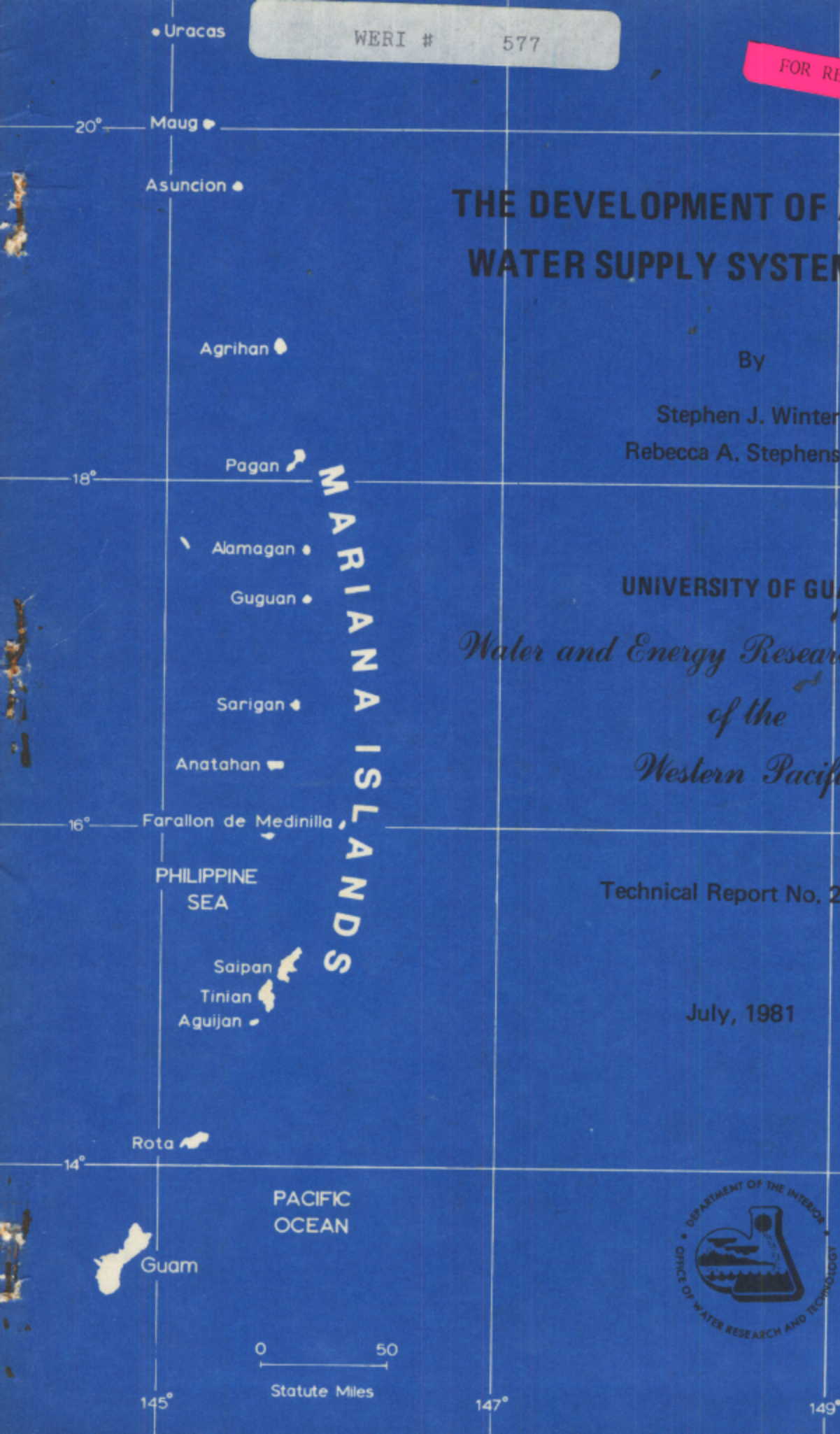

THE DEVELOPMENT OF A VILLAGE WATER SUPPLY SYSTEM IN TRUK

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Project Completion Report

for

DEVELOPMENT OF VILLAGE WATER USE SCHEMES IN MICRONESIA

OWRT Project No. B-003-Guam, Grant Agreement No. 14-34-0001-0261

Principal Investigaters: S. J. Winter, R. A. Stephenson, and J. F. Ayers

Project Period: October 1, 1979 to June 30, 1981

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This report is dedicated to the children of Truk with the hope that this and similar projects will bring them a healthier and happier childhood.

ABSTRACT

The village of Nemwan on Moen Island, Truk, was selected as the site for a pilot project that would lead to improvements in the village water supply system. Prior to the project, each household had to provide for its own water supply from rooftop rainwater catchments or shallow wells. During the dry season, it was often necessary to travel great distances to obtain a supply of potable water.

Since Nemwan is a fairly traditional village, a strong effort was made to consider cultural factors in the planning and design of the water system. In spite of this effort, misunderstandings of these cultural factors were largely responsible for the failure to complete the project. These factors included permission to use the land on which the water source to be developed was located, as well as attitudes toward physical labor and money. In addition, in hindsight, it was recognized that the water system, as planned, may have been too complex to be operated and maintained on the village level. Also, funding had not been identified that would be sufficient to complete all phases of the project.

The portions of the project that are expected to be completed are a long concrete-lined trench for collection of shallow groundwater and a sand filter. These will improve both the quantity and quality of water available for consumption. Facilities for water storage and distribution are not expected to completed.

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INTRODUCTION

Truk is an atoll lying in the central Caroline Islands in Micronesia, located at approximately 7° north latitude and 152° east longitude (Figure 1). Its total land mass is approximately 37 square miles. Truk consists of a number of high volcanic islands surrounded by a low barrier reef (Figure 2). The resulting lagoon is approximately 40 miles in diameter.

Truk enjoys a tropical island climate with an average daily temperature of approximately 81° F. Average daytime and nighttime temperatures are approximately 5° F above and below the daily average. The average annual rainfall for Truk is approximately 145 inches; however, the rainfall is not uniform and distinct wet and dry seasons occur (Figure 3). The rainfall may vary significantly from year to year and droughts are common.

Politically, Truk is one of the four states of the newly created Federated States of Micronesia (FSM), a political entity which will become formalized with the dissolution of the U. S. Trust Territory of the Pacific Islands (TTPI). The TTPI now consists of the FSM, the Republic of Belau (formerly Palau), and the Government of the Marshall Islands. The Commonwealth of the Northern Mariana Islands, which was formerly a part of the TTPI, now functions as an independent entity.

The island of Moen (Figure 4) is the center of both state and commercial activities on Truk. The district center area is composed of parts of at least four separate traditional villages known as Iras, Nepukos, Nantaku, and Mwan. The airport and seaport are located in this area. Only a limited portion of Moen is served by public water, electric, and sewer systems. Roughly speaking, public power and water are available in the area from Mechitiw to South Field. Only the area near government offices (Nantaku) is sewered.

Consequently, most of the villages on Moen, as well as the villages on the other islands of Truk, must rely on traditional methods for obtaining a supply of potable water and for disposing of wastewater. Sources of potable water for these islands include streams, shallow wells, springs, and various rainwater catchment systems (Figures 5, 6, and 7). Wastewater from washing clothing and kitchenware and from bathing is simply allowed to fall to the ground in the washing area (Figure 8). Toilet facilities typically consist of over-land or over-water penchos* (outhouses) (Figure 9).

Unfortunately, traditional methods of water supply on Truk often do not provide water of adequate quality and in sufficient quantity. Surface and groundwater are often contaminated because of animal and human wastes, the worst situation occurring where an upstream pencho may contaminate water for downstream users. Since penchos are often located in inconvenient locations, one will frequently pangaw (literally, defecate bad; i.e., in a 'bad' place, not in the pencho) which further contaminates waters derived from surface runoff.

*Traditional Trukese spelling is used. To the American, this word sounds like benjo (borrowed from Japanese). However, Trukese does not utilize the letters "b" or "j".

Rooftop catchment systems, which produce the highest quality water, generally are not functional during the dry season (January through March) both because of insufficient collection and storage capacity. Perennial streams do not exist in all villages. In the dry season, the yield of shallow wells may be seriously reduced or eliminated completely. The result is great inconvience for the local people (i.e., carrying water for a long distance) (Figure 10), compounded by increased consumption of water of marginal quality (i.e., no rooftop water available).

A few Trukese villages have attempted to solve their water problems by constructing community water supply systems, frequently with the purpose of exploiting distant elevated sources. Some of these systems have been successful; many have not, often because of a failure to consider cultural factors. Two examples of the latter will be given, one where the problem might reasonably have been forseen, the other where the problem was more obscure.

Case 1. With the help and advice of Peace Corps volunteers, a pipeline was constructed from a remote mountain source to a storage tank in a Trukese village. The pipeline crossed a number of parcels of land without providing taps, so that the water could not be utilized by the landowners. After the project was completed, one of these landowners heaped coconut husks over the (plastic) pipeline, started a fire, and destroyed the project.

Case 2. The sole water source for a small island in Truk was an elevated spring somewhat distant from the village. A pipeline was built in an effort to bring the water closer to the consumers. Holes were soon chopped in the (plastic) pipeline by teenage boys as the remote water source was one of the few places where girls could rendezvous with their would-be lovers while making the legitimate excuse of fetching water, washing clothes, bathing, etc.

