6.4		1630	705	583	121	3040	7.6		1
5021-01	05/23/72	43	84	103	116	19	79	0	55	552	0.1	19		1030	634	569	65	2020	7.4	19.5	1
5129-02	04/18/68	52	29	27	265	18	324	0	86	304	0.8	1.6		945	182	0	265		6.7	24.0	7
	06/17/68	34	31	30	295	15	337	0	60	380	1.0	22		1060	200	0	276		6.7	23.5	7
	01/20/69	30	18	13	55	3.0	124	0	17	70	0.2	6.6		290	97	0	101		7.1	23.5	7
	04/08/69	59	30	39	280	14	352	0	51	330	0.5	17		996	234	0	288		7.4	24.0	7
	08/07/69	30	32	41	245	7.7	356	0	64	300	0.2	17		924	249	0	291		7.3	23.5	7
	10/30/69	54	36	41	290	10	369	0	27	370	1.5	14		1030	266	0	301		7.3	23.0	7
	01/13/70	47	32	39	200	7.0	280	0	35	273	2.2	13		790	242	11	230		7.4	23.0	7
	04/14/72	51	33	37	325	15	353	0	66	420	0.5	16		1140	235	0	289	1970	7.9		1
5224-02	04/14/72	62	17	31	230	17	208	0	48	325	0.5	16		848	170	0	171	1480	7.7		1
5226-01	06/17/68	58	43	25	405	22	421	0	81	508	2.5	32		1400	262	0	345		6.9	26.0	7
	01/20/69	74	35	58	390	22	598	0	62	478	0.7	12		1450	375	0	490		7.2	26.0	7
	04/08/69	71	46	55	385	23	524	0	61	465	0.6	16		1380	340	0	429		7.3	26.0	7
	08/07/69	33	26	50	375	26	480	0	64	458	0.4	18		1300	268	0	393		7.2	26.0	7
	10/30/69	32	42	61	300	17	480	0	38	450	1.9	14		1200	354	0	393		7.2	26.0	7
	01/13/70	59	58	62	275	19	390	0	44	477	2.7	14		1210	398	80	320		7.3	26.0	7
5226-02	06/17/68	60	18	27	350	21	234	0	69	490	1.7	23		1190	158	0	191		6.9	23.5	7
	01/20/69	72	17	29	242	14	235	0	47	338	0.7	15		904	161	0	192		7.2	23.0	7
	04/08/69	71	18	33	335	20	248	0	57	435	0.6	17		1110	180	0	203		7.5	24.0	7
	08/07/69	38	20	33	300	19	200	0	68	468	0.5	16		1070	182	22	164		7.3	23.5	7
	10/30/69	59	15	70	158	12	240	0	24	305	1.2	4.4		768	326	130	197		7.3	23.5	7
	01/13/70	56	28	34	230	14	180	0	38	376	2.2	13		884	208	62	148		7.4	23.5	7
5223-062	08/14/62	51	18	23	134		268	0	48	140	0.1	7.3	542	553	141	0	220		7.3		3
5240-01	04/23/68	57	90	85	435	26	193	0	134	890	0.3	11		1830	575	416	158		7.2		7
	07/02/68	56	120	124	700	24	193	0	178	1440	0.6	0.0		2750	810	652	158		7.2		7
	01/22/69	34	25	21	62	4.0	129	0	25	102	0.1	2.0		365	150	43	106		6.6	23.0	7
	04/09/69	61	95	137	640	26	194	0	122	1325	0.1	17		2530	800	641	159		7.2	24.5	7
	10/31/69	52	115	117	552	10	192	0	89	1280	1.2	8.3		2320	770	610	157			24.5	7
	02/13/70	55	130	111	430	25	194	0	190	980	0.3	22		2040	830	670	159		7.2		7
5240-03	04/23/68	48	120	66	225	19	224	0	113	582	0.3	14		1300	570	388	184		7.2		7
