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FINAL EVALUATION

OPERATIONAL PROGRAM GRANT USAID 879-0251-GSS-1005-00

HA'APAI WATER SUPPLY PROJECT

KINGDOM OF TONGA

JUNE 30, 1981 - AUGUST 31, 1986

BY

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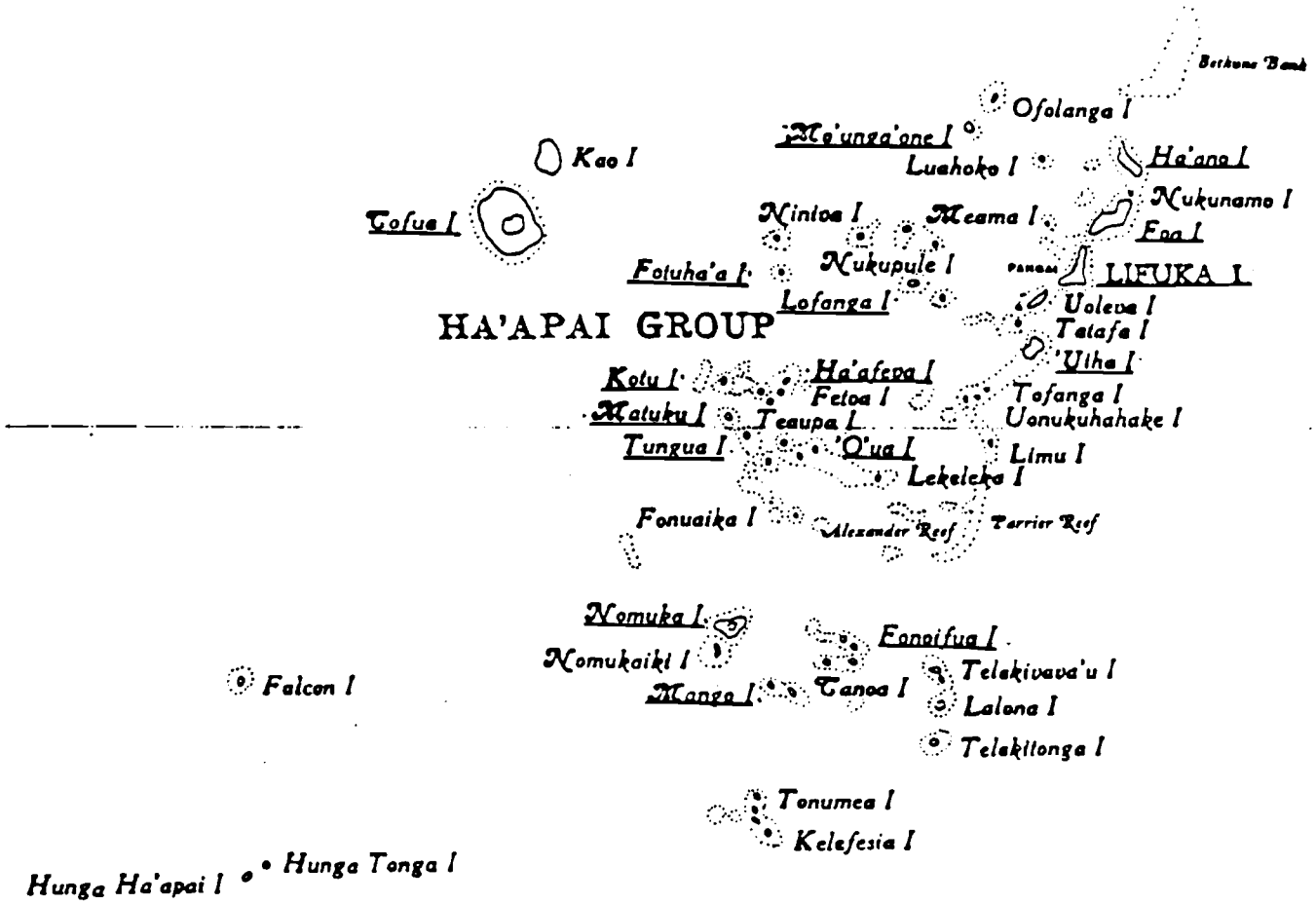
THE HA'APAI ISLANDS



NOTE:- The islands underlined (e.g. Tofua I) denote the inhabited islands of Ha'apai.