Other cases exist that are similar to these.

OBJECTIVES

The objective of this study was to develop a village water supply system that would improve both the quantity and quality of water available to village residents and also increase the convenience of utilizing the water. An extremely important part of the project was a consideration of cultural factors associated with water use. It was hoped that the resulting water system would be used as a model for the development of similar systems elsewhere on small western Pacific islands.

CHOICE OF PROJECT SITE

The need for improved village water supply systems on Truk is well-known. However, an awareness of the potential for unique unforseen cultural factors destroying an otherwise successful project postponed the initiation of such a project. In 1978, a Trukese civil engineering technology student at the University of Guam suggested that the village of Nemwan on Moen might be a suitable site for a village water supply project, both because of the interest of village residents in such a project and the potential for developing several promising water sources.

Nemwan is located on the Sapuk penninsula (Figure 11) of Moen Island. Although it is only three miles from the district center of Moen, it is a 45-minute ride by car because of the unimproved condition of the roads (Figure 12). Thus, Nemwan is typical of Trukese villages that are not served by public utilities and wherein travel by foot is the primary means of moving within the village (Figure 13).

In December, 1978, the principal investigators of the project (an engineer, a geologist, and an anthropologist) met with Nemwan residents in the village meeting house (Figure 14) in an effort to ascertain whether or not they would endorse a pilot water supply improvement project in their village. The nature of the project was explained, emphasis being placed on the fact that it would represent a partnership between Nemwan and the University of Guam for the duration of the project period. The University of Guam would provide engineering and scientific advice in a framework that would strive to be consistent with Trukese cultural practices. It would also provide limited funds for the purchasing of construction supplies. Nemwan would provide the labor needed for the actual construction. It was stressed that, at the completion of the project, the system would be the property of the residents of Nemwan.

An initial survey of potential water sources in Nemwan was also made during this first field trip. These included a number of shallow wells and a four-inch pipe protruding from a hillside above the village which village residents explained was laid during the Japanese administration of Truk (1918 to 1945).

A follow-up trip was made in February 1979 by the engineer and geologist, during which time dry season flow rates were measured. It was concluded that the traditional groundwater source (a shallow well) known as "Epikepin" (Figure 15) was the most promising in terms of potential yield (2.4 gpm dry season flow), although its elevation is quite low. This source had been improved in recent years by encasing it in a concrete block box and was already in use (Figures 16 and 17). It seemed clear, however, that Epikepin could be further improved in order to provide water of better quantity and quality. Various water quality measurements made during the trip indicated, as expected, that the water sources in the Nemwan area were highly contaminated (Table 1). Any water system designed to improve Epikepin would have to provide for water treatment.

During this trip, Nemwan residents were consulted in regard to the feasibility of using Epikepin, particularly the village chief and two senior men (brothers) in the family that own the land where Epikepin is located. Village residents again endorsed and supported the project.

The principal investigators made a third trip to Nemwan in December, 1979. A number of small trenches were hand-dug in the vicinity of the existing water source at Epikepin. These small trenches revealed that the groundwater flowed as a sheet down the hill on top of a layer of clay a foot or two below the ground surface. Whenever a trench was dug, water could be observed seeping out of the ground above this clay layer on the uphill side of the trench (Figure 18). In spite of the improvements previously made at Epikepin, apparently only a small portion of the groundwater potentially available at this site was being utilized. Based on the testing of the small hand-dug trenches, it was decided to exploit Epikepin further by constructing a trench-like shallow well, such that the desired amount of water could be intercepted.

During this trip, a village meeting was held in Nemwan. Support for the project was again unanimous. A decision was made that the completed water supply system would probably only serve the residents of the portion of Nemwan shown in Figure 11 because it was not anticipated that sufficient funds would be received to permit all of Nemwan to be served.

During this trip, the anthropologist administered a questionnaire which addressed quantitative issues such as household per capita water consumption and qualitative issues such as fresh water use customs as well as attitudinal issues related to the project. The findings of the questionnaire are discussed in subsequent sections of the report.

WATER USE CUSTOMS

23 Trukese heads of households, representing all the homes in the project area, responded to the questionnaire. Informants were interviewed in their homes and their household water supply systems were examined, photographed, etc. The data gathered from the questionnaires are presented in descriptive fashion in this portion of the report. A sample questionnaire appears in the Appendix with informants' responses tabulated in numerical fashion.

Household Data

The beginning questions addressed some standard types of household data. Eighteen men and five women were interviewed. A breakdown of their ages, the number of people living in their households, and the length of time their families have lived in those particular houses follows:

	Age of Informant	No. of People/Household	Time Residence/ Household
Males	22	4	1½ months
	23	16	8 years
	29	4	10+ years
	31	7	8 years
	33	12	3-4 years
	38	8	2 years
	39	7	8 years
	41	14	12 years
	42	7	5+ years
	42	10	3 years
	43	15	10 years
	45	16	11 years
	46	13	7 years
	55	15	8 years
	68	7	2 years
	72	9	4 years
	77	5	7 years
	80	18	4 years
Females	40	10	19 years
	41	7	3 years
	59	19	1 year
	59	2	8 years
	unknown	10	9 years

Informants were asked if they owned the house they were living in. 15 males and 3 females reported that they owned their houses. One man explained that his father owned the house he was living in, another man said the house belonged to his daughter, and the remaining man replied that the house belonged to his nephew. One woman simply reported that the house belonged to her side of the family and the remaining woman said her father owned the house.

In response to the question, "Do you own the land the house is on?", 8 men said yes. 5 men reported that the land belonged to their wives. The remaining 5 men gave the following answers: belongs to the head of the clan of my wife, wife's nephew's land, relatives (named a particular man and his sister), and nephew's land (2 separate responses). Of the 5 women interviewed regarding ownership of the land on which their house was located, two reported that they owned the land, one named her father as owner, another named her grandfather, and the last named the sister of a male relative. The frequency with which women were mentioned in the descriptive data illustrates the matrilineal, matrilocal model of kinship and descent on Truk (Schneider and Gough, eds., (1961), Goodenough (1966), Alkire (1977), and others).

Sources of Water

Informants were asked, "What are the sources of freshwater for your household?" A breakdown of the answers follows (many informants gave more than one answer):

SOURCE	NUMBER OF HOUSEHOLDS
a) Rainwater, individual households	
5-6 gallons (container unspec.)	1
1 55 gal. drum	7
2 55 gal. drums	4
3 55 gal. drums	2
4 55 gal. drums	1
6 55 gal. drums	1
1 55 gal. cement tank	1
1 500 gal. tank	1
b) Well water	
Major source Epikepin	17
Small well Fanifou	4
An unnamed well in another village	1
c) Stream Water	
..."2 little streams nearby..."	1
d) Another household's resource	
X's* house	6
Y's house	3
Z's house	1

*Householders names omitted to preserve anonymity.

Sources of Water for Specific Uses

Household heads were asked where they obtain water for use in specific categories. They were also asked where family members used water for washing dishes, washing clothes, and bathing. Their answers are shown below (some informants gave more than one answer):

CATEGORIES	WATER OBTAINED/ NO. OF HOUSEHOLDS	WATER USED/ NO. OF HOUSEHOLDS
a) Water for Drinking		
At home, rainwater	12	23
Epikepin	11	0
X's house	3	0
Fanifou (spring)	1	0
Fanmei (spring)	1	0
Well, unnamed	1	0
Z's house	1	0
b) Water for Cooking		
At home, rainwater	13	23
Epikepin	11	0
X's house	3	0
Fanmei	1	0
Well, unnamed	1	0
Y's house	1	0
c) Water for Washing Dishes		
At home, rainwater	12	14
Epikepin	11	8
X's house	3	4
Fanifou	1	2
Fanmei	1	2
Y's house	1	2
d) Water for Washing Clothes		
Epikepin	14	12
At home, rainwater	7	3
X's house	3	3
Fanifou	2	3
Fanmei	2	5
..."2 little streams..."	1	0
Y's house	0	3
e) Water for Bathing		
Epikepin	13	9
At home, rainwater	7	2
X's house	3	4
Fanifou	2	4
Fanmei	2	5
..."2 little streams..."	1	0
Y's house	0	3

Discussion of Water Use Customs

Drinking

Rainwater seems to be preferred for drinking (12 households). Epikepin is the second most frequent place to get drinking water (11 households). Other sources of water for drinking are insignificant (3 households or less).

Most of the households in Nemwan use at least one 55 gallon drum to collect rainwater. Some of the homes have installed gutters at the edge of their roofs, with drums placed strategically beneath, to catch roof runoff. Other homes simply have drums standing in the yard.

The informants said that outside water storage containers frequently rust and that it is best to keep such containers painted. If a drum is rusty, according to informants, the water is not really safe to drink; if there is no other drinking water available, people must make do with the rusty drum, boiling water taken from it, if possible.

People said that all freshwater should be boiled at home before drinking, but acknowledged that "sometimes" they did not boil the water. Finally, people stated that, although they may drink water at other places if they find themselves thirsty, most drinking water is consumed at someone's home.