	01/22/69	51	116	100	240	10	278	0	85	630	0.2	16		1420	700	473	228		6.8	25.0	7
	04/09/69	52	153	136	410	17	240	0	107	1040	0.1	15		2050	940	744	197		7.3	29.0	7
	08/11/69	47	135	105	340	6.8	232	0	100	853	0.3	14		1720	770	565	190		7.7		7
	10/31/69	46	135	98	356	9.4	232	0	65	909	0.9	13		1790	742	550	190		7.3	28.0	7
	02/13/70	60	140	109	170	15	246	0	120	600	0.2	15		1370	800	598	202		7.2		7
5321-01	06/17/68	48	38	46	425	22	34	0	112	750	0.8	10		1530	286	215	69		7.4	22.0	7

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
5321-01	01/20/69	57	11	10	71	4.9	76	0	25	105	0.5	5.8		352	70	6	62		7.8	21.5	7
	04/08/69	66	13	18	93	6.6	106	0	33	119	0.3	15		418	106	19	87		7.7	22.0	7
	08/07/69	33	16	19	130	4.6	106	0	53	183	0.3	14		510	118	31	87		7.2	21.3	7
	10/30/69	57	24	35	150	7.4	100	0	24	300	1.1	14		664	204	122	82		7.5	21.5	7
	01/13/70	53	9.0	11	60	4.3	70	0	20	76	1.0	8.6		279	66	11	57		7.7	21.0	7
5323-01	06/17/68	55	22	40	260	17	175	0	63	428	1.3	18		1010	220	75	144		6.8	23.0	7
	06/17/68	60	24	44	255	18	176	0	58	430	2.0	19		1000	239	43	144		6.8	23.0	7
	01/20/69	51	13	22	152	2.8	107	0	33	232	0.8	14		577	122	35	88		7.1	22.0	7
	04/08/69	71	20	41	245	16	180	0	49	385	0.7	18		937	220	72	148		7.4	23.0	7
	08/07/69	39	20	35	220	8.2	186	0	59	333	0.4	17		839	194	42	152		7.3	23.0	7
	01/13/70	56	25	46	250	14	140	0	36	448	2.7	14		964	250	137	115		7.2	22.0	7
5330-05	05/09/72	53	16	11	26	2.3	90	0	12	40	0.2	4.7		209	85	11	74	299	7.6		1
5330-092	01/13/60	48	18	16	16		91	0	27	22	0.0	0.8	200	192	113	38	75		7.5		3
	06/04/68	50	16	14	28	2.7	101	0	16	42	0.1	4.1	220	222	97	14	83		7.4		3
	06/19/68	47	18	11	26	2.2	86	0	20	40	0.6	5.8		228	90	20	70		6.7	22.0	7
	01/21/69	45	18	15	28	2.0	97	0	17	50	0.5	4.0		253	106	27	79		6.7	22.0	7
	04/07/69	61	19	16	25	2.0	94	0	21	38	0.1	7.0		236	112	35	77		7.3	22.0	7
	08/08/69	32	18	13	26	2.3	92	0	22	39	0.1	4.6		211	99	23	75		7.5	22.2	7
	01/12/70	31	23	10	24	2.3	75	0	21	45	0.3	4.6		198	98	37	61		7.5	21.8	7
5330-11	07/04/68	45	16	15	28	8.1	91	0	19	43	0.1	4.4	250	223	102	27	75		6.9		3
	03/14/72	76	18	13	30	2.2	99	0	21	43	0.1	2.6		254	99	18	81	339	7.6	22.5	1
5339-01	02/17/67	26	24	25	104	13	143	0	24	190	0.2	7.0	540	483	163	46	117		6.9		3
	07/28/72	57	26	27	120	6.5	145	0	29	210	0.2	7.2		554	176	57	119	954	7.6	21.0	1
5339-02	02/14/63	48	28	30	134	6.8	190	0	38	202	0.1	8.8	600	589	195	39	156		7.5		3
	02/17/67	33	25	27	103	14	143	0	22	180	0.0	6.2	500	480	167	50	117		6.9		3
