WATER-RESOURCES RECONNAISSANCE OF THE SOUTHEASTERN PART OF ST. PAUL ISLAND, PRIBILOF ISLANDS, ALASKA

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS 80-61

PREPARED IN COOPERATION WITH THE
NATIONAL MARINE FISHERIES

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No.
4. Title and Subtitle WATER-RESOURCES RECONNAISSANCE OF ST. PAUL ISLAND, PRIBILOF ISLANDS, ALASKA			5. Report Date June 1980 6.
7. Author(s) Alvin J. Feulner			8. Performing Organization Rept. No. AK-122
9. Performing Organization Name and Address U.S. Geological Survey, Water Resources Division 733 West 4th Avenue, Suite 400 Anchorage, Alaska 99501			10. Project/Task/Work Unit No. USGS/WRI/NTIS-80-61 11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address U.S. Geological Survey, Water Resources Division 733 West 4th Avenue, Suite 400 Anchorage, Alaska 99501			13. Type of Report & Period Covered Final 14.

15. Supplementary Notes

Prepared in cooperation with the National Marine Fisheries

16. Abstract (Limit: 200 words)

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17. Document Analysis a. Descriptors

Ground water, Ground-water quality, Aquifers, Islands

b. Identifiers/Open-Ended Terms

Alaska, Volcanic rocks, Saline ground water

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
No restrictions on distribution	Unclassified	15
	20. Security Class (This Page) Unclassified	22. Price

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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By Alvin J. Feulner

U.S. Geological Survey

Water-Resources Investigations 80-61

Prepared in cooperation with the National Marine Fisheries

Anchorage, Alaska
1980

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONTENTS

ILLUSTRATIONS

TABLES

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

Multiply	By	To obtain
inches (in.)	25.40	millimeters (mm)
feet (ft)	0.3048	meters (m)
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers (km^2)
gallons (gal)	3.785	liters (L)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)

Degrees Celsius (°C) = 5/9 [Degrees Fahrenheit (°F) - 32]

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ABSTRACT

A hydrologic reconnaissance of the southeastern part of St. Paul Island was made in August 1979 to determine if sufficient fresh water is available for a proposed harbor and fish-processing facility. Only three wells were being used in 1979, two by the community of St. Paul and one by the Coast Guard Loran facility. All wells are in the southeastern part of the island. The island has no established surface drainage, and no springs were found on the eastern part of the island during the survey. Drainage of ground-water from the island is assumed to be by seepage through the sandy deposits along the east coast and possibly by undersea discharge elsewhere on the island. On the basis of present well yields, amount of fresh water inferred to be present below the water table, and potential recharge from precipitation, it is concluded that it should be possible to design a well field in the southeastern part of the island that could yield more than a million gallons per day without danger of inducing saline water into the well field. The water is of good chemical quality.

INTRODUCTION

The village of St. Paul is situated on the southern tip of St. Paul Island, one of several volcanic islands within the Pribilof Island group (figs. 1 and 2), in the Bering Sea. St. Paul Island is the largest island in the group; it has an area of 44 mi^2. The island is treeless, and the vegetation is largely composed of grasses. There are also large bare areas of basalt. The climate is maritime, with cloudy and foggy weather predominating. Total annual precipitation averages about 24 in., and the mean annual air temperature is about 36°F. The topography of St. Paul Island has been only slightly modified since the island was formed. Volcanic flows, cones, and scarps appear fresh, and there is no development of surface drainage.

A hydrologic reconnaissance of St. Paul Island was made August 4-7, 1979, by the U.S. Geological Survey at the request of the National Marine Fisheries Pribilof Islands Program. The purpose of the visit was to determine the feasibility of providing fresh water for a proposed shore-based fish-processing plant and for harbor facilities. The study concentrated on the southeastern part of the island where all of the present wells are situated and where the best potential for water supply and processing facilities may exist.

