

Ground-Water Reconnaissance of American Samoa

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1608-C

*Prepared in cooperation with
the Territory of American Samoa*



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By DAN A. DAVIS

CONTRIBUTIONS TO THE HYDROLOGY OF ASIA AND OCEANIA

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UNITED STATES DEPARTMENT OF THE INTERIOR

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ABSTRACT

The principal islands of American Samoa are Tutuila, Aunu'u, Ofu, Olosega, and Ta'u, which have a total area of about 72 square miles and a population of about 20,000. The mean annual rainfall is 150 to 200 inches.

The islands are volcanic in origin and are composed of lava flows, dikes, tuff, and breccia, and minor amounts of talus, alluvium, and calcareous sand and gravel. Tutuila is a complex island formed of rocks erupted from five volcanoes. Aunu'u is a tuff cone. Ofu, Olosega, and Ta'u are composed largely of thin-bedded lava flows.

Much of the rock of Tutuila has low permeability, and most of the ground water is in high-level reservoirs that discharge at numerous small springs and seeps. The flow from a few springs and seeps is collected in short tunnels or in basins for village supply, but most villages obtain their water from streams. A large supply of basal ground water may underlie the Tafuna-Leone plain at about sea level in permeable lava flows. Small basal supplies may be in alluvial fill at the mouths of large valleys.

Aunu'u has small quantities of basal water in beach deposits of calcareous sand and gravel. Minor amounts of high-level ground-water flow from springs and seeps on Ofu, Olosega, and Ta'u. The generally permeable lava flows in the three islands contain substantial amounts of basal ground water that can be developed in coastal areas in wells dug to about sea level.

INTRODUCTION

PURPOSE AND SCOPE

The reconnaissance on which this report is based was made in cooperation with the Territory of American Samoa to obtain information on water resources that would assist in improving the water supplies of villages in the islands of American Samoa. Field work was done by Max H. Carson and D. A. Davis and included an examination of water sources in about 65 villages. Streamflow and surface-water supplies were examined by Carson, and observations on ground-water resources were made by Davis.

The report gives a brief description of streams of the islands. It relates the modes of occurrence and methods of development of ground water and estimates the availability of ground water in the various islands

LOCATION AND EXTENT OF AREA

The islands of American Samoa are a part of the Samoan archipelago, which lies roughly 1,000 miles south of the equator and forms a westward-trending chain between long 168° and 173° W. The principal islands of American Samoa are Tutuila, Aunuu, Ofu, Olosega, and Ta'u (fig. 1). These form the eastern part of the archipelago

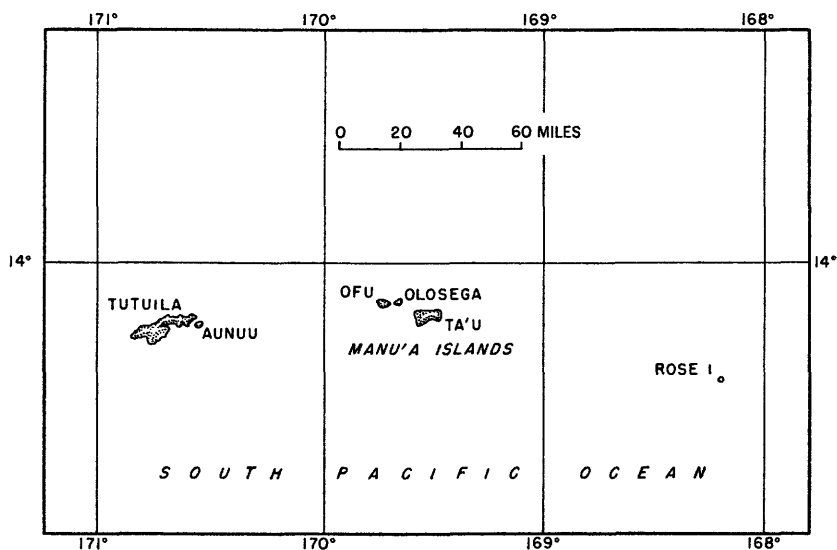


FIGURE 1.—Map showing islands of American Samoa.

and extend over a distance of about 100 miles along a line just south of lat 14° S. Ofu, Olosega, and Ta'u, which lie about 60 miles east of Tutuila, make up the Manu'a Islands. Two small atolls—Rose Island, about 200 miles east of Tutuila, and Swains Island, about 400 miles north of Tutuila—which are administratively a part of American Samoa, were not included in the study.

PREVIOUS INVESTIGATIONS

In 1941 and 1943, Harold T. Stearns, of the U.S. Geological Survey, made geologic and water-supply investigations in American Samoa for the U.S. Navy. Hydrologic work by Stearns consisted largely of investigations of water supplies for the Naval Station at Pago Pago Harbor and for a few small Naval and Marine Corps installa-

tions on other parts of Tutuila. The results of the geologic investigations are given in a published description of the geology of the Samoan Islands and a geologic map of Tutuila (Stearns, 1944). The petrography of Samoa, based on specimens collected by Stearns, has been described by G. A. Macdonald (1944).

ACKNOWLEDGMENTS

The Government of American Samoa provided transportation on Tutuila and between Tutuila and the other islands and extended numerous other courtesies during the investigation. Lei'ato, Governor of the Eastern District; Letuli, Governor of the Western District; and Lefiti, Governor of the Manu'a District, manifested great interest in the investigation and assisted in its progress in many ways. Appreciation is due particularly to the chiefs, the "pulenu'u" (administrative officers), and the people of the counties and villages who gave great material assistance in field work on all islands. Mr. Louis F. Tuu gave valuable service during the work as driver on Tutuila and interpreter on all the islands.