	05/12/72	53	25	22	108	6.0	148	0	25	175	0.1	5.2		492	153	32	121	842	7.7	20.0	1
5339-03	11/20/71	43	20	13	63	4.5	55	0	17	130	0.1	3.2		320	104	59	45	551	7.1	20.0	1
5340-01	04/22/68	32	29	22	97	6.9	114	0	26	186	0.1	3.6		460	164	70	93		6.6		7
	07/01/68	46	60	66	187	8.0	154	0	56	440	1.1	16		960	420	295	126		7.4		7
	01/22/69	45	61	53	190	8.0	148	0	51	400	0.1	20		931	380	249	121		6.7	25.0	7
	04/09/69	46	50	56	212	8.2	142	0	59	435	0.1	13		955	356	239	116		7.2	25.5	7
	10/31/69	46	47	114	99	4.1	142	0	25	459	0.8	6.3		877	580	470	116		7.2	24.5	7
	02/31/70	45	70	62	150	10	150	0	60	410	0.2	14		900	430	307	123		7.4		7
5340-02	01/22/69	36	14	15	63	3.7	56	0	17	115	0.2	4.0		322	95	51	45		7.1	22.0	7
	04/09/69	40	12	10	82	4.2	59	0	20	125	0.7	4.8		383	72	24	47		7.8	22.5	7
	08/11/69	44	16	15	110	5.9	74	0	47	177	0.1	3.6		456	100	41	60		7.5		7
	10/31/69	46	28	37	220	10	144	0	34	400	0.8	3.9		852	224	104	118		7.3	25.0	7
	02/13/70	40	30	30	130	5.0	76	0	30	280	0.6	6.6		631	200	137	62		7.7		7
	03/24/72	61	21	23	160	7.0	91	0	38	272	0.2	3.1		630	147	73	75	1080	7.4		1
5420-01	06/04/64	53	5.5	4.6	100	4.0	78	0	35	94	0.3	7.6	556	342	32	0	64		7.8		3
	08/09/68	46	4.8	1.6	95	0.8	79	0	31	76	0.4	14	320	308	18	0	65		6.9		3
5423-02	06/17/68	55	31	65	520	28	176	0	126	938	0.8	18		1880	360	217	144		6.7	24.0	7
	01/20/69	62	25	42	228	14	188	0	55	348	0.4	16		906	235	81	154		6.7	24.3	7
	08/07/69	33	24	30	230	8.7	196	0	59	338	0.4	16		842	180	23	161		6.5	24.3	7
	10/30/69	61	37	76	400	19	170	0	71	800	1.6	14		1570	406	268	139		7.2	23.0	7
	01/13/70	51	27	40	185	14	140	0	37	342	1.3	12		780	230	117	115		7.2	25.0	7
5424-01	06/17/68	62	19	28	325	19	172	0	69	485	1.2	20		1130	158	22	141		6.9	24.0	7
	01/20/69	72	16	35	250	15	172	0	52	395	0.7	19		954	182	43	141		7.0	22.5	7
	08/07/69	39	19	39	325	9.7	176	0	74	488	0.4	18		1110	208	64	144		7.3	23.0	7
	10/30/69	66	24	40	270	15	176	0	72	430	1.3	16		1030	226	80	144		7.4	23.0	7
	04/13/72	66	21	37	340	19	178	0	72	515	0.5	17		1180	205	59	146	2040	7.6		1
5513-01	05/11/67	28	12	13	67	10	59	0	15	120	0.2	2.8	320	297	83	35	48		7.0		3
5522-01	06/17/68	44	10	11	175	8.5	122	0	44	218	1.4	20		607	70	0	100		6.5	29.5	7
	01/20/69	46	2.0	3.6	55	3.4	88	0	19	36	0.6	1.4		228	20	0	72		7.2	23.0	7
	04/08/69	42	7.0	8.4	86	6.4	134	0	7.0	82	0.3	2.7		309	52	0	109		7.2	22.5	7
	08/07/69	29	9.0	13	180	52	130	0	57	223	0.3	16		649	75	0	106		7.2	22.0	7