Cooking

Families in Nemwan prepare food on a household by household basis, for the most part. 22 household heads reported that their families principally cook outside in the imwen kuk (cook house), a roof-like shelter set up away from the main house. Families prepare, especially, taro and breadfruit in kama (large cooking pots) over an open fire. Some food items are cooked in an uum (earth oven). 19 household heads reported that their families also cook inside their main house, using two or three burner kerosene stoves. Rice is normally cooked inside the house, and water is boiled here for coffee.

The sources of water for cooking are essentially the same as the sources of water for drinking. Rainwater is preferred for cooking (13 households) and the key reason is probably one of convenience. In the dry season, however, rainwater is in short supply. Freshwater must be carried home from another source for cooking if no rainwater is left in the drums at home. Epikepin is the second most important water source for cooking (11 households). Other sources of water for cooking are insignificant (3 households or less). Although water for cooking may be obtained at various sources, virtually all cooking is done at home.

Washing Dishes

Dishes are washed in metal or plastic wash basins outside of the homes, using a little detergent, and then stacked up to dry. Cooking pots are scrubbed out with a cloth, brush, or coconut husk. Probably because of

convenience, rainwater is preferred for washing dishes (12 households). If necessary, the dirty dishes are carried to Epikepin (11 households), or other sources, in order to be cleaned. The sources of water for washing dishes are essentially the same as for drinking and cooking.

Washing Clothes

Washing clothes is a manual chore traditionally performed by the women (Figure 19). No conveniences exist in the village to ease this chore; clothes are soaked, then beaten with a paddle or scrubbed by hand or a brush, after having been lathered with bar soap. As with washing dishes, soiled clothing may be washed at home if there is rainwater in the drum. If not (and sometimes even if rainwater is in supply at home) the clothing is carried to another location by the women and children. This is because the washing of clothes can become a quasi-social activity, less tedious if performed in the company of women who are neighbors and friends. Leisurely talk and sharing of village news, bathing simultaneously while washing clothes, and the usual reliability of water at the water source enhance the work effort.

Water for washing clothes is most commonly drawn from Epikepin (14 households). 12 households indicated that their families wash their clothing at Epikepin. 7 householders said they collected rainwater at home for washing clothes; only three householders noted that they actually washed clothes at home. The second most popular area to wash clothes is Fanmei (5 households). Two households acknowledged that they obtained water at Fanmei for washing clothes. Those who actually wash clothes at home number the same as those who seek out three other away-from-home locations namely, X's house, Fanifou, or Y's house (3 households each).

Bathing

People do not commonly bathe (tütü) at home (2 households). Bathing facilities are unimproved at most homes; people seem to seek some degree of comfort and convenience for this frequent activity. Epikepin is the most popular source of water for bathing and also is a popular place to bathe. 13 people indicated their families obtain water for at Epikepin; 9 of these families actually bathe at this site. Pieces of roofing tin have been set up about 2 or 3 ft. high to form an enclosed area (Figure 19). Water is brought to this enclosure by means of a pipe from Epikepin (about 50 ft. away) and a water faucet located about 2 ft. off the ground. A cool and shady place on a hillside, this area is frequented by women and children during the day, busy at washing clothes and bathing at the same time. The faucet is usually left on while bathing or washing takes place. Men who pass by the area should modestly avert their eyes. As the sides of the enclosure are low and the area is one with frequent passers-by, whether coming to the source directly or walking on the main road below, women who bathe here customarily squat down while bathing and leave the clothes they have been wearing on while pouring water over themselves. Small children who are being bathed may be allowed to stand; older children are encouraged to squat. After the bathing process, clean clothes are carefully donned at one side of the bathing area. Men bathe throughout the day when the source is available.

The bathing area known as Fanifou (Figure 20) is a spring away from the road at the southern end of the village. It is not as frequently used (4 households) because it is very small, and because it is removed from the heart of the village.

The bathing area called Fanmei (utilized by 5 households) (Figure 21) is a spring located just above the shoreline in the heart of the village. Situated on a hillside below the main road near the church, the area is shady and cool and protected from public view by large trees. Women and children from the central area of the village like to come here to bathe. Modesty is required (again, one's clothes are left on while bathing), but more freedom of movement is possible. Bathers do not have to carefully remain squatting. Clothing is often washed here.

For the immediate neighbors, the bathing area at Y's house (Figure 22) is a very popular place (3 households). With boards on three sides so the bather can stand in complete privacy, a drum of water is at hand which is brought from Epikepin by means of a hose.

Finally, people in the heart of the village may also bathe at X's house (4 households) (Figure 23). Here, freshwater is available from a hose that is connected to the pipe protruding from the hillside behind the village. There is no enclosure here and the bather must squat.

Household heads were of the opinion that all family members should bathe as often as possible, from two to five times a day. Adults and youths should bathe in the morning and evening, children should bathe several times a day, and babies should be bathed whenever necessary. The firm feelings about the necessity for frequent bathing reinforce the need for adequate fresh water resources in Nemwan village.

Water Consumption

Household heads were asked to estimate the amount of fresh water their families used on a daily basis. Their estimates ranged widely, as shown below:

CATEGORIES	RANGE OF ESTIMATES OF GALLONS PER DAY PER HOUSEHOLD
Drinking	1 quart to 55 gallons
Cooking	2-3 quarts to 55 gallons
Washing dishes	2-3 gallons to 60 gallons
Washing clothes	5 gallons to 250-300 gallons
Bathing	3 gallons to 250 gallons

The estimate of per capita consumption in Nemwan ranged from 3 gallons to 45 gallons per day. The average estimate was 19 gallons (However, a higher design consumption was used for the water supply system to reflect the amount of water desired).

Householders in Nemwan said that water should not be used carelessly; but they seemed confused by the question, "Is fresh water ever rationed among your family members?" The attitude prevailing seemed to be: "There's

nothing we can do about it." People apparently use fresh water generously when sufficient quantities are available, make do when water is in short supply, and only seek alternative sources of fresh water when no rain water is available from drums at home. People interviewed in Nemwan did not seem to think that fresh water should be regarded as a limited natural resource. They acknowledged readily, however, that in the dry season lack of water is a problem of serious concern to all.

Water Rights*

None of the people reported having a public faucet or public well on their property. All land is privately owned in Nemwan. Nine people said others must seek permission from them if they controlled access to a fresh water source; ten people indicated they would seek permission of a land owner before collecting water from a private source. Four people stated that others would not need permission from them; four also said they would not need permission from others to use a private water source. Three informants described the situation in terms of "family ties". Eleven people do not have an adequate water supply themselves such that others would want to use it; 8 people did not give a clear response to the question. Those Nemwan villagers who regularly make use of the water at Epikepin apparently do so in accordance with a long-standing arrangement with the land owners. The arrangement is not a legal one; neither are details of the arrangement well-defined according to customary laws.

Significance of Customs to the Project

In the course of learning about water use customs in Nemwan, key factors that influenced the project were brought to light, including the following:

1) When available, Nemwan village residents make use of a considerable amount of water for a remote area because of their cultural practices.
2) Epikepin is the second most common source of fresh water in the village besides rainwater. In the dry season, it becomes the principal source.
3) Long term permission to use the water at Epikepin appears to exist between the land owners and other village residents.

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* In regard to water rights on Romonum, a small island in Truk lagoon, Goodenough (1966) notes that... "...water itself is the property of no one, especially fresh water. The main source of drinking water on Romonum is a spring in the center of the island. The land on which it is located is owned, but the spring itself is free to all, and in the old days before the introduction of rain barrels was used by everybody on the island. When the native storekeeper recently ran a pipe from this spring to his house some distance away, he incurred no obligations toward the people owning the land from which the water is piped."

ATTITUDES TOWARD THE PROJECT

All households in the project area were in favor of the proposed efforts to improve their fresh water supply system. In terms of how their families would be helped if fresh water was more readily available, householders gave such responses as "convenience," and "need."

People had various opinions as to where public faucets should be constructed, if they were to be a part of the new system. Seven people felt that such faucets should be placed near the church, for it is centrally located in the village on the main road. Six people expressed the opinion that the faucets should be located at Epikepin, since people are accustomed to going there to collect water. Seven other people said that either place would be appropriate. Three people did not respond. A few people expressed concern as to the use of such public faucets. It was felt that children or others might leave the water running and waste the water. It was suggested that the faucets should be locked when not in use. The village chief or perhaps the church pastor should be in charge of the key. If public faucets were to be located near the church, several householders felt that people from other villages who were not church members should not be allowed access to the faucets.

Those consulted were asked if people in their households would be willing to help build the new water supply system. Fifteen householders of 23 in the sample indicated that a person or persons from their households would be available to lend a hand with construction efforts. The work crew had 29 potential participants. Most of the individuals named were male youths who were not otherwise gainfully employed, but some were local men working at other full-time jobs who would contribute their time and energy on the weekends. The interviewer asked if potential workers would be willing to work on this project without pay. The answer was always, "Yes, if pay is not available."

The question was posed, "Do you think the people of Nemwan should pay a tax to the government for their fresh water supply?" Two people said yes, one said no, and four responded maybe. Sixteen persons found the question confusing since they have never paid such a tax to date; accordingly, their responses are not discussed here.

Finally, people were asked, "Would you like to have water piped directly into your house?" Not surprisingly, all 23 householders consulted answered yes.