GEOGRAPHY

SURFACE FEATURES

The islands of American Samoa are volcanic in origin and exhibit topographic and drainage features that commonly are found in Pacific islands of this type. The area and maximum altitude of the islands covered in this report are given in the following tabulation.

<i>Island</i>	<i>Area (square miles)</i>	<i>Maximum altitude (feet)</i>
Tutuila.....	53	2, 140
Aunuu.....	. 6	300
Ofu.....	2	1, 590
Olosega.....	1. 5	2, 090
Ta'u.....	15	3, 050

Tutuila (fig. 2) is long and narrow and is dominated by a high irregular ridge extending throughout its length. Except on the relatively low Tafuna-Leone plain, which forms a bulge on the south side of the western half of the island, closely spaced streams have eroded the island into generally steep slopes. On parts of the island, streams have radial patterns around centers of former volcanic activity. The streams have steep gradients, except near the shore where widening of valley floors results in small coastal flats contained between the seaward ends of steep intervalley ridges. The coast between the mouths of the valleys is rocky, and the land rises in cliffs which range from a few tens of feet to several hundred feet in height. Drowned valleys form several embayments, the most striking of which

is Pago Pago Harbor. The Tafuna-Leone plain, which is a young surface formed by late volcanic activity, has no streams and is altered only slightly by erosion.

Aunuu, off the east end of Tutuila, is a small volcanic cone that is dominated by a slightly dissected crater whose rim rises 200 to 300 feet above sea level. The floor of the crater is occupied by a marsh and lake. Marine erosion has developed steep cliffs on the east and south sides of the cone; on the west and north sides the cone is bordered by a low coastal flat.

The islands of Ofu and Olosega form a doublet separated by a shallow narrow channel. Both islands rise from the sea in spectacularly steep slopes that culminate in sharp summit ridges, and no flat land is to be found on either island except for narrow coastal flats along some shores. There are no significant valleys on the islands.

Ta'u, like Ofu and Olosega, rises abruptly from the sea; but, in contrast with the smaller islands, it is dome shaped. Streams are few and have cut only poorly defined shallow valleys. Narrow coastal flats occupy parts of the island.

CLIMATE

The climate of Samoa is tropical, characterized by uniformly warm temperatures and high humidity. The islands lie in the belt of the southeast trade winds, which tend to be strongest in the winter months, June to August, and weakest in the summer, December to February, when the intertropical front moves southward.

Rainfall records in American Samoa are insufficient for more than speculation on the total rainfall and the geographic distribution. During the period 1900 through 1940, a record of rainfall was kept at the U.S. Naval Station on Tutuila; but the location of the gage is not known definitely, and it probably was moved a considerable distance at one or more times during the period of record. As it stands, the 41-year record indicates a mean annual rainfall of about 200 inches. Based on rainfall records kept by Mr. Max Halleck, the mean annual rainfall at Pago Pago during the period from 1946 through 1956 was about 164 inches. Monthly means from the Pago Pago record during the 11-year period are shown in the following tabulation:

<i>Month</i>	<i>Mean rainfall (inches)</i>	<i>Month</i>	<i>Mean rainfall (inches)</i>
January -----	17.3	July -----	8.2
February -----	16.4	August -----	9.2
March -----	17.2	September -----	7.1
April -----	11.6	October -----	16.2
May -----	14.1	November -----	14.9
June -----	10.4	December -----	21.5

POPULATION AND DEVELOPMENT

The distribution of population of American Samoa, as indicated by the 1960 census, is shown in the following tabulation.

<i>Island</i>	<i>Number of villages</i>	<i>Population</i>
Tutuila.....	66	16, 814
Aunuu.....	1	436
Ofu.....	1	605
Olosega.....	2	429
Ta'u.....	5	1, 661
Total.....	75	19, 945

All the people live in villages, and most of the villages are on lowlands near the shore.

A road system connects the villages on the south side of Tutuila, extending from Tula on the extreme east end to Amanave on the west end. Fagasa and Aoa, on the north coast, are connected to the south side by passable roads, but communication with other villages on the north side is by boat or trail only. Electric power, telephone service, and public water are available in the administration area at Pago Pago Harbor, but these facilities do not extend beyond the harbor area. Transocean and interisland radio communication is provided through a station at Pago Pago.

There are no roads on Aunuu, Ta'u, Ofu, and Olosega, but the villages are connected by well-kept trails. Small electric-power plants are operated at dispensaries on Ta'u and Ofu, and radio communication is maintained between the dispensaries and the station at Pago Pago.

Agriculture consists mainly of growing coconuts, breadfruit, bananas, cacao, taro, and yams. Copra from coconuts is the principal agricultural export. Some sugarcane is grown, chiefly for its leaves for thatch, and pandanus is grown for mats. Crops are grown without irrigation, mostly on steep hill sides. A few swine, poultry, and cattle are raised for food.

The principal industry is a fish cannery on the north shore of Pago Pago Harbor, which is supplied with fish caught by a Japanese fleet operating out of Pago Pago.

Most of the working population is engaged in subsistence agriculture. Smaller numbers are employed by the government, the fish cannery, or in commercial and service activities.

GEOLOGY

The geology of the Samoan Islands has been described by Stearns (1944). The following discussion, which is based largely on Stearns' more elaborate description, is limited in general to features that are pertinent to the occurrence of water in the islands.

TUTUILA

Tutuila is made up chiefly of basaltic rock that was erupted from five volcanoes arranged in a rough east-west line. The major activity, which occurred at four centers in Pliocene or early Pleistocene time, produced shield-shaped masses that merged into a single elongate island, longer and broader than the present Tutuila. After activity at the four centers ceased, deep valleys were cut by streams, and the shoreline retreated under the attack of waves. Toward the end of Pleistocene time, the island had been reduced to approximately its present size and form. More recently, the fifth volcano became active and built the Tafuna-Leone plain, and a small submarine eruption off the east end of Tutuila built the tuff cone that is now Aunuu. During the subsequent erosional period, sedimentary deposits were formed at the foot of steep slopes, on valley floors, and along the coast. The general character of the rocks on the island and their relative ages are shown in the following stratigraphic section.