	10/30/69	61	10	28	160	13	122	0	50	235	0.9	14		634	140	40	100		7.2	22.0	7
	01/13/70	52	14	15	166	8.0	150	0	29	200	1.2	11		574	96	0	122		7.2	21.5	7
	12/10/70	55	10	12	167	7.5	148	0	39	195	0.4	16		574	75	0	121	948	7.0		1
	04/13/72	58	11	14	190	9.3	133	0	48	245	0.4	15		656	85	0	109	1120	7.4		1
5533-02	04/21/70	7.0	7.2	2.0	5.3	1.0	35	0	4.0	7	0.0	0.2		51	26	0	28	84	6.5		1
5540-01	09/16/71	49	16	34	225	14	146	0	50	362	0.3	11		833	180	61	120	1490	7.7		1
5540-03	09/14/71	46	9.7	20	122	8.0	166	0	26	149	0.3	5.3		468	107	0	136	796	7.0		1
5640-01	04/22/68	55	8.0	6.9	83	5.1	71	0	23	106	0.2	8.8		332	49	0	58		7.4		7
	07/02/68	49	19	44	250	12	77	0	66	455	0.8	7.6		956	230	165	63		8.1		7
	01/22/69	92	7.0	7.4	61	3.0	61	0	14	85	0.3	7.2		340	48	0	50		7.1	20.0	7
	04/09/69	46	6.0	8.5	67	3.5	60	0	15	90	0.1	7.4		274	50	1	49		7.9	20.0	7
	08/11/69	58	13	15	158	9.7	66	0	55	235	0.2	6.5		585	92	40	54		7.4		7
	10/31/69	51	24	57	170	26	83	0	34	400	1.0	9.1		815	296	228	68		7.7	20.0	7
	02/13/70	55	40	17	120	6.0	64	0	26	260	0.9	7.7		584	158	105	52		7.8		7
	03/24/72	44	9.0	15	160	6.9	70	0	34	250	0.2	4.6		558	84	27	57	962	7.1		1
5641-01	04/23/68	39	33	39	255	23	124	0	130	430	0.3	15		1050	244	141	102		7.4		7
	07/02/68	56	43	59	465	20	157	0	124	840	1.0	13		1710	350	221	129		7.1		7
	01/22/69	44	18	26	195	8.8	106	0	80	300	0.3	10		767	150	65	87		7.0	21.5	7
	04/09/69	52	36	66	385	17	128	0	107	660	0.2	16		1410	362	257	105		7.5	22.0	7
	08/11/69	61	40	61	475	24	150	0	100	808	0.3	13		1660	350	228	123		7.6		7
	02/13/70	50	80	56	440	20	172	0	100	850	0.4	13		1700	430	288	141		7.1		7
5641-02	04/23/68	51	27	35	280	19	105	0	86	473	0.4	11		1040	212	125	86		7.5		7
	07/02/68	52	38	53	430	19	103	0	120	780	1.0	11		1560	310	225	84		7.9		7
	11/09/69	22	24	34	240	9.5	92	0	64	390	0.1	3.2		841	198	124	75		8.1	23.0	7
	02/13/70	50	45	70	550	20	119	0	100	975	0.2	4.3		1880	400	303	97		7.7		7
5731-01	04/19/68	16	3.0	1.1	12	1.7	20	0	5.0	13	0.1	0.2		62	12	0	16		6.2	23.5	7
	06/19/68	28	11	6.8	32	2.7	104	0	9.3	22	0.6	1.5		166	56	0	85		6.8	24.0	7
	01/21/69	36	13	7.1	28	2.2	106	0	16	17	0.3	1.4		173	61	0	86		7.2	23.0	7
	04/07/69	13	13	9.1	34	2.6	119	0	13	20	0.1	2.7		166	70	0	96		7.9	23.5	7

Chemical Analyses of Maui Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
5333-01	08/13/71	51	10	13	82	5.3	50	0	22	142	0.1	0.8		350	79	38	41	604.	6.9	21.0	1