I. Introduction

On June 30, 1981, the United States Agency for International Development (USAID) approved a grant for the Foundation for the Peoples of the South Pacific (FSP) to provide partial support for a water supply project in the Ha'apai Group of islands - small isolated islands with very limited fresh ground water supplies. The original general aims of this project were:

a. To develop new rural water supplies by building rain water catchment systems and groundwater pumping systems where feasible;

b. To improve and/or renovate existing water supply systems so as to supplement the new water supply systems;

c. To improve the overall health and sanitation of the Ha'apai people by providing adequate supplies of fresh water.

The initial grant period was June 30, 1981 through December 31, 1982. This grant was amended on December 15, 1982 to extend the project through February 28, 1983 with no additional funds.

On February 27, 1983, the project was extended for an additional two year period (March 1, 1983 through March 1, 1985) with the goal of providing 520 water tanks of 1,000 gallon capacity for individual houses in the Ha'apai group.

On January 30, 1985, a grant modification extended the term of the project through May 31, 1985, with no additional funds.

FSP conducted three evaluations of this program in September, 1982, January, 1984, and April, 1985. The final evaluation completed in April of 1985 revealed that 630 tanks (80% of the total constructed) were leaking, 156 catchment systems (20% of the system) had incomplete gutter systems, and that a majority of the catchment systems were not being maintained properly to assure a sanitary water supply to consumers.

Mr. David Wyler, FSP Tonga Country Director, recommended that the project be extended for a fifteen-month period (June 1, 1985 - August 31, 1986) to correct these problems and to specifically:

a. Repair leaking tanks;

b. Repair gutter systems as needed;

c. Install water taps as needed;

d. Provide further training in the proper maintenance and improvement of existing water systems.

This extension was approved in June of 1985 bringing the total amount of USAID funding provided for the project plus the extension to US$372,113.00. The project also was aided at various stages with grants from UNICEF for guttering and tanks, as well as local contributions from the Government of Tonga and the Ha'apai villages. This report is the result of a final evaluation of the project (and the project extension) carried out during September 15 - 24, 1986.

As with previous evaluations of the project, FSP invited participation in the evaluation from government ministries and departments directly involved in water supply programs and policies. A six member team conducted the evaluation:

Mr. Manamo'ui Kaufusi	Central Planning Department
Mr. Sepeti Kauvaka	Ministry of Health
Mr. Maka Vaipuna	Ministry of Works
Mr. Richard Stoll	World Health Organization
Mr. Maunaloa Taufahema	FSP Accountant
Mr. Jon Lindborg	FSP Country Director

FSP wishes to express its appreciation to the participants and their respective ministries and departments for their willingness to take part in this strenuous evaluation. In an eight day period, the evaluation team surveyed 747 tanks on 14 islands utilizing the Fisheries research vessel, 'Albacore', for transport to and from Nuku'alofa and within the Ha'apai group. Seas were very rough the first two days of the evaluation but the stamina of all participants was exceptional.

The insights of the Government and WHO participants were invaluable and the evaluation was an excellent opportunity to survey the water supply situation as well as view first hand Current conditions on many remote Ha'apai islands.

II. Administration of Project

The Project was administered by Mr. David Wyler, FSP Country Director, from July 1981, through February, 1986. On March 1, 1986, Mr. Jon Lindborg replaced Mr. Wyler as Country Director who took up the post of FSP Regional Director based in Suva. Mr. Lindborg administered the final six months of the project assisted by an excellent local staff including the Assistant Country Director, Ms. Seini Vakasiuola, the Accountant, Mr. Maunaloa Taufahema, and Secretary, Ms. Tukasi Pale.

The FSP Office administered the project funds, assisted with purchase and shipping of supplies to Ha'apai, and provided quarterly reports on the project to USAID and the Central Planning Department, the latest report covering the time period December 1, 1985 through May 31, 1986. Project updates were also provided on a monthly basis to the Tonga Village Water Committee which includes representatives from the Ministry of Health, Ministry of Works, Central Planning, Tonga Water Board, WHO, and FSP.

The ferrocement tank repair project was implemented in the field by the Niuola Women in Development Organization, a local non-government women's development organization headed by Ms. Temaleti Vakasiuola. She completed her repairs in April of 1986. Repair of the zincalume tanks was coordinated by Mr. John Borman, a Peace Corps Volunteer experienced in tank building programs, who was assigned to FSP from November, 1985 through August, 1986.