The large number of eruptive centers in a small area, the overlapping of rocks erupted from different volcanoes, and the presence of dikes and interbedded tuff, cinder, and breccia among the lava flows have produced complex geologic conditions on Tutuila. The bulk of Tutuila is formed by aa and pahoehoe lava flows that range from thin-bedded flows with high permeability to thick-bedded dense flows with low permeability. The late flow rock on the Tafuna-Leone plain is mostly thin bedded, but on older parts of the island, particularly along the coast, the flows are mostly thick and dense.

Dikes are dense and impermeable, and where their spacing is close, they may reduce greatly the permeability of the rock that they cut. Unweathered tuff may have moderate permeability, but weathered tuff is almost impermeable. The breccia is mostly dense and has low permeability. The permeability of fresh cinder is high, but it may be greatly decreased by weathering because of consolidation that occurs during chemical decomposition. Lava flows, although they far exceed the other types of rock in total volume, are divided by dikes and interbedded tuff and breccia into units which are irregular in size and shape. The total vertical and horizontal extent of any unit of flows is small as compared to the size of the island.

Stratigraphic section of Tutuila (after Stearns, 1944) and water-bearing characteristics of the rocks

Geologic age	Formation	Thickness (feet)	General character	Water-bearing characteristics
Recent	Sedimentary rocks	200+	Alluvium on valley floors; talus at foot of steep slopes; calcareous sand and coralline gravel along coast.	Alluvium in mouths of valleys is moderately permeable and contains fresh to brackish water. Talus locally yields water in seeps and small springs. Sand and gravel contain small supplies of fresh water.
	Leone Volcanics	200+	Olivine basalt in pahoehoe-lava flows; tuff in cones and veneer over lava flows; ash and cinder in cones.	Lava flows under Tafuna-Leone plain have moderate to high permeability and may contain considerable fresh water at about sea level. Tuff and ash have low permeability and yield little water. A few small springs flow from cinder.
	Aunuu Tuff	200+	Tuff forming Aunuu island.	Low permeability and yields little water.
Pliocene and earliest Pleistocene (?)			— Erosional unconformity —	
	Trachyte	2,140+	Trachytic dikes, plugs, and crater fill younger than most of the Pliocene volcanics.	Low permeability. Yields water in high-level seeps and small springs.
	Taputapu Volcanics	1,639+	Thin-bedded olivine basalt with interbedded tuff beds and cinder cones.	Moderate permeability. Yields water at many scattered high-level seeps and small springs.
	Pago Volcanic Series (extracaldera volcanics)	1,609+	Lower member of thin-bedded olivine basalt; includes thin dikes and thin tuff beds. Upper member of massive basaltic and andesite flows; interbedded tuff and cinder deposits.	Moderate to low permeability. Yields water at many scattered high-level seeps and small springs.
	Pago Volcanic Series (intracaldera volcanics)	2,141+	Massive basaltic and andesitic lava flows and some interbedded tuff and breccia and cinder cones; few thin lenses of gravel.	Mostly low permeability. Yields water at scattered high-level seeps and small springs.
	Alofau Volcanics	963+	Thin-bedded olivine basalt with numerous dikes.	Lava flows between dikes have moderate to high permeability. Rocks yield water at many high-level seeps and small springs.
	Olomoana Volcanics	1,074+	Olivine basalt and andesitic basalt; interbedded cinder cones and tuff beds.	Moderate permeability. Yield water at many high-level seeps and small springs.
				— Erosional (?) unconformity —
	Masefau dike complex	200+	Thin basaltic flows cut by many dikes.	Low permeability. Yield little water.

The sedimentary rocks of Recent age consist of talus, alluvium, calcareous sand, and coralline gravel. The talus is poorly sorted material, in which large blocks are prominent, accumulated at the bottoms of steep slopes along the coast and in steep-walled valleys; the permeability of the talus is variable. Thick deposits of alluvium, comprising poorly sorted mixtures of clay, sand, gravel, and boulders derived from volcanic rock, underlie the lower ends of large valleys; the alluvial fill extends below sea level at the mouths of some valleys

and has a permeability ranging from low to high. The calcareous sand and gravel are composed of material originating in the reefs that fringe a considerable part of the island and are most abundant in beaches at the mouths of valleys; the calcareous deposits generally are more permeable than the alluvium.

Beneath a part of the late volcanic rock underlying the Tafuna-Leone plain are sediments that were deposited before the eruption of the Leone volcanics. The nature and extent of these deposits are not known, but they probably consist partly of talus and mainly of calcareous beach deposits and alluvium.

AUNUU

The bulk of Aunuu is an indurated bedded tuff produced by submarine volcanic explosions. The tuff, in general, is relatively fine grained and has been altered sufficiently by weathering to make the material nearly impermeable. The coastal flat on the west and north-west sides of the island is underlain by material washed down from the cone and by permeable deposits of calcareous sand and gravel.

OFU AND OLOSEGA

The islands of Ofu and Olosega are remnants of a larger island built by a single volcano. Erosion by streams and by the sea has cut deeply into the original island and has reduced it to two small steep islands separated by a narrow channel. The islands are composed mainly of thin-bedded basaltic lava flows whose permeability is high. Numerous dikes cut the lava flows on the east end of Ofu and the west end of Olosega. Talus is common around the coast, and deposits of calcareous sand and gravel mantle considerable parts of the shore of each island.