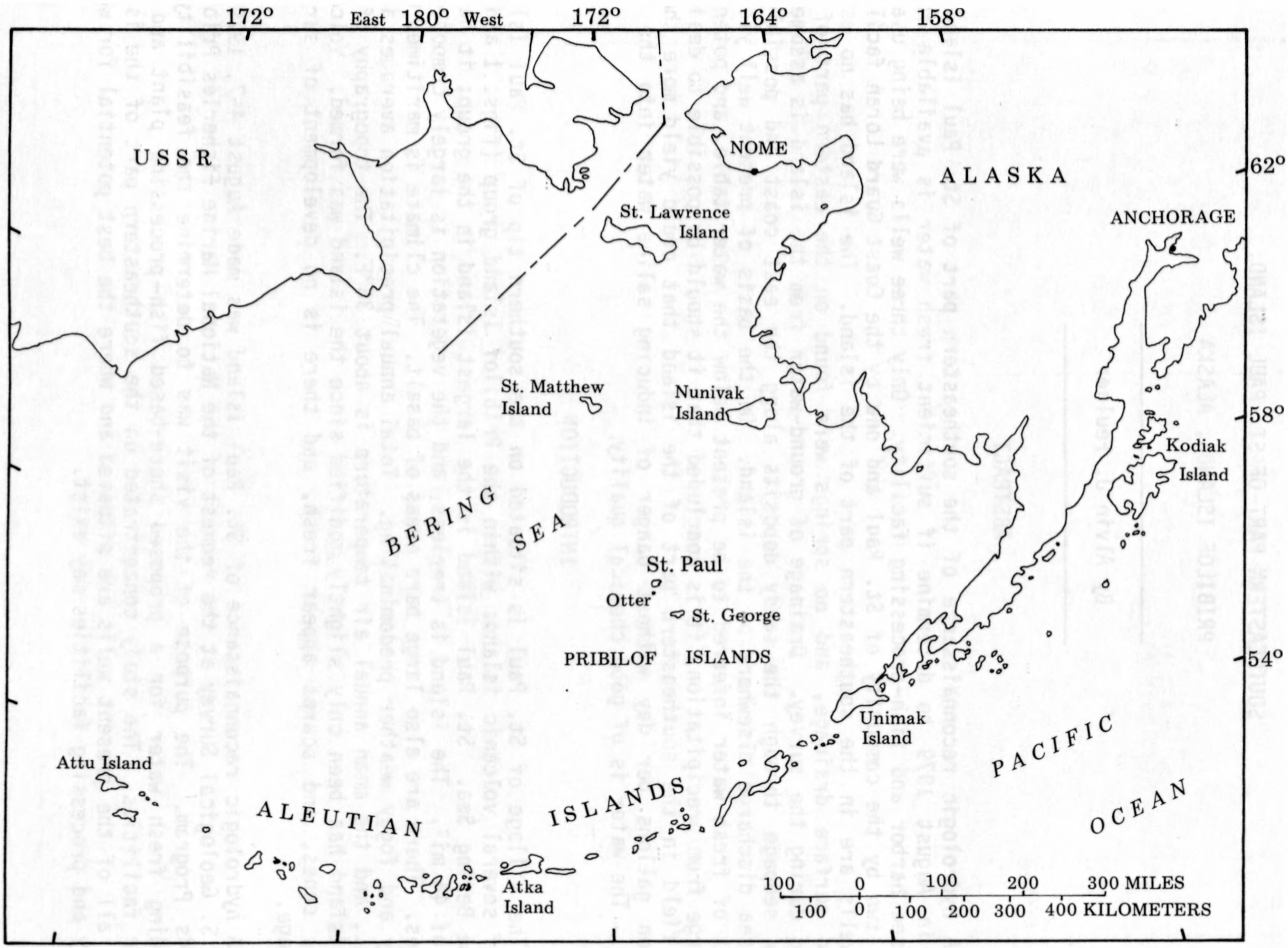