DESCRIPTION OF WATER SYSTEM

This section provides a qualitative description of the water system. As originally envisioned, it would include seven components (Figure 24):

1. Collection trench
2. Sand filter
3. Chlorinator
4. Holding tank
5. Pump
6. Storage tank
7. Distribution system.

The objectives of the sys em were to improve the quantity (item 1), quality (items 2 and 3), and convenience (items 4, 5, 6, and 7) of water available to the residents of Nemwan.

The collection trench was designed to intercept the desired amount of groundwater which would then be applied to a slow sand filter to remove turbidity and, hopefully, other contaminants. After being filtered, the water would pass through a chlorinator and into a holding tank. At regular intervals, water in the holding tank would be pumped to a storage tank on the top of an adjacent hill. From the storage tank, the water would flow via a distribution system to the homes to be served.

As the project progressed, it became apparent for a number of reasons (enumerated in the Conclusions section of the report) that it would be impossible to complete the project within the allotted time period (approximately one year). As this report is being written, the collection trench has been completed and the construction of the sand filter is in progress (Figure 25). It is probable that other components of the system will not be built. However, it is emphasized that completion of the collection trench and sand filter will have a significant impact on water supply in Nemwan as both the quantity and quality of water available for consumption will be increased.

Following is a more detailed description of each component of the system, especially the collection trench and sand filter for which final designs were developed.

Collection Trench

By means of the questionnaire and village meetings, it was decided to design the system for 40 gal/capita/day at the present population of around 250 (10,000 gal/day or around 7gpm). It is noted that this might be considered to be a rather high per capita consumption for an undeveloped area. However, this quantity of water is required because of the bathing habits and other household needs of the village residents, as discussed in the previous section.

Epikepin is a shallow well approximately five feet in diameter; that is, it intercepts around five linear feet of groundwater flow down the side of the hill. The flow measured in the dry season was approximately 2.5 gpm.

Thus, around 0.5 gpm per foot perpendicular to the flow direction was anticipated to be available from groundwater in the vicinity of Epikepin. Small hand-tug trenches confirmed the presence of additional groundwater but not the flow rate. In order to intercept the desired amount of water (7 gpm), a 14 foot trench would be required. In order to be conservative, the trench was made 20 feet long.

The collection trench was made of reinforced concrete (Figure 26) and perforated on the uphill side in order to permit water to enter. The bottom of the trench was sloped in two directions:

1) in a downhill direction, such that water would not flow out of the trench.
2) axially, such that water would flow to one end of the trench.

The trench was covered with a plywood cover to protect it from litter and animal activity.

Sand Filter

Water collected from one end of the collection trench will be piped to a slow sand filter where it will be distributed uniformly over the surface of the sand. This will be accomplished by means of a perforated pipe discharging onto a perforated sheet of plywood which will be placed over the surface of the sand.

The sand filter will essentially be a large reinforced concrete box approximately four feet deep. The bottom surface of the of the sand filter will be sloped toward a sump which will drain into a pipe leading to the chlorinator and holding tank. Going from bottom to top, the bottom foot will be filled with aggregate of gradually decreasing size and the upper three feet with sand. The surface area of the filter was designed to be approximately 120 square feet (at the rate of .05 gpm/ft.^{2}) (Fair, Geyer, and Okun, 1966). However, on an experimental basis, the filter will be constructed at half this size (owing to limited land area available). If filtration is inadequate, then the second half of the filter will be added.

Filtration will occur as the water seeps through the sand. As the upper layer of sand becomes clogged, it will be removed; after a foot of sand has been removed, it will be replaced.

Chlorinator

A tablet-type chlorinator was selected because of its simplicity and maintenance-free operation. The water leaving the sand filter would pass through the chlorinator, gradually dissolving the tablets. The holding tank would insure adequate exposure time of the water to the chlorine.

Holding Tank

The holding tank was to be constructed of reinforced concrete and be rectangular in cross section. It seemed desirable to make its volume as large as possible (probably half the volume of the storage tank) in order to minimize the number of times per day that water would have to be pumped up to the storage tank.

Pumps

A gasoline or diesel powered centrifugal pump of suitable capacity would be used to pump the water to the storage tank. It was hoped that an identical back-up pump would be available so that pump maintenance/repair could take place without interrupting service.

Storage Tank

The storage tank was to be located on top of the hill directly inland from Epikepin. It would be constructed of reinforced concrete and be rectangular in cross section. Its volume would be 10,000 gallons, equal to the anticipated daily consumption. Thus, no margin of safety was planned for pump failure, etc.

Distribution System

As planned, the distribution system would consist of a main line going in either direction from the storage tank along the main road. Reducing tees and valves would be provided at appropriate locations so that individual households could hook up to the system at their convenience. All piping would be made from galvanized steel to resist damage from vandals. Village residents had asked that the pipes be buried if at all possible, again, to minimize damage from vandals.

CONCLUSIONS

This was a pilot project directed at solving a water supply problem in a typical undeveloped Trukese village. This section presents some broad conclusions that can be drawn from the project and offers reasons why the supply system was not completed.

Although the principal investigators were generally aware of water problems in remote villages, this project provided first-hand experience with these problems. Shortages are especially acute in areas such as Nemwan, that do not have a supply of surface (stream) water during the dry season. The only source of potable water (which is often contaminated) is from shallow wells. These are often very far from many homes. These shortages are exacerbated by the very desirable (from the sanitary point of view) Trukese custom of frequent bathing. This custom was the reason for the fairly high (for a remote area) design consumption of the proposed water supply system.

As noted above, frequently the only source of water that is available during the dry season is groundwater from shallow hand-dug wells. This groundwater occurs in areas having a water table (generally, near taro patches) or in areas of interflow. This project was an effort to exploit subsurface water of the latter type. A great deal more shallow groundwater can be utilized than is presently the case. This could significantly reduce or eliminate water shortages. However, measures must be taken to improve water quality as it is always (in all cases checked) contaminated from human and/or animal wastes.

In the course of this study and as a result of observations in other villages in Truk, it is apparent that little serious attention has been given to collecting and storing all rainwater that falls on the roofs of homes. It has been observed that, in the case of a very few homes that do utilize all available rainwater, there is no need to rely on other sources. Thus, these homes enjoy a year-round supply of high quality water.

In remote areas, water is utilized in a fairly traditional manner. Only minimal efforts have been made on the individual or village level to improve water supply systems. The improvements that presently exist at the water source at Epikepin (concrete block-lined well and water supply pipe and tap) are typical. Pilot projects such as this one can serve as models that can be imitated by other villages. Unfortunately, this project probably will not be completed.

There are many reasons why this project probably will not be completed as designed. Even though a special effort was made to consider cultural factors, certain errors unintentionally occurred:

1) The explicit permission to use the water source from its owner (i.e., the person who has the authority to act as spokesperson for the land-owning family) was not obtained until late in the project. It was erroneously assumed that permission given by various members of the land-owning family implied permission by the owner. These misunderstandings delayed progress.

2) Funds were not available to compensate the owner of the water source for its development or for payment to the men of Nemwan who served as construction workers (Late in the project, funds from Moen Municipality were available to pay workers.). It was believed that the anticipated benefit of the water system to the community would be adequate compensation. While this may be partially true, monetary compensation may have provided a significant added incentive.
3) It was difficult to obtain an enthusiastic crew of construction workers. This may be due to at least three factors:
   a) lack of monetary compensation (discussed above)
   b) an attitude toward physical labor which is different from the western attitude
   c) obligations to other ongoing projects (two churches were under construction) (Figure 27).
4) It is felt that the principal investigators of this project did not spend enough time in Nemwan while the water system was under construction. This placed an excessive burden on the local technician charged with directing construction work. Although the principal investigators had other responsibilities at the University of Guam, their more frequent presence in Nemwan may have inspired the physical efforts of construction (The principal investigators were able to spend a sufficient amount of time in Nemwan during the planning stages of the project. Perhaps, this is why these stages progressed so smoothly.).
5) This was a very large complicated project, perhaps too great to be undertaken in a remote village area. After construction was started, it became apparent that, at the prevailing rate of progress, completion of the project might be a few years away. A simpler, less time-consuming project would provide much more incentive as goals would be easier to achieve, although it might sacrifice some of the convenience associated with a complex system.

As envisioned, the water system included a gasoline or diesel-driven pump. It was expected that maintenance of this unit would be a problem; installation of a back-up unit was recommended by the engineer.

Finally, funding required to purchase all construction supplies had not been precisely identified. Funding from the Federal grant that initiated the project was only sufficient to purchase construction supplies for the collection trench and sand filter. The Truk District Legislature is presently considering the awarding of additional funds to the project. Also, costs associated with the distribution system could be minimized by utilizing used pipe available from the Truk Department of Public Works. However, a great deal of time and labor would be required to obtain this pipe and recondition it for use in Nemwan.

RECOMMENDATIONS

As a result of the conclusions of the previous section, the following recommendations are made:

1) A high priority should be placed on providing adequate water supplies for remote Trukese villages.
2) A high priority should be placed on the assessment and development of shallow groundwater for village water supplies.
3) Reasons why rooftop rainwater catchments are not more common should be explored and a highest priority should be placed on promoting the use of this source.
4) Pilot studies such as this one should be supported in an effort to provide model village water supply systems.
5) Obtain permission (preferably, in writing) from owners of water sources to be used. Similar permission should also be obtained from owners of land that will be utilized by a water system.
6) Consider the appropriateness of providing monetary compensation to owners of water sources or land and to construction workers. If no compensation is to be provided, be certain that this is clearly understood.
7) If a project is dependent on a local village labor supply, be certain that this labor will be available when required.
8) Project principal investigators should provide for on-site direction at initiation of each construction phase of a project.
9) Village water systems should be designed as simply as possible. If pumping is required, alternate energy sources deserve consideration. Wherever possible, gravity-fed systems should be used.
10) A project should not be initiated until all required funds are clearly identified.