TA'U

Ta'u is the remnant of a single basaltic dome that has been reduced in size and modified in profile by marine erosion and, possibly, by faulting. The island consists mainly of thin-bedded lava flows, except a small sector in the northwestern part, which is formed by several tuff cones. Narrow flats around the shore are underlain by beach deposits of calcareous sand and gravel.

GROUND WATER

The source of all fresh water in the islands is rainfall. A part of the rainfall escapes rapidly as direct runoff into the sea, and a part escapes by evaporation and transpiration. The remainder moves downward through the soil and rock and enters storage in ground-water reservoirs.

Some of the ground water is held above sea level or separated from sea water by barriers or impermeable beds such as dikes or beds of tuff and breccia similar to those shown in figures 3 and 6. The name "high-level ground water" is applied to the water impounded in the rock above sea level. In Samoa it generally is in small reservoirs that discharge underground at low points in the impounding members or at the surface of the ground where the impermeable structures intersect erosion surfaces. Discharge at the ground surface is through springs and seeps that maintain the flow of streams during periods of low rainfall.

Ground water that is not held up by impermeable barriers moves down to about sea level where it accumulates generally as lenslike bodies floating on the slightly heavier sea water that saturates the rock below sea level. (See figure 4.) The ground water near sea level, including the fresh-water lens and the sea water in which it floats, is called "basal ground water." It generally is the source of the springs that discharge along the shore and that are particularly evident along some sandy beaches at low tide.

The principal water-bearing rocks in Samoa are the basaltic lava flows. The occurrence and availability of the ground water are controlled by the permeability of the lava flows, the relation of the flows to dikes and other rock that are relatively impermeable, and the extent to which the lava terranes have been dissected by erosion. Locally, tuff, cinder, talus, and calcareous beach sand and gravel yield water, but the volume of these materials is small in comparison to that of the lava flows.

STREAMFLOW

Nearly 200 perennial and ephemeral streams flow from the mountains of Tutuila into the sea or onto the Tafuna-Leone plain. Drainage areas of the streams range from less than 0.1 square mile to about 2 square miles and average about 0.25 square mile. Many of the small ephemeral streams flow down precipitous slopes into the sea. The gradients of the larger streams are from 500 to 1,000 feet to the mile, except near the shore where the gradients are gentle for short distances on valley floors of alluvial fill.

The base flow of the perennial streams comes from numerous small springs and seeps discharging from high-level ground-water reservoirs. Many of the streams have trickles of a few hundred to a few thousand gallons per day during dry weather. The largest streams seem to have average flows of a few million gallons per day and dry-weather flows of a few hundred thousand gallons per day.

Gaging of streams on Tutuila was started in 1958 by the Geological Survey in cooperation with the Government of American Samoa. The

program includes continuous measurements of flow on about 6 streams and occasional measurements on about 50 streams. Records of the gaging are compiled for publication in Water-Supply Papers issued by the Geological Survey.

The water used in most of the villages of Tutuila is obtained from reservoirs or pools in streams. The reservoirs generally are formed by low masonry or concrete dams across small streams. Some reservoirs have capacities of several thousand gallons, but most hold only a few hundred gallons and are little more than diversion structures for pipelines that lead to villages. The supply in some villages is dipped from pools in streams; the upstream pools are used for drinking water and the downstream pools are used for washing and bathing. Occasional water shortages affect many of the villages because of deficient streamflow or inadequate storage.

A reservoir formed by a relatively large dam across the Fagaalu Stream supplies a large part of the water used in the administration area at Pago Pago. The dam impounds flow from a large spring and runoff from the upper part of the Fagaalu Valley.

The combined discharge of the major streams on Tutuila probably is sufficient to meet all demands for domestic water on the island. Collection and storage of water from the scattered sources and distribution to areas of need would involve considerable construction.

Aunuu has no streams. A few springs on the slopes of Ofu and Olosega may feed streams that flow short distances, but the water soon sinks into the permeable rock.

Charts of Ta'u (fig. 7) show a stream called Laufiti River on the south side of the island, but it is in a remote area and no information is available on it. A small apparently perennial stream on the north slope of Ta'u near the village of Fitiuta has a flow of a few thousand gallons a day. This supply is piped to Fitiuta, Maia, and Leusoalii. Other similar streams may flow on the upper north slope of the island, but none reaches the shore. A small rain catchment and reservoir has been used at Siufaga for water supply.

TUTUILA

HIGH-LEVEL GROUND WATER

High-level ground water is hydrologically important on Tutuila because it is the source that maintains the base flow of the streams. Discharge to the streams occurs in numerous springs and seeps, some of which are large enough to be easily seen but many of which are so small or diffuse that their additions to the streams are almost imperceptible. Because of the heavy cover of soil and vegetation, conditions

that control the occurrence and discharge of high-level ground water usually are not readily apparent.

At many places on Tutuila, permeable lava flows lie on relatively impermeable layers of tuff, breccia, or old soil. Water moving downward through the lava is intercepted and accumulates on, or moves along, the surface of such an impermeable layer. The thickness of the water body will depend on the areal extent and the dip of the surface of the barrier, the permeability of the aquifer, and the rate at which water is added to it from above. The thickest water bodies tend to form on widespread flat-lying impermeable layers. If an impermeable layer does not intersect the surface of the ground, water will flow over the edges of the layer and move on down through the rocks. Where the layer is cut by a cliff or a valley slope, the water will discharge at the surface in springs and seeps from which it may flow into streams or be absorbed again in the rocks. Discharge of ground water in this manner tends to be in long narrow zones, and, on Tutuila, the rate of flow from the aquifer commonly is so low that the discharge along seepage zones or lines of small springs may be obscure unless the cover of soil and vegetation is thin or is cleared away.