5340-01	07/07/64	53	29	19	195	12	88	0	48	352	0.3	3.8	788	755	149	77	72		7.2		3

CHEMICAL ANALYSES OF HAWAII GROUND WATER

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CARB	COND	PH	TEMP C	LAB
0335-01	05/14/71	45	6.0	4.6	12	1.5	44	0	14	8.0	0.3	1.9		114	34	0	36	128	7.0	19.5	1
0533-01	04/12/72	43	33	86	680	24	46	0	169	1240	0.2	0.0		2300	436	399	37	4180	7.0	19.0	1
0533-02	04/12/72	43	20	44	320	14	42	0	86	580	0.1	0.7		1130	231	197	34	2120	7.1	19.0	1
0533-03	04/12/72	43	18	38	272	12	41	0	75	500	0.2	1.7		980	202	168	34	1850	7.0	19.0	1
0632-01	04/12/72	41	17	33	245	11	44	0	66	440	0.2	1.3		876	178	142	36	1620	7.3	19.0	1
0830-01	04/12/72	32	9.6	16	118	5.5	34	0	37	205	0.2	0.7		440	90	62	28	830	7.1	19.0	1
0831-01	04/12/72	41	9.2	12	80	4.4	43	0	24	136	0.2	1.2		329	73	38	35	561	7.3	19.0	1
0831-02	03/01/72	46	10	16	88	4.8	40	0	28	165	0.2	0.8		378	91	58	33	681	7.1	18.5	1
1123-01	04/13/72	42	6.6	3.6	7.2	1.0	43	0	10	3.5	0.2	0.9		96	32	0	35	99	7.2	19.0	1
2132-01	12/06/63	72	16	31	170	8.5	54	0	65	345	0.1	0.3	838	734	145	101	44		7.4		3
2487-01	03/03/72	41	6.6	3.3	54	3.8	42	0	22	70	0.2	0.0		221	30	0	34	344	7.3	23.0	1
2753-01	12/17/58	24	22	8.5	54		10	34	30	90	0.2	0.4	316	268	89	25	64		9.4		3
	03/14/68	31	15	12	60	6.1	59	0	19	93	0.2	4.6	320	269	55	7	48		7.4		3
	06/02/70	45	20	11	60	5.0	49	0	23	108	0.0	4.8	308	300	64	24	40		7.6		3
	03/16/72	50	9.4	11	64	4.3	47	0	22	107	0.4	1.0	292	292	69	30	39	474	7.3	19.0	1
2753-02	05/16/63	49	7.6	8.9	68	2.0	49	0	28	106	0.3	1.1	320	295	56	16	40		7.0		3
	03/20/67	36	6.1	8.2	53	7.5	49	0	14	72	0.2	1.9	220	223	48	8	40		7.3		3
	06/02/70	44	8	8.2	54	5.0	49	0	20	89	0.0	3.6	270	265	52	12	40		7.6		3
	03/16/72	52	9.6	12	77	4.8	44	0	25	129	0.3	1.3		332	74	38	36	555	6.7	19.0	1
2783-01	09/06/62	59	182	324	3090		262	0	681	5850	1.5	0.5	11700	10300	1790	1580	215		6.9		3
2986-01	03/03/72	54	3.9	3.3	16	3.3	51	0	12	6.0	0.3	0.5		124	23	0	42	126	7.6	22.5	1
2986-02	03/03/72	50	2.7	3.3	17	3.4	50	0	13	6.0	0.8	0.2		121	20	0	42	127	7.4	22.5	1
3080-01	03/15/68	44	48	26	97	14	283	0	5.5	125	0.3	2.4	540	501	228	0	232		7.7		3
	05/22/70	39	120	96	64	10	976	0	3.8	72	0.2	9.7	766	895	700	0	800		7.0		3
	03/03/72	39	72	31	57	7.6	393	6	11	54	0.3	27		498	307	0	332	793	8.4		1
3185-01	05/05/64	59	4.2	4.8	16	2.0	46	0	6.7	16	0.2	0.2	122	131	24	0	38		7.7		3
3185-02	05/22/72	49	5.8	3.6	23	3.2	56	0	6.9	23	0.3	0.0		142	30	0	45	165	7.6		1