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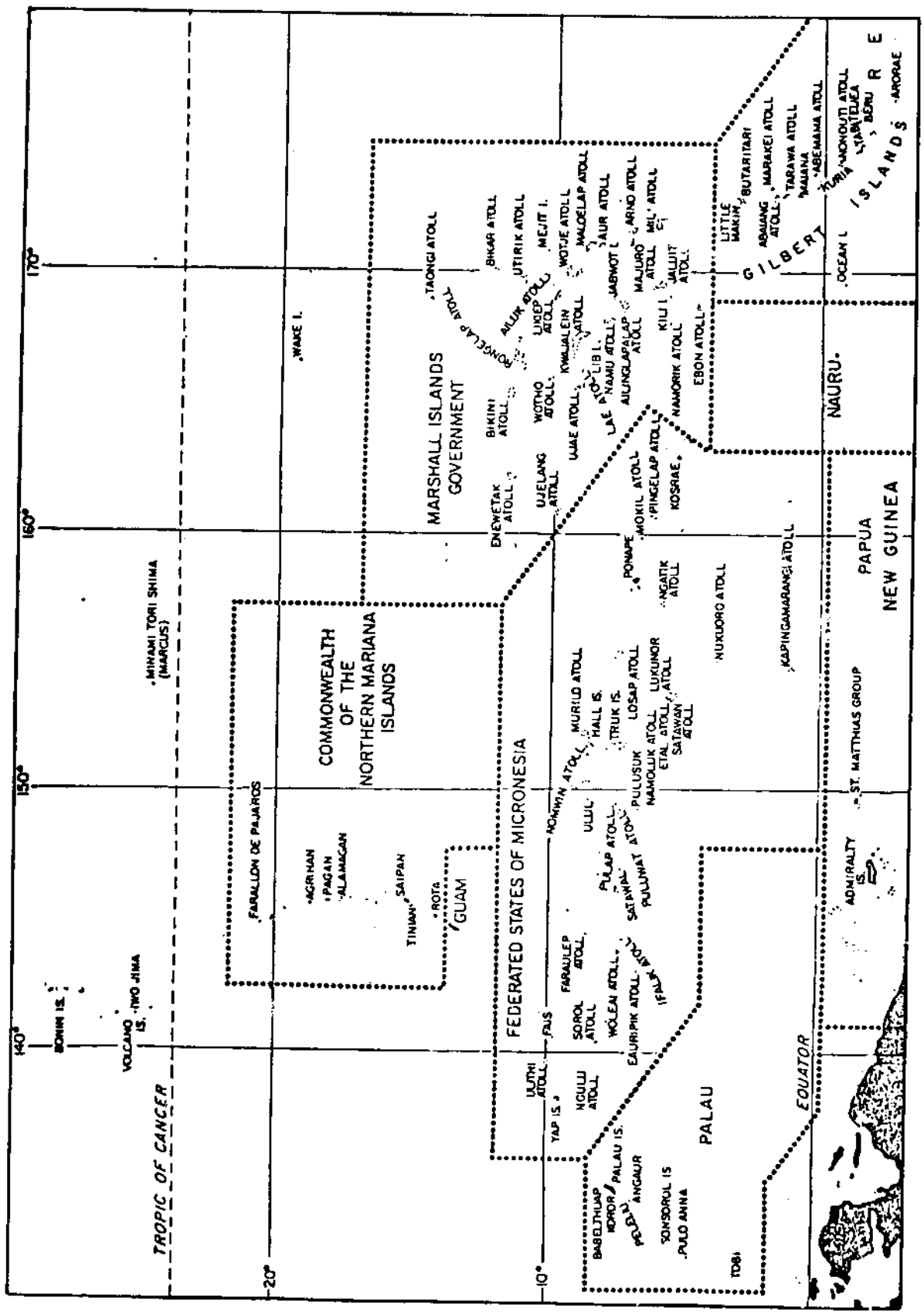

Figure 1. Micronesia

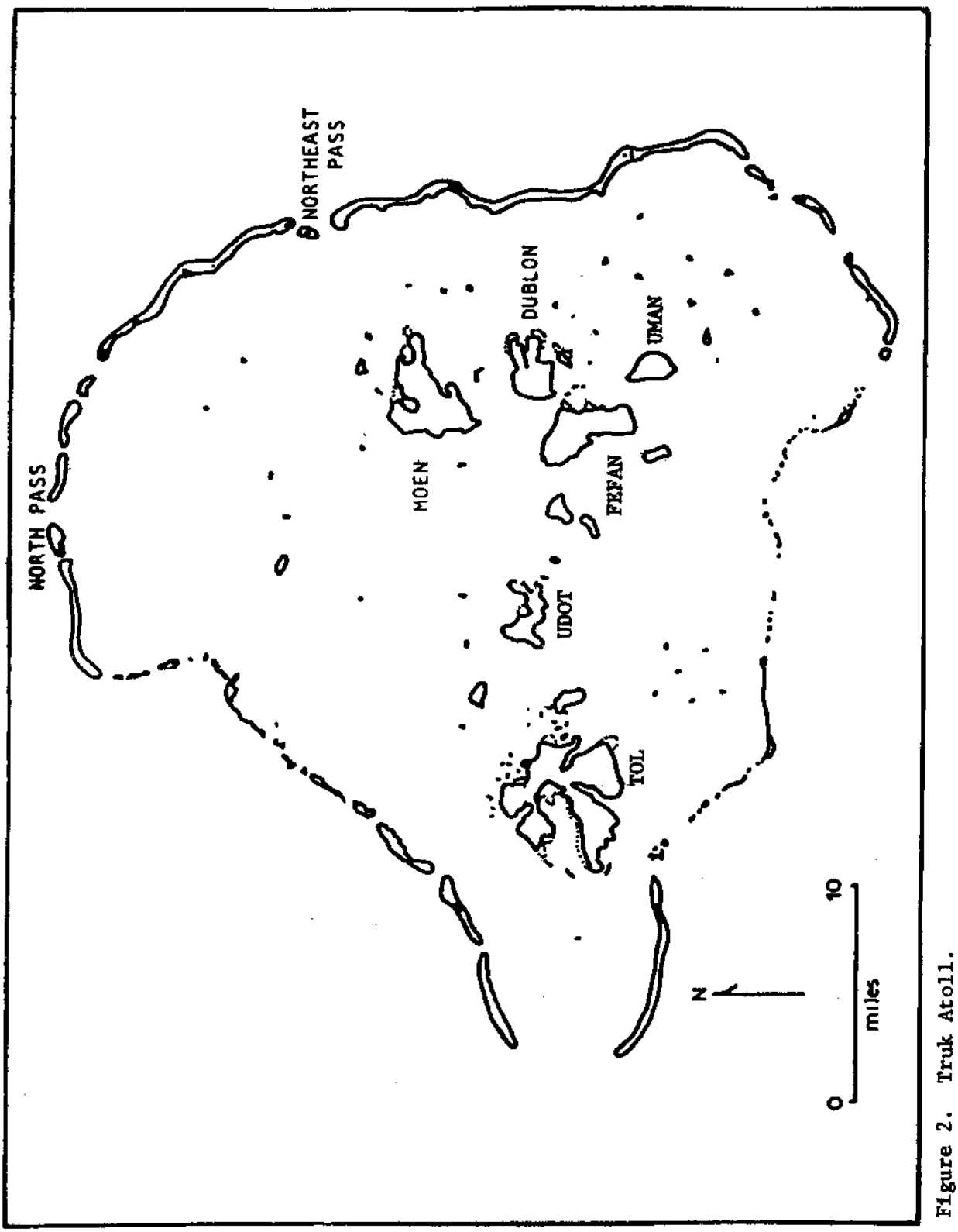

Figure 2. Truk Atoll.