Dikes are vertical or have steep dips, and where they occur in groups, the country rock is divided into segments bounded by walls of dense dike rock. These segments are variable in size and shape according to the spacing and orientation of the dikes. A series of parallel dikes will produce a corresponding sequence of slices of country rock. A second series transverse to the first will divide the rock into cells that have well-defined lateral boundaries and may have considerable vertical extent. Generally, the spacing of intersecting dikes is uneven and the parallelism is crude; consequently, the cells of country rock have a great range in size and shape. Rocks with high permeability that lie between widely spaced intersecting dikes are potentially highly productive aquifers, but as the distance between dikes decreases, the overall permeability of the rock is lowered because of the increasing proportion of dense dike rock. Discharge of water from dike compartments usually takes place over the dikes at low points where they are crossed by streams. Dikes are numerous in some parts of Tutuila, but, in general, they are so closely spaced that the yield of water, in the form of springs, from the dike compartments apparently is small.

The simple conditions described above may be seen in a few places on Tutuila, but most of the high-level ground water apparently is controlled by complex combinations of the simple relations. For example, dikes or faults, or both, may complicate the simple combination of permeable lava lying on impermeable tuff or of erosional unconformities and overlapping of rocks from different eruptive centers:

when combined with other structures, these combinations may produce intricate patterns of permeability. As a result, most of the high-level reservoirs are small.

Some high-level water accumulates in talus and appears as seeps and small springs, generally near the foot of the talus slopes.

High-level ground water in cinder is the source of small springs in a few places. An example of this occurrence is on the upper slopes of the cinder cone Olotele, where interbedded lava flows and weathered layers less permeable than the fresh cinder hold up small bodies of perched water.

The total amount of high-level water discharged daily in all of Tutuila is large, but, with one known exception, it is widely dispersed in many small springs and seeps. An exceptional spring near the head of Fagaalu Valley has a reported flow of about 500,000 gpd (gallons per day). This spring is behind a dam built across the Fagaalu Stream, and the resulting reservoir is used as a principal source of water for the supply system in the Pago Pago Harbor area.

BASAL GROUND WATER

Fresh ground water accumulating at sea level and floating on the heavier sea water forms lenses that vary in size and quality with the character of the rock, the amount of fresh-water recharge, and the tidal movement in the ground water. If the permeability of the rock and the rate of recharge are favorable, the lens will remain perennially fresh. Movement of the ground water in reaction to the tide promotes mixing of the fresh water and sea water, and if the mixing is not damped within the rock or its effect is not balanced by sufficient recharge of fresh water, the lens will become salty.

The coast of the mountainous part of Tutuila has not been explored for basal ground water with any thoroughness; however, the dense and massive appearance of the lava flows near the shore suggests that the permeability of the rock is too low for large basal supplies. Springs in beaches and along rocky shores, which are the most common evidence of basal water discharge, are rare in this part of the island.

In an effort to develop basal ground water, a well was dug near the head of Pago Pago Harbor in 1943. The well has 325 feet of horizontal infiltration tunnels at the bottom of a shaft 76 feet deep. At the time of construction, the static water level was 24 feet above sea level, and the yield was about 200 gpm (gallons per minute). The rocks cut by the tunnels are lava flows, breccia, and dikes. Two faults were crossed by the tunnels. The high water level and the complex geology exposed in the tunnels indicate that the ground water

at the site of the well is impounded and separated from sea water by dikes and other structures. Hydrogeologic conditions in many parts of Tutuila probably are similar to those at the Pago Pago well.

The rocks of a large part of Tafuna-Leone plain appear to be favorable for a considerable supply of basal water. Tuff is found in the area, but most of the plain is underlain by thin-bedded pahoehoe lava flows which appear to form a highly permeable unit. Some springs, several of which discharge a considerable volume of water, are reported to flow along the shore of the plain. Although some are brackish, the springs indicate that a large amount of water moves through the rock under the plain, and reasonably fresh water probably saturates the rock more than half a mile inland. The sedimentary rocks that underlie the basalt along the inland edge of the plain may affect the quality and quantity of the water in the basalt, but their effect cannot be determined without subsurface exploration.

Alluvium underlying the lower ends of large valleys probably contains water that is recharged by streams.

DEVELOPMENT AND USE OF GROUND WATER

Ground water from the spring in the reservoir in Fagaalu Valley and from the well at Pago Pago supplies a large part of the needs in the Government area on the shore of Pago Pago Harbor. Outside the harbor area, however, only a few ground-water sources are developed. A few villages channel water from high-level seeps and springs into basins or small reservoirs, from which the water flows through pipelines to one or more outlets in the villages. Most of the springs are in dense lava flows or tuff and flow only a few gallons per minute. Two springs in cinder on the slope of Olotele have a combined discharge of about 20 gpm, and this flow is piped to the villages of Iliili, Futiga, and Vaitogi. (See figure 2.)

The water supply at Tula, on the east end of the island, comes from a sealed tunnel driven into a high-level aquifer concealed by soil and vegetation. A tunnel and spring in talus near the shore of Fagasa Bay supply a few gallons a minute to Fagasa village. Figure 3 shows the geologic conditions at a seepage zone at Fatamafuti, where a tunnel in lava overlying breccia and tuff develops about 5 gpm. The water collected by tunnels and other improvements at springs commonly is equaled or exceeded by the amount that escapes.

No basal water has been developed in the communities of Tutuila. However, water flowing from basal springs along the shore of the Tafuna-Leone plain is used occasionally.