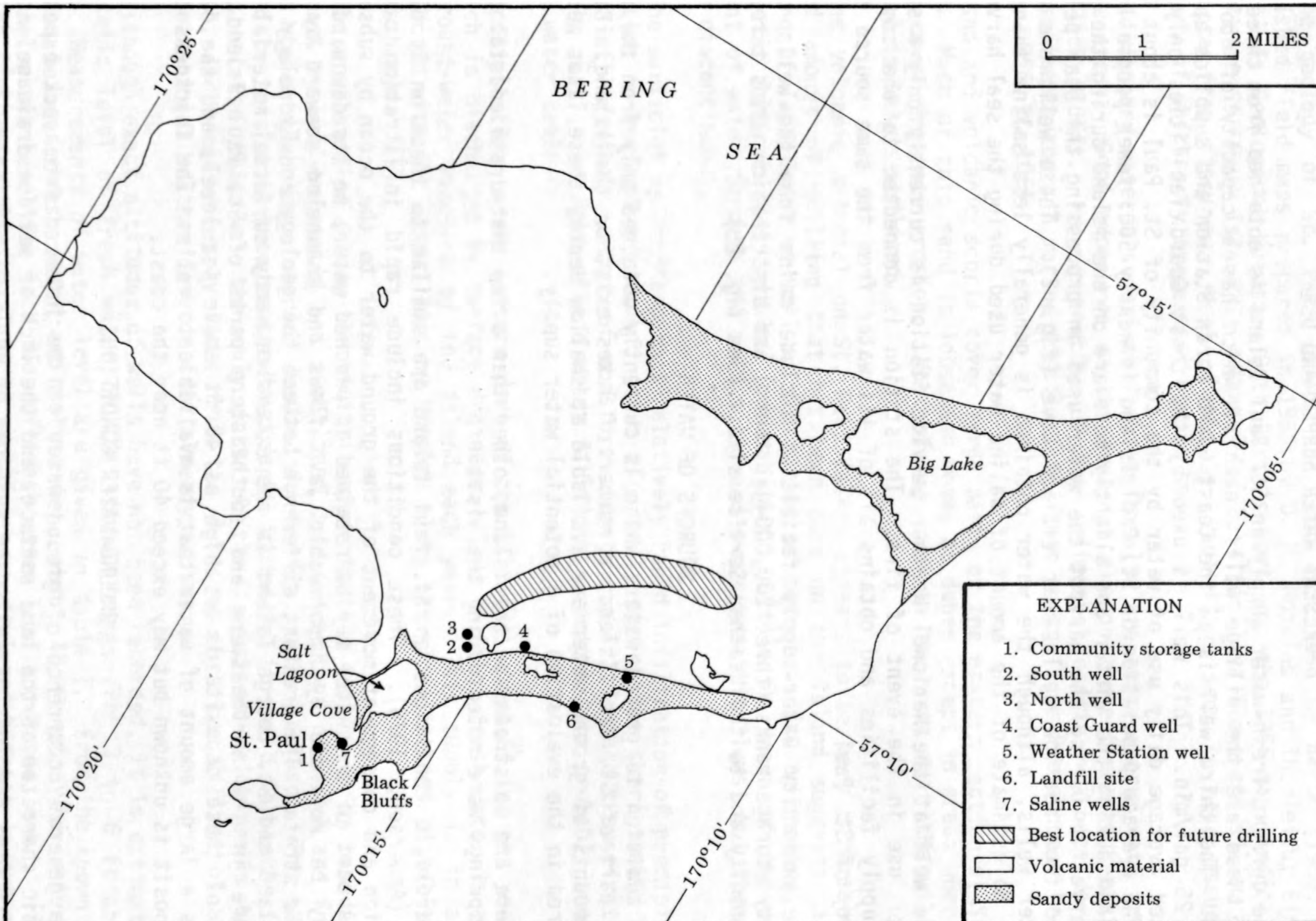