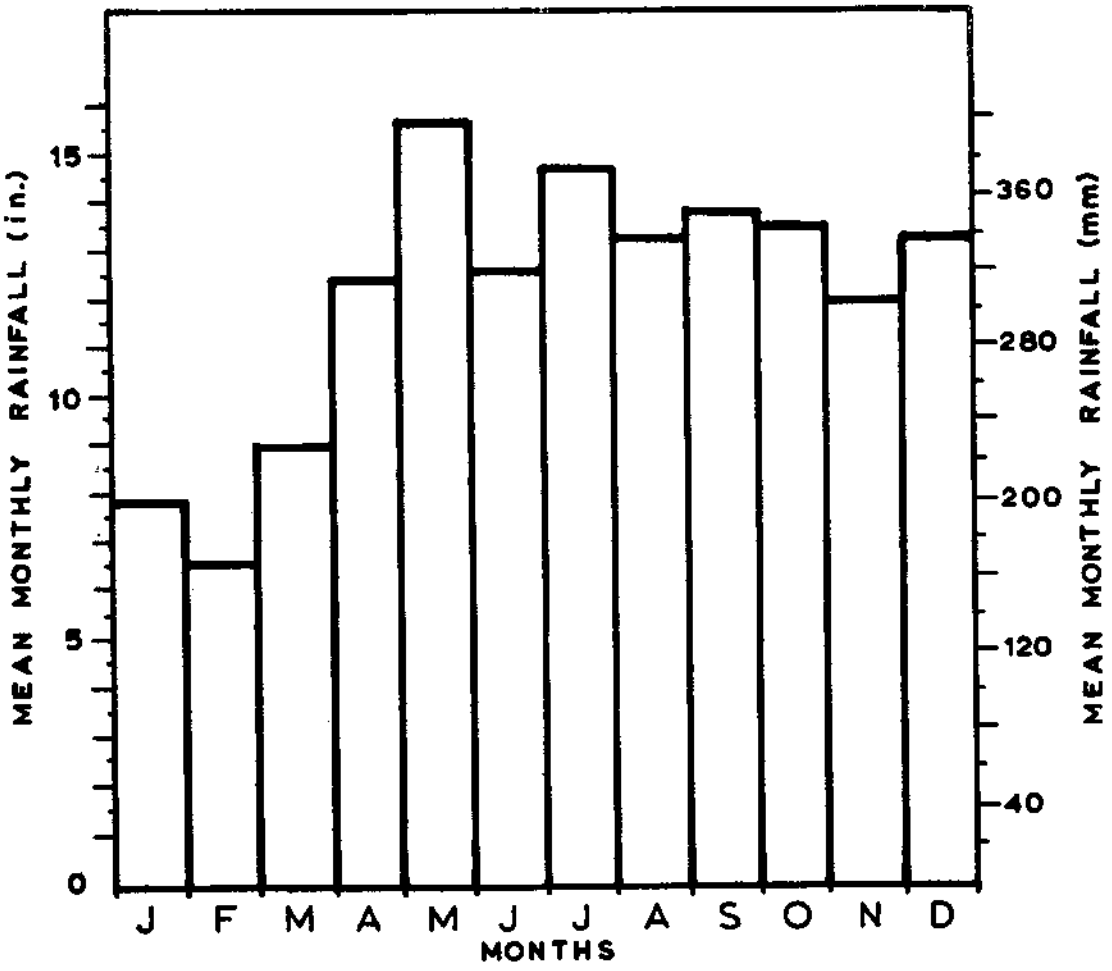

Figure 3. Average monthly rainfall of Truk for the period 1946 through 1977. The data is from the Moen Island, National Weather Observation Station (NOAA) climatology summary, 1977.

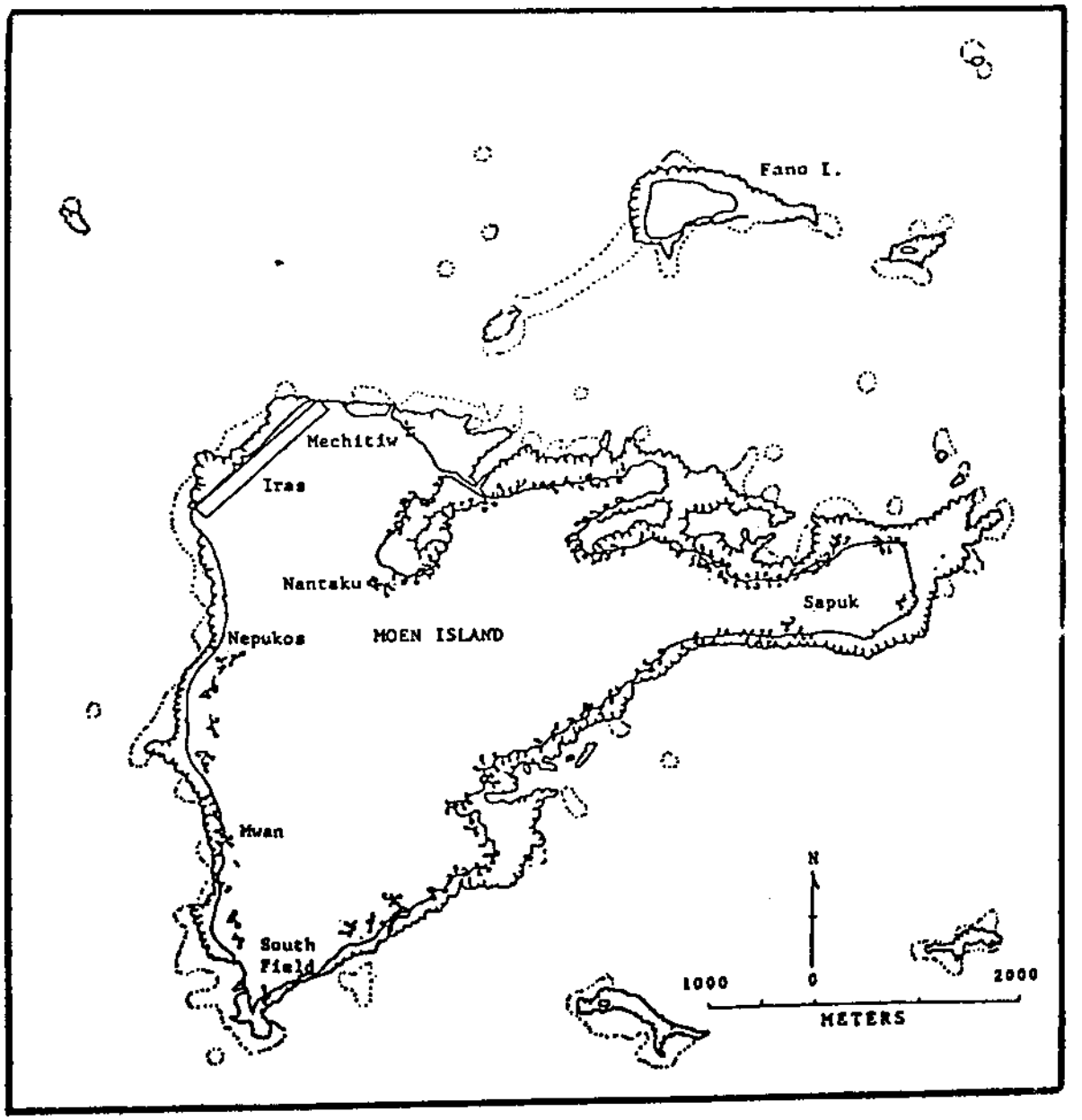

Figure 4. Moen Island.

Figure 5. Stream.

Figure 6. Shallow well.

Figure 7. Rooftop rainwater catchment system.

Figure 8. Dishwashing area.

Figure 9. Over-water pencho.

Figure 10. Girls carrying water from source to home.

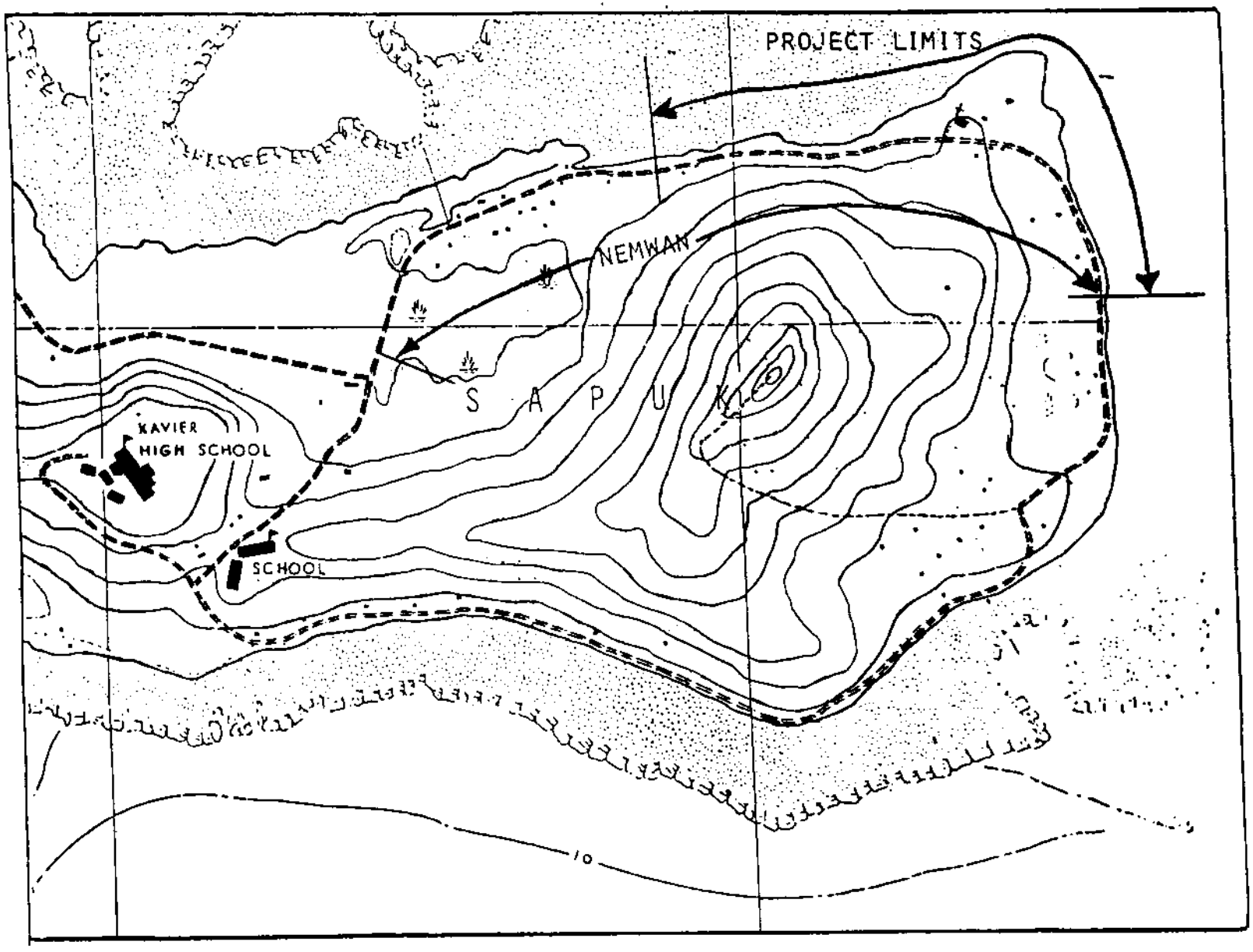

Figure 11. Nemwan location map.