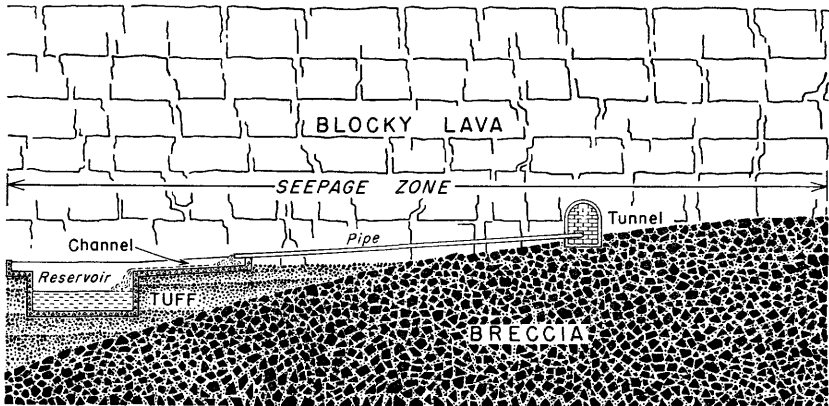


FIGURE 3.—Sketch showing geologic conditions at a high-level seepage zone and water-development tunnel near Fatamafuti, Tutuila.

POTENTIAL DEVELOPMENT OF GROUND WATER

Geologic conditions in most of Tutuila appear unfavorable for the development of ground water in large quantities at single installations. However, high-level supplies in the mountains probably could be found to meet modest demands in many of the villages. These sources could be developed by means of tunnels or other structures designed to intercept effectively the flow from springs and seepage zones. Selection of most sites for development would require careful examination of the geology and the occurrence of water. Construction work necessary to develop the supplies would be relatively simple, and the work would be within the capabilities of the labor available in most of the villages. Hydrologic guidance and engineering advice, however, would be necessary in most development work. Potential capacities of individual water sources are variable; the normal range probably is 5 to 10 gpm, but a few sources may yield as much as 20 gpm.

High-level water supplies of a few hundred gallons per minute possibly could be developed in some places by elaborate wells consisting of long infiltration tunnels draining into pump sumps. The well at Pago Pago, supplying a part of the water in the Harbor area, is of this type. This manner of development is costly, however, and normally suitable sites are difficult to find without detailed and expensive exploration.

There is no evidence of basal ground water in large quantities in the volcanic rock along the shore of the mountainous part of Tutuila; however, evaluation of this potential source can be made only after a careful study of the coast of the island. Small basal supplies in lava flows probably are available in many places, but their development would require the digging of wells from which the water would have

to be pumped. Capacities of 5 to 10 gpm could be expected in most dug wells. Depths of the wells, which would be sunk at least to sea level, would depend on the altitude of the locations. An increase in the salt content of the water in basal wells is always a possibility, especially if pumping rates are high.

Alluvium underlying the lower ends of some large valleys may contain considerable amounts of basal water that could be developed in dug wells. The most favorable places to explore for this water are the two valleys entering Pago Pago Harbor at Aua and at Pago Pago.

Large quantities of fresh basal water may be available in lava flows underlying the Tafuna-Leone plain, but exploratory drilling at several sites would be necessary to find the best well sites. Information needed for selection of well sites includes the quality of the ground water, the altitude of the water table, and the water-bearing character of the rock at and below sea level.

AUNUU

High-level ground water on Aunuu is insignificant, but a basal ground-water body of appreciable volume exists in the calcareous sand and gravel that underlie the coastal flat on the west and north-west sides of the island. Four or five shallow dug wells in the calcareous deposits supply the water used in Aunuu village. According to reports, the wells are a dependable source of supply for the village, and the salinity does not rise excessively during dry periods. A fresh-water lake and swamp occupies the floor of the crater of Aunuu cone, and ponds and swamps lie on the inland edge of the coastal flat.

OFU AND OLOSEGA

Ofu and Olosega are composed largely of thin-bedded lava flows that have high and generally uniform permeability and do not appear favorable for the existence of large reservoirs of high-level ground water. If such water bodies exist, they are deep within the masses of the islands and do not discharge at the surface. Locally, dense lava beds perch small bodies of water, some of which produce small springs having flows of 1 or 2 gpm. Seeps and a small spring discharge along dikes at the west end of Olosega.

The thin-bedded lava flows at sea level contain large volumes of fresh basal ground water. The fresh water flows from the lavas into beach deposits of sand and gravel and discharges into the sea at springs along the shore (fig. 4).

Although the flow from high-level springs in Ofu is small, these sources are used for public water supply. The water from two springs, each discharging about 1 gpm, is piped to outlets in the village of Ofu. (See figure 5.) The reservoirs into which the springs flow are often empty, and the village frequently is short of water.

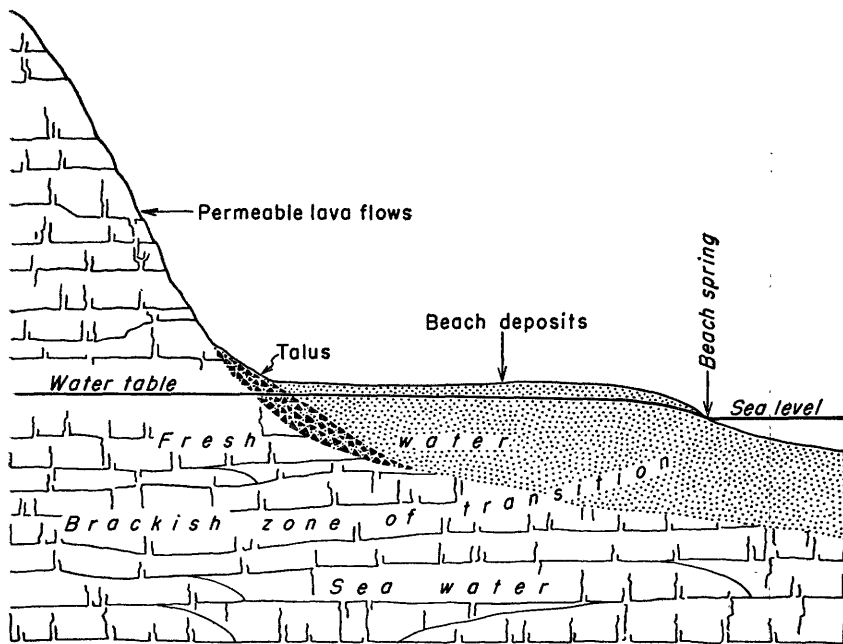


FIGURE 4.—Sketch showing the occurrence of fresh basal ground water in lava flows and beach deposits.