3557-01	03/16/72	49	7.2	4.0	12	2.1	49	0	9.9	7.0	0.3	3.9		119	35	0	40	126	7.2	20.0	1
3557-02	03/20/67	46	5.5	4.8	20	7.5	74	0	8.0	15	0.2	3.4	120	146	33	0	61		7.2		3
3557-03	02/28/70	45	6.5	4.0	14	2.2	48	0	9.0	8.5	0.4	4.6		117	33	0	39	133	7.8		1
3557-04	02/05/71	46	6.7	4.4	18	2.5	46	0	11	16	0.3	5.4		132	35	0	37	162	7.6	20.5	1
	03/16/72	41	4.9	5.0	17	2.3	52	0	10	14	0.3	3.5		123	33	0	42	147	7.5	20.0	1
3702-01	06/07/72	40	6.0	2.7	5.8	2.4	38	0	5.5	4.0	0.1	2.8		88	26	0	31	87	7.0	23.0	1
3758-01	09/14/49	68	16	28	261		58	0	79	460	0.1	3.1	1008	943	208	161	47				3
	11/21/49	46	15	9.7	292		71	0	81	450	0.1	1.3	978	930	144	86	58				3
	03/11/55	33	78	35	200		51	0	78	485	0.2	0.8	1170	935	340	298	42		7.8		3
	12/10/58	26	15	37	236		44	0	76	440	0.2	0.8	1160	852	189	153	36		7.1		3
3802-01	03/23/34	12	1.6	4.3	14		32	0	6.1	14			72	67	22	0	26				6
	02/03/55	20	8.1	3.4	6.3		30	0	14	4.0	0.2	0.2	72	70	34	9	25		7.4		3
	03/03/72	31	4.6	2.9	5.7	1.8	36	0	5.0	4.0	0.1	0.5		73	24	0	30	78	7.4	24.5	1
3802-03	06/07/72	33	4.8	2.8	5.2	1.9	35	0	5.3	4.0	0.2	0.0		74	24	0	28	77	7.0	19.5	1
3802-05	06/07/72	36	5.5	3.3	5.2	2.1	38	0	5.5	4.0	0.1	1.5		81	27	0	31	88	7.4	22.0	1
3900-01	03/07/72	33	6.5	5.9	39	3.7	44	0	12	58	0.1	3.6		183	40	4	36	296	7.3		1
3900-02	07/15/66	33	11	20	126	7.0	39	0	34	230		2.5	504	482	112	80	32	905	6.3		8
	03/07/72	33	6.8	7.1	54	4.1	44	0	16	81	0.1	3.6		227	45	9	36	380	7.3	19.5	1
4003-01	03/13/72	37	7.8	3.3	5.3	1.6	50	0	1.4	4.0	0.1	0.0		85	33	0	40	91	7.5	22.0	1
4202-01	11/10/53	28	38	15	80		34	0	32	180	0.2	0.1	440	390	158	130	28		7.4		3
	10/12/54	23	40	16	76		32	0	46	186	0.1	0.0	488	402	168	142	26		7.4		3
	02/02/60	8	8.2	12	62		35	0	7.6	108	0.0	0.1	286	223	69	40	29		6.7		3
4203-022	08/20/64	33	8.0	4.4	10	1.0	50	0	2.5	11	0.0	0.2	128	94	38	0	41		7.0		3
4203-03	03/02/72	36	6.0	3.6	7.4	1.8	44	0	2.0	7.5	0.1	0.8		86	30	0	36	95	7.1	23.5	1
4203-04	03/27/72	55	8.4	2.9	6.9	1.8	47	0	2.6	6.5	0.1	0.0		107	33	0	38	94	7.2	26.0	1
4353-01	03/10/65	80	27	77	250	12	439	0	60	370	2.0	8.3	1090	1100	384	24	360		7.3		3
	03/17/72	76	28	69	270	13	424	0	75	370	2.2	6.2		1120	354	7	348	1920	8.0	20.0	1
4358-02	07/15/68	37	6.1	7.9	61	0.6	73	0	10	78	0.1	0.0	250	236	48	0	60		7.1		3
4953-01	08/11/72	36	16	26	218	12	91	0	71	340	0.9	3.8		768	147	72	75	1390	7.9	22.0	1
5005-01	03/23/72	45	12	10	7.8	0.6	74	0	17	12	0.1	0.5		141	72	11	61	174	7.2	23.0	1