Figure 1.--Location of Pribilof Islands.



Modified from St. Paul Community Map, Alaska Department of Regional and Community Affairs, 1978

Figure 2.--St. Paul Island showing location of wells, water facilities, landfill site, and area for possible future water-supply development.

PRESENT WATER SUPPLY AND USE

The current fresh-water supply on St. Paul Island is obtained from three wells. Two of these are the village wells, each of which has a capacity of about 100 gal/min. The third well is at the Coast Guard Loran Station and supplies approximately 25 gal/min. This well is used by the Coast Guard facilities only. The estimated average daily use of water by the community of St. Paul is about 80,000 gal. The average population of St. Paul Island is nearly 500; fewer people live on the island during the winter and slightly more are on the island during the summer seal harvest. During the harvest the water used in processing the seal pelts is obtained from shallow wells near Village Cove (fig. 2). These wells are called saltwater wells, although the water obtained is generally less saline than ocean water. No estimate of the amount of saline water used during the seal harvest is available.

The well at the National Weather Service Station is currently only a standby well for use in the event of fire. The station is connected to the community water-supply facilities and obtains all of its water from the same source as the community of St. Paul.

The community water-supply facilities include mains from the wells to the community storage tanks (three 200,000-gal tanks) and distribution mains throughout the community and to the Weather Service site. (See fig. 2.)

SOURCES OF WATER

In addition to ground water, which is currently obtained only from the southeastern part of St. Paul Island, a number of lakes exist on the island. Because large amounts of ground water are available at shallow depth, these lakes were not considered in the evaluation of a potential water supply.

There are no streams on the island, other than a few that drain coastal ponds, and no springs were noted during the visit

Hydrologic conditions on St. Paul Island are similar to those on St. George Island (Anderson, 1976). These conditions include rapid infiltration of precipitation and consequent movement of the ground water to the ocean by subsurface flow. A part of the water may be retained as perched water, or its downward movement may be retarded by impermeable lava flows and channeled seaward by other permeable strata. The greatest difference between the geology and hydrology of St. Paul Island and St. George Island is the extensive sandy surficial material along the shore in the northeastern and southeastern parts of St. Paul Island. The surface of these deposits is as high as 40 ft above sea level, and the deposit contains a large amount of water that is available to wells. The thickness of the sand deposit is unknown but may exceed 40 ft near the coast.

GROUND-WATER CONDITIONS

The general occurrence of ground water can be inferred from rock exposures, geomorphic character of the land surface, and the lack of surface drainage, as well as from records and logs of wells and response of wells to pumping.

The geology of St. Paul Island has been described by Barth (1956) and on unpublished field maps prepared in 1965 by D. M. Hopkins and Thorleifur Einarsson of the U.S. Geological Survey. Both Barth's work and the 1965 maps indicate that the bulk of St. Paul Island is composed of basaltic lava flows and sills, as well as ejecta from fissures. Most of the St. Paul flows seem to have issued from fissures, of which only traces can now be seen.

Sedimentary materials derived from the basalts are interlayered with the flows in some areas. Good exposures of the deposits are on the extreme southeast shore near Black Bluffs. No explanation of the sediments' origin has been developed. These sediments contain marine fossils that range in age from Pleistocene to Recent (Barth, 1956, p. 106).

Sand and volcanic scoria cover large parts of the eastern section of St. Paul Island. Much of this sand is loose and moves as dunes except in areas where vegetative cover prevents erosion. Most of the sand in the area near the village of St. Paul is well stabilized.

The volcanic material on St. Paul Island appears to be very permeable. The limited amount of drilling that has been done on the island suggests that the layering of lava beds, as well as fracturing of some beds due to cooling, results in greater lateral than vertical permeability. Little is known of the vertical movement of water through the more solid and dense basaltic flows, but these flows may be discontinuous.

The surficial sediments permit relatively rapid infiltration of precipitation. Vegetation on much of the island grows vigorously during the short summer and may retard infiltration. Losses of moisture through evaporation and transpiration are probably small, and most of the water falling as precipitation probably penetrates to the water table.