Figure 14. Nemwan Village meeting house.

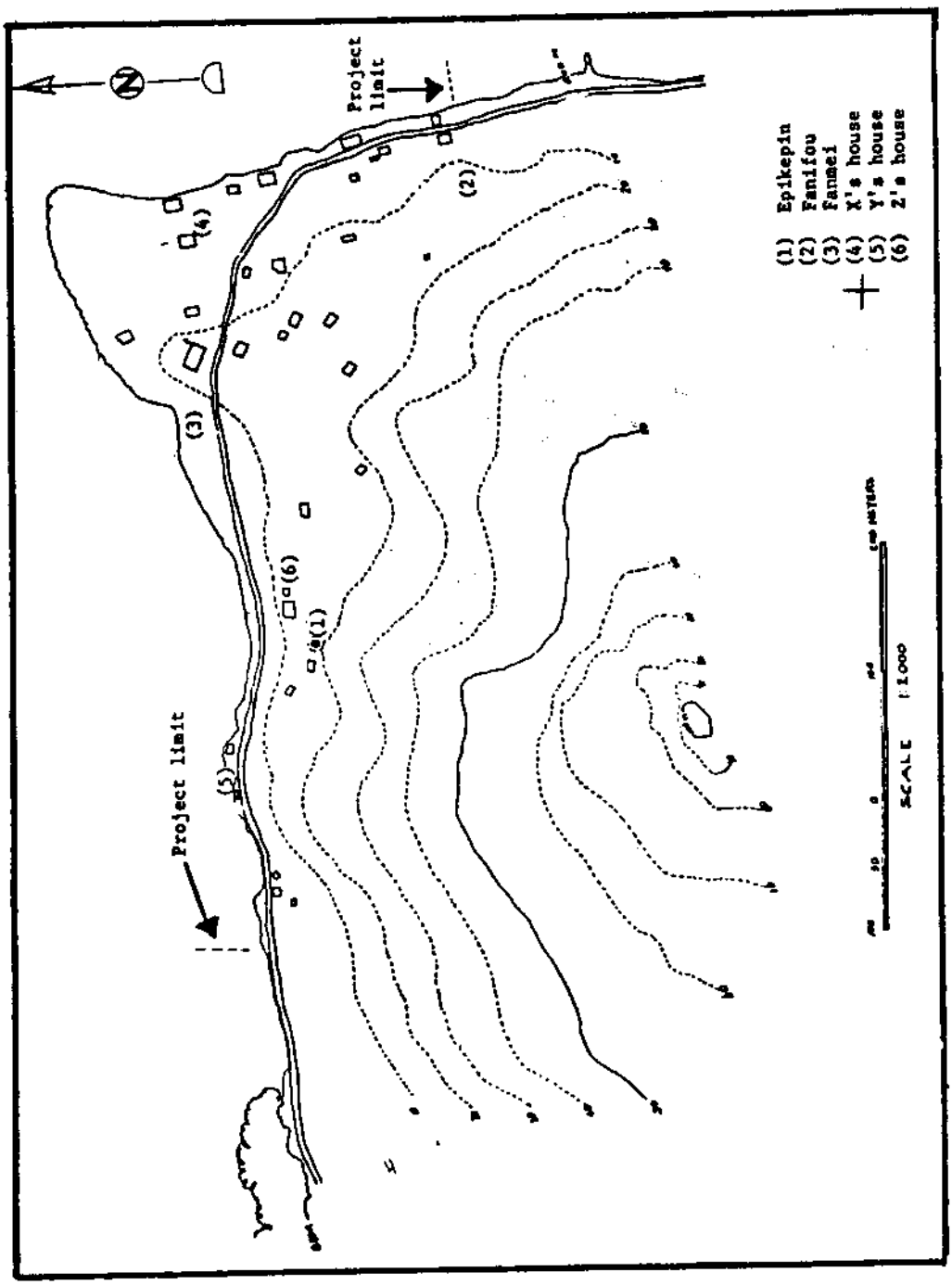

Figure 15. Location map for Epikepin and other water sources.

Figure 16. Present structure at Epikepin.

Figure 17. Pipe and faucet at Epikepin.

Figure 18. Groundwater seeping from on top of clay layer in vicinity of Epikepin.

Figure 19. Washing clothing at Epikepin.

Figure 20. Fanifou.

Figure 21. Fanmei

Figure 22. Y's bathing area.

Figure 23. X's bathing area.

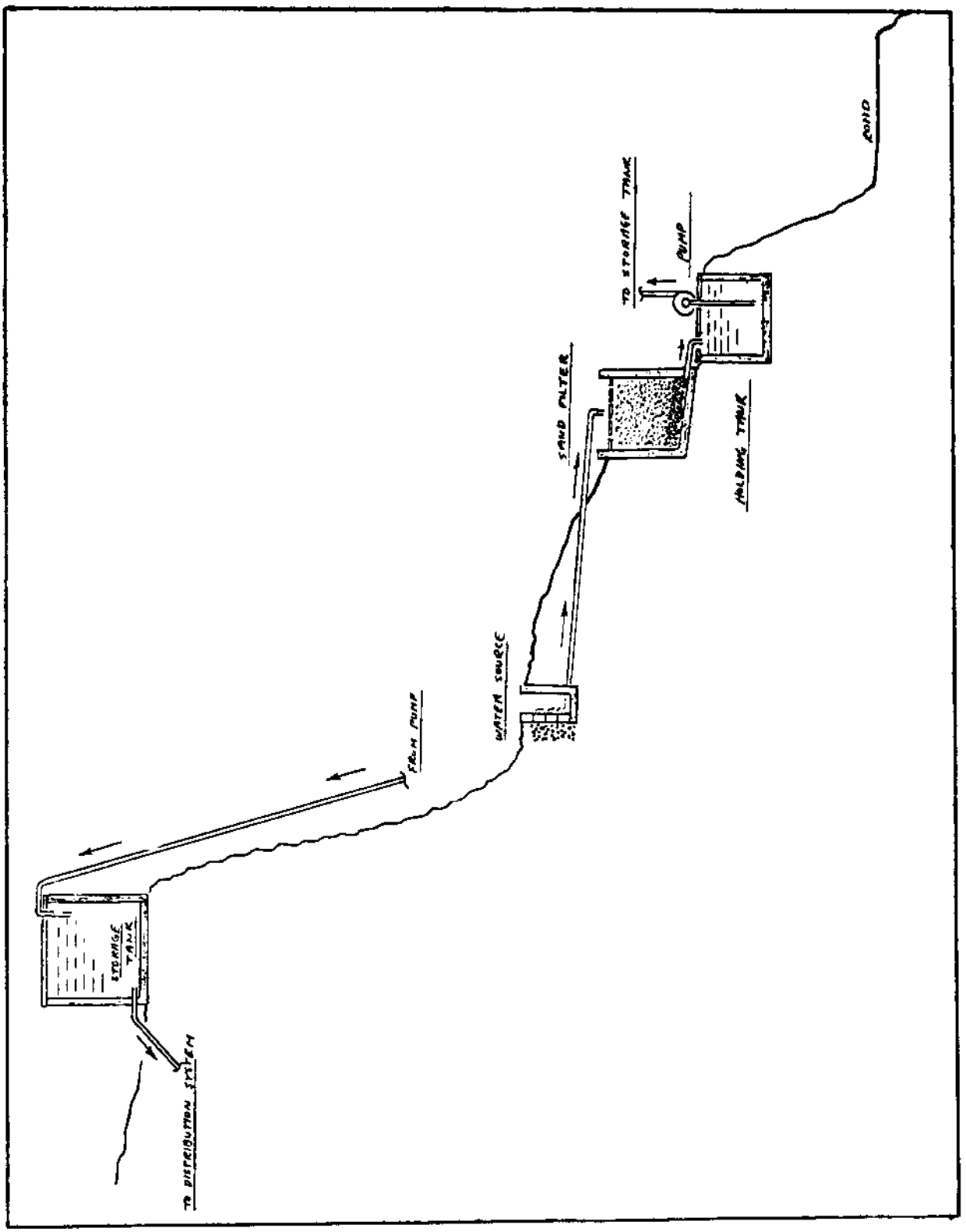

Figure 24. Schematic of water system.