5005-02	06/13/56	22	9.4	9.0	9.6		63	0	7.4	8.0	0.1	5.6	116	102	68	16	52		6.2		3
	07/06/70	12	10	9.6	10	3.0	78	0	0.0	13		1.2	75	97	66	2	64		6.1		3
5033-05	05/03/72	23	25	33	160	8.5	78	0	45	322	0.1	0.0		655	198	134	64	1220	7.7	20.0	1
5543-01	10/27/71	56	28	45	316	24	142	0	97	542	0.3	3.8		1180	255	139	116	2130	7.5	29.0	1
	04/03/72	82	28	47	330	22	142	0	95	550	0.5	3.1		1230	264	148	116	2110	7.6		1
5743-01	06/29/70	56	7.0	11	32	4.0	99	0	15	26	0.3	6.0		206	63	0	81	276	8.0	26.5	1

Chemical Analyses of Hawaii Ground Water (continued)

WELL NO.	DATE	SIO2	CA	MG	NA	K	HCO3	CO3	SO4	CL	F	NO3	SOLIDS DET	SOLIDS CALC	HARD CA,MG	HARD NONC	ALK CAPB	COND	PH	TEMP C	LAB
5745-01	07/28/70	64	8.0	11	30	5.0	98	0	16	30		0.0	206	212	64	0	80		7.8		3
	04/05/72	80	6.1	11	33	4.3	102	0	18	26	0.4	3.8		234	65	0	83	280	7.5		1
	08/16/72	42	8.0	9.0	35	4.4	104	0	15	29	0.0	1.2	200	194	64	0	85		6.7		3
3314-01	05/16/72	23	15	11	37	3.3	58	0	11	74	0.2	0.2		203	83	35	48	365	7.1	20.5	1
3348-01	04/09/70	49	20	37	250	15	95	0	68	430	0.3	5.3		921	202	124	78	1670	7.3		1
5049-02	05/ /72	51	21	34	216	15	94	0	62	390	0.3	3.2		838	193	116	77	1500	7.6	26.0	1
5043-01	05/17/72	51	21	34	216	15	95	0	62	390	0.3	1.9		837	193	115	78	1520	8.1		1
5043-02	05/17/72	50	58	119	974	50	106	0	249	1740	0.3	3.8		3300	635	548	87	5840	7.8	26.0	1
5049-03	05/17/72	50	58	111	896	46	103	0	236	1610	0.2	3.2		3060	602	517	84	5480	7.5	26.0	1
5117-01	07/20/54	24	34	13	22		36	0	31	85	0.1	0.1	338	226	138	108	30		7.9		3
	06/22/55	28	22	6.9	16		44	0	21	40	0.0	0.0	162	155	83	47	36		6.9		3
	02/27/67	25	17	21	75	9.5	54	0	17	160	0.1	1.3	460	352	127	83	44		7.5		3
	06/16/70	43	16	21	125	8.0	54	0	36	230		0.0	640	507	134	90	44		7.3		3
	04/18/72	43	11	14	78	4.9	62	0	21	135	0.2	1.0		338	85	34	51	599	7.6		1
5147-01	06/25/63	89	32	33	135	14	109	0	54	250	0.2	2.9	796	663	214	125	89		7.3		3
	06/25/63	78	32	31	128	13	101	0	49	255	0.2	4.2	660	640	208	125	83	1070	6.9	35.8	1
5143-01	03/22/72	66	24	32	180	13	82	0	42	340	0.3	3.8		741	192	125	67	1330	7.8	28.0	1
	06/20/72	32	32	30	175	14	0	0	70	340	0.3	0.8	860	694	180	180	0				3
5321-01	02/28/67	27	15	21	77	8.8	66	0	20	165	0.2	2.0	480	368	123	69	54		7.3		3
	04/18/72	37	16	19	102	5.6	53	0	29	195	0.1	0.0		429	118	75	43	806	7.6	18.0	1
7347-02	07/19/49	42	8.0	5.5	15		45	0	9.6	22	0.1	0.9	128	125	47	10	37				3
7445-01	03/28/72	63	60	72	450	20	98	0	120	890	0.2	3.7		1730	446	365	80	3230	7.2	24.5	1