Precipitation in the eastern part of the island is about 24 in. per year, none of which is discharged by surface drainage. Thus 2 ft of fresh water is added to the ground-water resource of the island each year. This supply is in apparent equilibrium with the annual loss by seepage along the shoreline and possibly undersea discharge.

The area studied during the visit is approximately 4 mi². It is bounded along the coast by well-vegetated and stabilized dunes, the tops of which are from 5 to 10 ft higher than the interior basins which they partly enclose. The study was limited to this area because the topography indicated it was a favorable site for water, because this was the only part of the island on which wells had been drilled, and because supply lines from the wells to both the village of St. Paul and the National Weather Service site already exist.

Although exact altitudes of wells have not been recorded, it is estimated that the static level of fresh water on the island ranges from 3 to 6 ft above sea level. Measurements of water level are given in table 1. From the known density relation between fresh water and salt water, about 40 ft of fresh water should exist below sea level for each foot of fresh water head above sea level. (See fig. 3.) The fresh-water lens may not be as thick as postulated because layers of dense

Table 1.--Records of wells

St. Paul Island village well 1 (South Well)
Driller: unknown
Reported depth: 86 ft; casing diameter 6 in.; water level unknown.

St. Paul Island village well 2 (North Well)
Driller: unknown
Reported depth 112 ft; casing diameter 6 in. The depth reported by John R. Merculief, National Marine Fisheries, St. Paul Island, is 91.75 ft, and the depth to static water level is 79 ft (12.75 ft of water in the well). This well may have been backfilled in the lower 20 ft, as was the Coast Guard well.

U.S. Coast Guard Loran site well
Driller: B. E. Strotman, Seattle, Washington
Depth: 44 ft; completed depth 36 ft (lower 8 ft filled with broken rock); casing diameter 6 in.; depth to water 27 ft (9 ft of water in well).

Log of Well

	Thickness	Feet
Sandy clay	19	19
Broken basalt	8	27
Solid basalt	6	33
Broken basalt	7	40
Solid basalt	4	44

National Weather Service site well
Dug well; 15 ft deep; no additional data available. At present (1979) used only as a fire-protection water supply.