A spring at 790 feet above sea level on the west slope of the island supplies water for the dispensary in the village. When flow from these sources is insufficient, water for drinking is obtained from beach springs that are uncovered at low tide.

Sili village, on Olosega, uses water from a small spring flowing from breccia cut by dikes. This source is reported to fail occasionally, and the installation around the spring is in danger of damage from flood debris in the intermittent stream that flows over it. Supplementary supplies are provided by a shallow well dug in beach deposits and a beach spring. A small spring high on the east slope of Olosega supplies water for Olosega village. Additional water for the village is obtained from several shallow dug wells in the sand and gravel underlying the flat on which the village is located.

Large supplies of high-level ground water probably cannot be developed on Ofu and Olosega, but ample supplies are present in the basal aquifers along the coast. Some water used on Olosega is dipped from shallow wells tapping basal water in beach deposits. Supplies could be obtained on both islands from wells dug in lava rock at the inland edge of the coastal flats. However, because of the excavation in hard lava, the cost of this development would be high, and these wells would be farther from the villages than the beach wells.

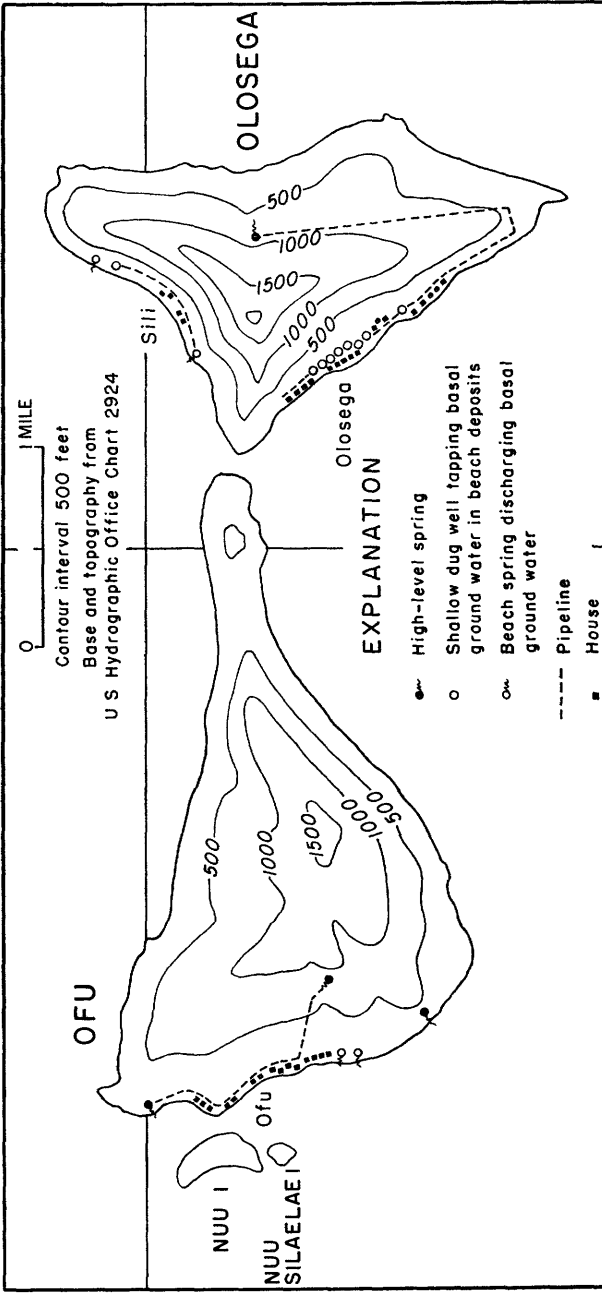


FIGURE 5.—Map of Ofu and Olosega showing principal springs and wells.

TA'U

The central part of Ta'u may contain considerable quantities of high-level ground water, but erosion has not cut deep enough into the volcanic dome to expose any large reservoirs that exist. A few seeps and springs in cliffs at the coast flow from the tops of dense lava flows or from lava lying on tuff beds (fig. 6) ; in the northwest corner of the

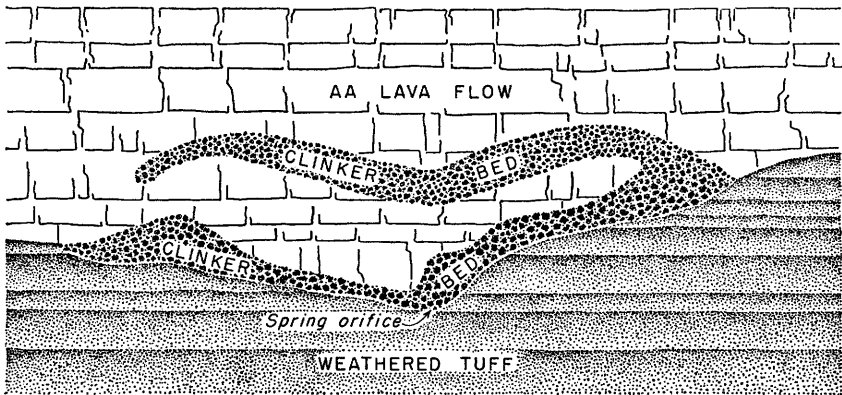


FIGURE 6.—Sketch showing geologic conditions at a small spring near Fagamalo, Ta'u.

island, some water flows from joints in tuff beds. As on Ofu and Olosega, springs along the shore indicate the presence of fresh basal ground water.