Figure 25. Excavation for sand filter.

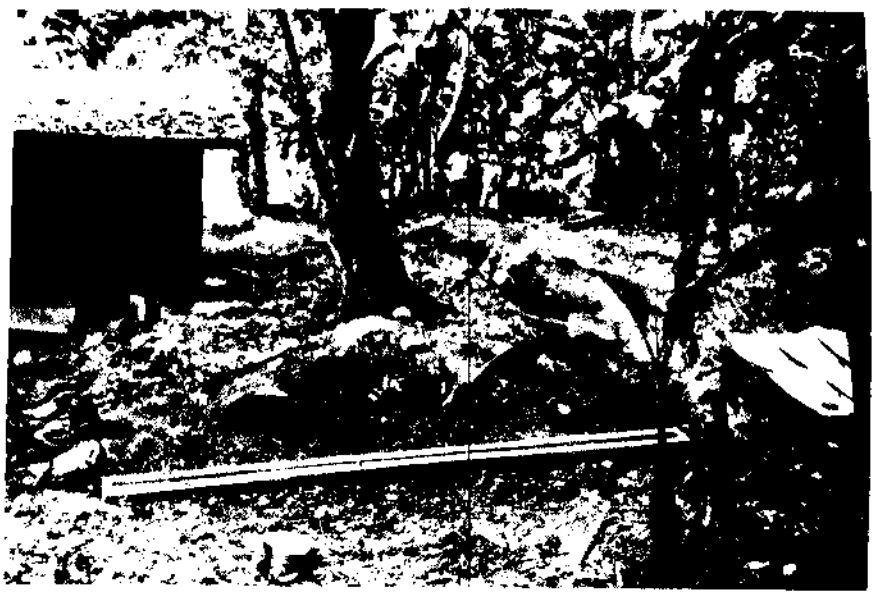

Figure 26. New concrete-lined water collection trench and existing water source.

Table 1. Water quality data for typical water sources.

	Temp. °C	Specific Conductance µmho	Total Coliform col/100 mℓ	Fecal Coliform col/100 mℓ	pH	Turb NTU's	Chl mg/ℓ	Hardness mg/ℓ
Site 1	27.6	120	112,000	24,400	6.18	7.7	16.4	18.9
Site 2	27.3	90	18,350	1,530	5.10	5.0	12.5	20.9
Site 3	27.8	80	3,700	80,000	7.50	0.33	13.5	14.9
Site 4	27.3	95	17,200	23,000	6.05	0.65	10.4	24.9
Site 5	26.6	100	6,550	7,000	6.10	2.6	11.2	23.9

	Total Residue mg/ℓ	Ortho Phosphorus mg/ℓ	Nitrite Nitrogen mg/ℓ	Nitrate Nitrogen mg/ℓ	Total Dissolved Solids mg/ℓ	Total Non-Filterable Residue mg/ℓ
Site 1	65	0.137	<.001	<.001	41	24
Site 2	54	0.003	.001	.079	40	14
Site 3	61	0.032	<.001	.003	56.2	4.8
Site 4	59	0.029	<.001	.001	54.2	4.8
Site 5	70	0.071	<.001	.108	66	4

Site 1 Winnipwin (primarily washing)*

Site 2 Winnipwin (primarily drinking)*

Site 3 Pipe protruding from hillside above Nemwan (drinking and washing)

Site 4 Fanmei (washing and some drinking)

Site 5 Epikepin (drinking and washing)

* Not in Nemwan

APPENDIX

The Questionnaire with Frequencies of Response Indicated

Newman Project Survey, Truk
Water Resources Research Center
University of Guam
December/January 1979/80

Date _____

Name of Head of Household: 23 informants Age: 22 to 80

House number: 1-23 How many people eat here: 2-19
Sleep here: 2-19 Household income: variable.

How long have you lived in this house? 1½ months - 10+ years /
yes=16
Do you own this house? no=7 If not, who is the owner? Does he/she live in Sapuk? variable Other arrangement: variable ?
Do you own the land the house in on? yes = 9; other answers = 14 4.

Water Supply See WATER USE CUSTOMS section

What are your sources of fresh water for your household? _____.

Where do you get water for drinking? _____.
for cooking? _____.
for washing dishes? _____.
for bathing? _____.
for washing clothes? _____.

Where do your family members cook? _____.
wa[illegible]lishes? _____.
bathe? _____.
wash clothes? _____.

How much fresh water (such as rain water) can be stored outside your house? _____.

Please estimate how much fresh water your family uses every day for
drinking: _____.
for cooking? _____.
for washing dishes? _____.
for bathing? _____.
for washing clothes? _____.

Are there other ways that your family uses fresh water regularly that we have not yet mentioned? variable.

Do you store fresh water outside your home? yes=20;no=3 What is the source of that water? (rain water? other?)? rain = 19; other = 14
What do you store the water in? Metal containers 18 Plastic containers? 3 Glass containers? 1 Other? 3.

If fresh water is carried into the house, who brings it in? Elderly people? 0
0 Men? 4 Women? 16 All adults? 0 Youths? 0
Children? 18. n/a = 3

Page 2

When is fresh water brought into the house?_____ Early morning? 5
Mid morning? 0 noon? 3 afternoon? 0 early evening? 3
after dark? 0 whenever needed? 15 other? 6.

Do you boil fresh water before you drink it at home? yes = 14; no = 1; sometimes = 8
Why? variable.

Do you water plants or animals with your fresh water supply at home? yes=15;no=8
(especially water pigs)
Do you use fresh water for medical practices? yes=3 How? variable

Would you use fresh water for any of the following ailments?
cold? 1 Headache? 1 body aches? 1 childhood disease? 1
other? lovemagic1 How? variable

How often do family members bathe? Men? once a day - 1 Women?
Youths? Children? when dirty-1 Babies? when dirty - 1
all/2-3 times - 2 all/3 times a day - 18 all/3,4,or 5 times - 2
What time of day do people bathe? Men? night - 1 Women? Youths?
Children? when dirty-1 Babies? when dirty - 1.
morning & night - 3 morning,noon and night - 16 other - 5
Do outside water storage containers ever rust? yes - 17 other - 6.
Is the water safe to drink then? yes - 2 no - 4 other - 17.
To use for other purposes? yes - 1 n/a - 14 no response - 8.

Is fresh water ever rationed among your family members? yes - 7 no-5 n/a-11.

Do you ever re-use fresh water? variable - 2 no-1 n/a - 20.

Do you think fresh water should be regarded as a limited natural resource?
limited - 4 enough - 2 no - 5 n/a - 12.

Does your family ever experience a shortage of fresh water? yes = 23.
When/under what conditions? dry season = 23.
How does your family conserve water? variable -3 not conserve - 4.
no response - 16
Do you have any other customs or special practices concerning fresh water?
not applicable = 22 other - 1.

Is there a public faucet or public well on your property? no = 23.

Who owns the fresh water that you use? I do 4 My family does 3
rent or lease the government no one owns it
other (please list) 9 n/a - 9.

Do other families ever get fresh water from your house if they have a water shortage? yes=8 Which other people in Nemwan might get water at your house? variable - 8 n/a - 14 no response - 1.

Do you think Nemwan's fresh water supply system should be improved? yes = 23.

Would it help your family if fresh water was more readily available? yes - 21
How? various responses no response - 2.

If we put public faucets in Nemwan village, where do you think we should construct them? at the church-7 at Epikepin-6 either place-7 no response-.
Why do you think these places you have named would be a good place? various responses.

Would people in your household be willing to help build the new water supply system? yes-15 How many people? various How many days could they work? _____
Would your household contribute money if there is not enough government money available? yes-6 Would you contribute supplies for building if necessary? yes-2. would volunteer labor - 16
no workers available - 8

If you controlled access to fresh water (such as if the public faucet was on your land), how would other people acquire the use of that water?
No permission needed from landowner? 4 Just tell you they need some water? _____ Permission from you? 9 Trade or exchange with you? _____
Rent from you? ____ Family ties? 2 Pay you? _____ Other? 1
not applicable - 11.

If you yourself or your family members were going to get fresh water (from a faucet on someone else's land), how would you acquire the use of that water? No permission needed from them? 4 Just tell them you need some water? _____ Permission from them? 10 Trade or exchange with them? _____ Rent from them? _____ Family ties? 1 Pay them? _____
Other? no response-1 not applicable-8.

If the faucet was on public land, who would maintain it? various responses-5.
no response - 4 not applicable - 14

Do you think the people of Nemwan should pay a tax to the government for their fresh water supply? _____ Why or why not? various responses
yes-2 no-1 maybe-4 not applicable-16.

Would you like to have water piped directly into your house? yes - 23

Waste Water Disposal

These are sensitive questions on Truk. Only 6 families were asked these questions.

Where does your family go to the benjo? overwater - 5; overland - 1.

For sanitary purposes, where do you think people should go to the bathroom in this village? overland - 4; flush toilet - 1; other - 1.

Do you think that going to the toilet in the boonies can pollute the drinking water? yes - 2; maybe - 2; no - 1; don't know - 1.

If you use an overland benjo, do you think this will pollute the drinking water? yes - 2; maybe - 2; no - 1; don't know - 1.

Do you think the type of toilet people use can have an effect on health of people in the area? yes - 4; maybe - 1; don't know - 1.