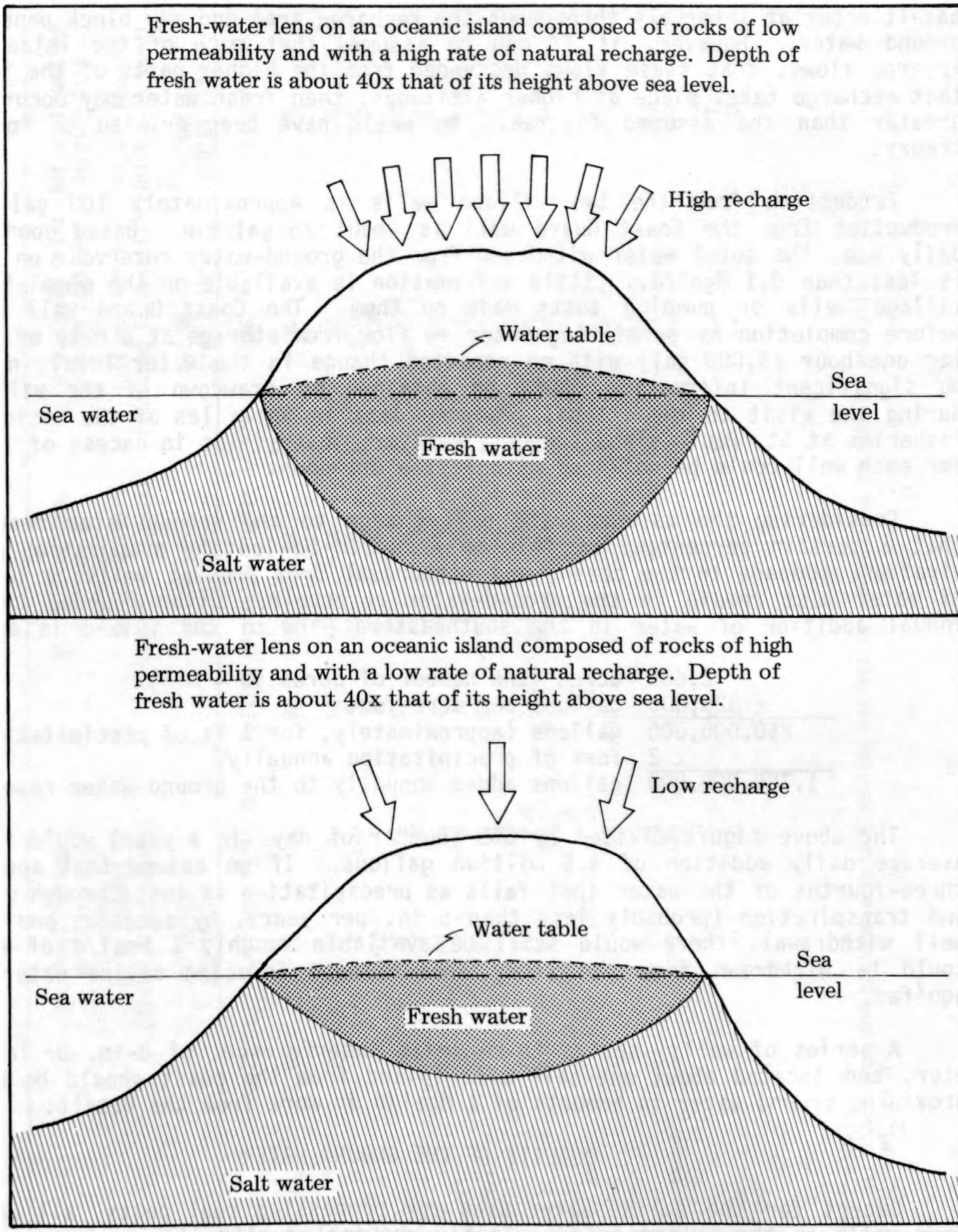


Figure 3.--Schematic diagram of a fresh-water lens in an oceanic island.
(Modified from Anderson, 1976).

basalt occur at intervals throughout the recharge area and may block penetration of ground water. However, if it can be assumed that much of the island contains layered flows, that these flows descended from the higher parts of the island, and that recharge takes place at higher altitudes, then fresh water may occur at depths greater than the assumed figures. No wells have been drilled to confirm this theory.

Production from the two village wells is approximately 100 gal/min each. Production from the Coast Guard well is about 25 gal/min. Based upon estimated daily use, the total water withdrawn from the ground-water reservoir on the island is less than 0.1 Mgal/d. Little information is available on the completion of the village wells or pumping tests made on them. The Coast Guard well was tested before completion by permitting water to flow from storage at a rate of 50 gal/min for one hour (3,000 gal) with no reported change in the water level in the well. No significant information could be obtained on drawdown of the village wells during the visit to the island. Pumping data in the files of the National Marine Fisheries at St. Paul Island suggest, however, that yields in excess of 100 gal/min for each well could be obtained with little drawdown.

Considering the assumed rate of recharge to the ground-water reservoir and that a certain percentage of this water would be lost by evaporation and transpiration, seepage to the ocean, and withdrawal from present wells, a large amount of water must remain in the ground-water reservoir. Using rounded figures, the annual addition of water in the southeastern part of the island is as follows:

2,600	acres (the number of acres in 4 mi^2)
x 325,000	gallons per acre-foot
850,000,000	gallons (approximately, for 1 ft of precipitation)
x 2	feet of precipitation annually
1,700,000,000	gallons added annually to the ground-water reservoir

The above figure divided by 365 (number of days in a year) would indicate an average daily addition of 4.6 million gallons. If we assume that approximately three-fourths of the water that falls as precipitation is lost through evaporation and transpiration (probably less than 5 in. per year), by seepage, and to present well withdrawal, there would still be available roughly 1 Mgal/d of water that could be withdrawn from the study area without inducing saline water into the aquifer.