Water piped to outlets in Luma, Siufaga, and Fagamalo villages flows from a small spring in aa lava lying on tuff. (See figure 7.) This source is inadequate for the villages, and most washing and bathing is done in beach springs that flow at low tide in front of the villages. Faleasau obtains part of its water from small springs flowing from tuff and part from wells dug in beach deposits. A small surface-water supply at Fitiuta, Maia, and Leusoalii is supplemented by a few dug wells tapping basal water in beach deposits.

The basal ground-water supply on Ta'u probably is sufficient to meet all needs on the island. This water can be developed most readily in wells dug to about sea level into lava flows at the inland edge of coastal flats. Sites for wells should be selected carefully. Wells should be in permeable lava flows and not in tuff or other relatively impermeable rock that yields water to wells only at low rates.

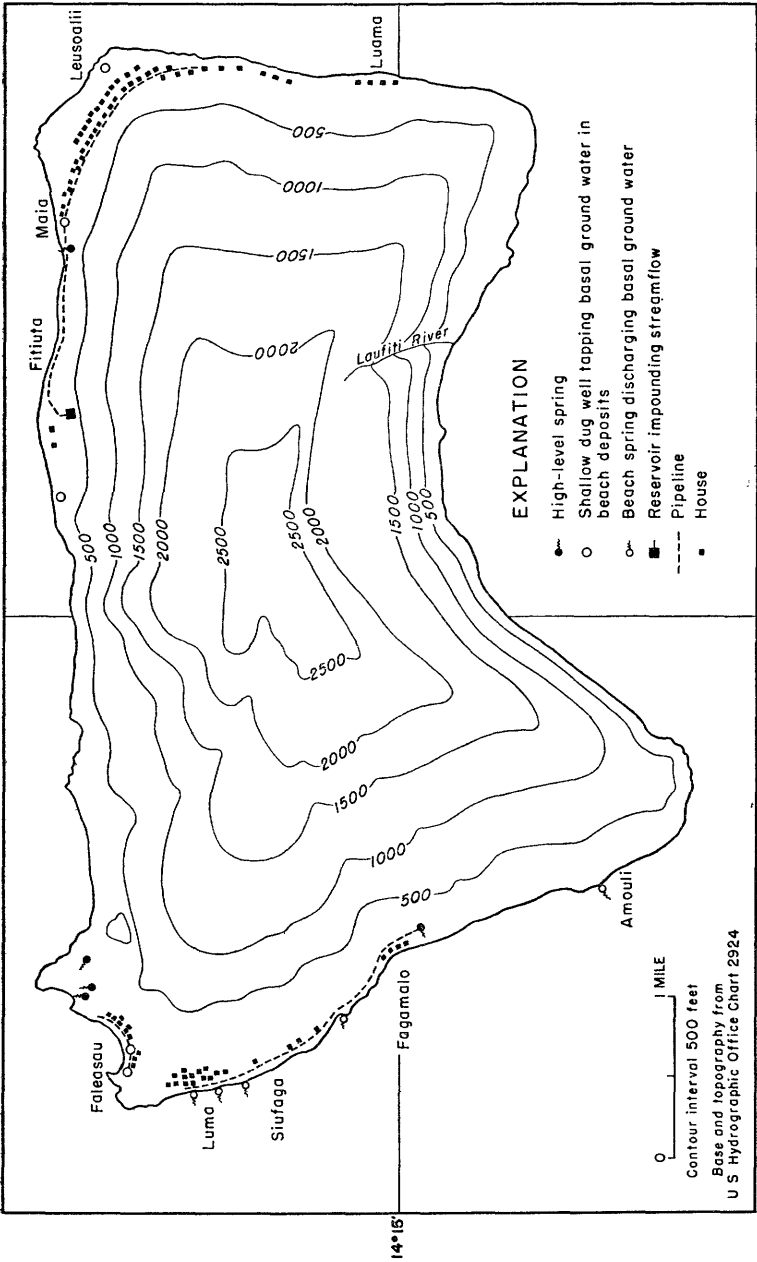


FIGURE 7.—Map of Ta'u showing principal springs and wells.

SUMMARY

Ground water in the mountainous part of Tutuila is largely high-level water contained in many small reservoirs that discharge at small springs and seeps. The water at a few springs and seeps is developed in short tunnels or channeled into basins for village supplies, but streams are the source of water used in most villages. Additional village supplies of as much as 10 gpm could be developed by means of short tunnels or other improvements at numerous spring and seepage zones. Larger supplies of high-level water, as much as a few hundred gallons per minute, might be obtained in elaborate infiltration-tunnel systems.

Basal ground water in large quantities apparently is not available at most places on Tutuila because of the low permeability of the rock at sea level. Substantial supplies of basal water may underlie the Tafuna-Leone plain, but exploratory drilling would be needed to find the best sites for wells.

Beach deposits on Aunuu contain small quantities of fresh water, which is tapped in shallow dug wells.

The islands of Ofu, Olosega, and Ta'u have only minor high-level ground-water resources, but the basal water supplies are large. A few high-level springs and several shallow wells dug to basal water in beach deposits are the sources of water for the villages. Good supplies can be obtained in wells dug to about sea level into permeable lavas at the inland edge of many of the coastal flats.

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