A series of wells, spaced to minimize interference, of 8-in. or larger diameter, and located about one-half mile inland from the coast should be capable of providing ground water in amounts of 1 Mgal/d or more from the basalt.

QUALITY OF THE GROUND WATER

Except for the saline water used for processing seal pelts, all water drawn from wells on the island is of suitable chemical quality for most uses. Analyses are presented in table 2. Water from the wells used for processing of seal pelts has not been analyzed. Well locations are shown on figure 2.

Table 2.--Selected chemical analyses.

(mg/L = milligrams per liter; µg/L = micrograms per liter)

	St. Paul Village Well No. 1 (South) AK No. 80059 (finished in basalt)			St. Paul Village Well No. 2 (North) AK No. 80193 (finished in basalt)				U.S. Coast Guard Loran Station AK No. 80194 (finished in basalt)	National Weather Service Site AK No. 80230 (finished in sand)
Latitude	57°08'56"			57°08'56"				57°09'08"	57°09'28"
Longitude	170°15'36"			170°15'38"				170°14'41"	170°13'17"
Date	8/22/55	6/27/58	11/21/72	6/27/58	6/--/61	4/16/69*	8/6/79	8/6/79	1/6/70
Sample depth (ft)	86	86	86	92	92	92	92	36	15
Silica (mg/L)	28	27	26	25	29	24	28	28	28
Iron (µg/L)	0	0	110	0	20	60	a20	a10	450
Manganese (µg/L)	0	10	0	0	40	0	a 3	a 3	170
Calcium (mg/L)	13	12	14	12	13	15	11	9.0	22
Magnesium (mg/L)	7.4	9.2	7.4	8.0	7.4	5.5	6.4	7.3	19
Sodium (mg/L)	46	48	45	44	45	44	42	42	90
Potassium (mg/L)	5.5	4.9	4.6	4.8	5.0	5.0	4.4	3.6	7.9
Bicarbonate (mg/L)	83	83	78	83	90	87	--	--	121
Carbonate (mg/L)	0	0	0	0	0	0	--	--	0
Sulfate (mg/L)	13	12	9.9	11	11	7.4	12	12	27
Chloride (mg/L)	61	69	64	57	59	60	55	64	149
Fluoride (mg/L)	.2	.1	.9	.0	.3	.5	.2	.1	--
Nitrate (mg/L) as N	.00	.02	.43	.02	.02	.43	b .33	b .45	.27
Dissolved solids calculated (mg/L)	215	223	212	203	214	206	195	193	405
Hardness (mg/L)	63	68	66	63	63	60	54	53	130
Specific conductance (µmhos at 25°C)	360	372	366	335	351	328	--	--	710
pH (units)	6.8	6.3	7.8	6.4	7.3	7.6	--	--	7.1
Color (platinum-cobalt units)	--	0	0	5	0	5	--	--	0

*-Treated-water sample
a-Dissolved. All other iron and manganese determinations reflect concentrations at time of analysis.
b-Dissolved NO_2 + NO_3 as N

The quality of water used for the village supply and the water pumped at the Coast Guard Loran site is well within the standards of the Environmental Protection Agency (1976) for potable water supplies. Water from the previously used dug well at the National Weather Service site meets the standards for potable water, although the dissolved-solids concentration is somewhat higher than that of water from the wells currently in use.

ALTERNATIVES FOR DEVELOPMENT

Two potential sources of water are available on St. Paul Island: lakes and ground water. The development of lakes as a supply source was not considered for several reasons: No data are available on the lake depths; chemical quality of lake water is not known; potential changes in the chemical quality of lakes throughout the year are not known; most lakes are near the coast where saline water additions may occur through precipitation; most lakes are not believed to be of sufficient volume to provide an annual supply of water in the amounts required; and drawing water from most of the lakes would require lengthy extensions of the water-supply system.

Ground water can probably be developed nearly anywhere on the island. The southeastern part of the island is most attractive for harbor and processing facility development because of the apparent high potential yield of wells and proximity to the village of St. Paul and the Village Cove area. In addition, there are large, relatively low areas away from the ocean where wells could be developed. Present wells in the general area have penetrated lava flows and obtained water of a better quality than those nearer the coast in the sand aquifer. (See table 2.)

Another alternative to the drilling of wells could be the construction of a gallery water-supply system. This possibility was not studied because the data collected indicated that drilled wells would supply more than 1 Mgal/d on a sustained basis. A gallery system could supply as much or more water, but construction costs would probably be higher because of the extensive sand in the area.

SANITARY CONSIDERATIONS

The general area in which future development of water supplies has been proposed is relatively free from contaminants at the present time. The only known point at which pollution would threaten future wells or supplies in the area indicated in figure 2 is in the vicinity of the Coast Guard Loran site. This area is currently served by septic tanks. Care has been taken at the site to prevent any other sort of contamination.

The landfill (fig. 2) currently in use is near the coast. Pollutants from this site would enter the water table and eventually be discharged into the ocean with no danger to the proposed well field.

Care should be exercised in future developments, however, because the sandy deposits underlying much of the study area have the capacity to quickly transmit contaminants, such as spilled fuel oil, to the water table.

POTENTIAL DEVELOPMENT FOR FISH PROCESSING

One of the principal reasons for this preliminary survey of the availability of water supply on St. Paul Island is the possible development, near Village Cove, of a fish-processing facility. A shore-based cannery or fish-processing plant constructed adjacent to Village Cove would have the advantage of being nearer the potential well field than the water system of the community of St. Paul. Although the potential demand for water for such a facility is not known, at least 1 Mgal/d of water could be provided by wells within a few miles of the site. If more water than the projected yields of wells is required, it would probably be on a short-term basis. That is, larger quantities of water would be needed for one or two days, after which very little water might be used for several days. If this were the case, additional short-term water supplies could be provided through the provision of tank storage at the processing site. A million gallons of tank storage to augment pumpage would provide 2 Mgal/d of fresh water for fish processing.

If saline or brackish water could be utilized in any step of the processing activities, a nearly limitless supply could be obtained either through direct withdrawal from the ocean at Salt Lagoon or through construction of wells near the lagoon.

SUGGESTIONS FOR ADDITIONAL STUDIES

The ground-water evaluation presented in this report is based on studies of surficial geology, present rainfall records, assumed infiltration rates, and incomplete information on the existing production wells, as well as incomplete and perhaps misleading information on the altitudes of these wells.

The altitude of the water table should be accurately determined at the existing wells. Through construction of contours on the surface of the water table between the existing or new wells and the shoreline, more complete information may be acquired on the amount of ground water available in storage and the potential for its use.

On the basis of this initial survey a test drilling program or a geophysical survey of the possible production area appears to be more costly than is warranted with respect to either present or potential future water-supply development. From a simplified description of ground-water conditions on the island, it can inferred that relatively large amounts of ground water, probably at least 10 times the amount currently being withdrawn for use, could be obtained in the same general area as that in which the present wells are situated without lowering the water level enough to cause saline water intrusion from the ocean.

If there is an increased demand for potable water supplies, the exact altitude of the ground surface should be determined before drilling, and drilling should be stopped within a few tens of feet below sea level. The wells should, in general, penetrate into the basaltic material from which good water is available. Equipment for drilling large-diameter holes (to accommodate larger pumps) should be utilized. Water samples should be taken from each water-bearing zone to determine which of the zones contains water of the best quality. Estimates of daily addition to the ground-water reservoir and the known rates of production of the present wells suggests that screened, large-diameter wells should be capable of producing 250 - 750 gal/min each and that several such wells could be spaced so that the drawdown caused by pumping each well would not influence adjacent wells, yet the group of wells would be capable of yielding more than 1 Mgal/d of fresh water on a sustained basis.

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