III. Project History

In 1979, the Peace Corps and Government of Tonga, with financial support provided by USAID's Accelerated Impact Program (AIP), initiated a program to improve and expand water supplies in the Ha'apai group. The program met serious administrative difficulties and FSP, at the request of the Government of Tonga and USAID, agreed to administer the project. As noted in the 'Introduction', FSP began its association with the project in July of 1981.

The project was designed to be a collaborative effort between the Government of Tonga, represented by the Ministries of Health and Works, and FSP. Initially, a Peace Corps Volunteer, Mr. Tom Hicks, was recurited as Project Manager and placed in Pangai, Ha'apai with the Ministry of Works (MOW). He supervised a crew of four MOW employees to implement the project.

The initial goals of this project were to construct one groundwater pumping system in the village of Fangale'ounga on Foa Island and to construct 5,000 gallon capacity ferrocement community water tanks, as well as adjacent roof catchment areas in all other villages of Ha'apai.

This plan was however totally revised in 1982 when Cyclone Isaac devestated Tonga. The Ha'apai Islands were hardest hit with nearly 90% of the houses there either severely damaged or totally destroyed.

FSP and the Government of Tonga proposed a two-year extension of the original grant in March of 1983 which called for the construction of 520 1,000 gallon capacity water tanks which would be provided to individual private homes. This project was to coincide with the Government's hurricane housing reconstruction program which would construct approximately 700 new houses for villagers in Ha'apai.

Because an extended drought followed the cyclone for eight to nine months, it was decided to construct metal 1,000 gallon tanks (Lysaught's Zincalume) because they could be constructed much more quickly than ferrocement tanks. When an evaluation of the project was carried out in January of 1984, a large number of the zincalume tanks were found to be leaking. There was also very little community participation in the implementation of the project.

As a result, it was the recommendation of the evaluators that the program should stop the construction of zincalume tanks and start to construct ferrocement tanks. The Niuola Women in Development Organization was approached by the FSP Country Director early in 1984 regarding the possibility of implementing the construction of ferrocement tanks. The Niuola group had already been building ferrocement tanks of their own design on Tongatapu with active community participation.

It was agreed that the Niuola group would construct ferrocement tanks for the FSP Project with a capacity of 2,250 gallons for the remainder of the project and they began construction of the tanks in April of 1984. A central thrust of the Niuola implementation philosophy was that villagers should become actively involved in the construction of tanks. To this extent, it was viewed not only as a tank building project but as a training project focused on village-based development.

It should be noted that late in 1983, the manager and his MOW crew experimented with the construction of WHO designed 1,000 gallon capacity modular square ferrocement tanks. However, these proved to be too expensive and were also found to be inappropriate in terms of ease of construction in the field. After constructing five WHO tanks, this activity was terminated.

The final evaluation of the project was carried out in April of 1985. As stated previously, the evaluation team found serious problems with the catchment systems and recommended that a 15-month extension of the project be initiated to correct the shortcomings of the original project. The extension phase officially ended on August 31, 1986.

IV. Accomplishment of Project Goals:

A. Original Project (June 30, 1981 - May 31, 1985): The goal of the original project was to increase the fresh water supply in the Ha'apai Islands by 520,000 gallons by constructing 520 water tanks of 1,000 gallon capacity each.

The project was able to achieve the construction of 786 water tanks with a total water capacity of a little over 1.5 million gallons capacity. Therefore, the project exceeded its goal for total possible water capacity by 170%.

B. Project Extension (June 1, 1985 - August 31, 1986): The goals of the extension project were as follows:

1. Repair a minimum of 630 leaking water tanks;
2. Repair a minimum of 156 gutterings;
3. Install a minimum of 91 water taps;
4. Provide proper covers and mosquito screening for tanks as needed;

The measurement of these goals is summarized in Table 1.

Table 1

	A. April 1985 Survey	B. September 1986 Survey	Repairs Achieved (1985 total less 1986 total)	Percentage of Goal Achieved
No. of leaking tanks	630	441*	189	30%
No. of incomplete gutterings	156	48	108	70%

* Of this total of 441 leaking tanks, 79 were judged to have major leaks and 362 were judged to have minor leaks.

As is clear in Table 1, the project was not successful in repairing a minimum of 630 tanks. In fact, it fell 70% short of this goal. However, it should be noted that the 1986 survey classified leaks as either major or minor; major leaks being leaks which rendered the tank virtually useless while minor leaks were slow seeping leaks which did not represent significant sources of water loss. Such classification of major and minor leaks in the 1985 survey would have helped the 1986 evaluators to better guage the success of the project.

In terms of repairing guttering, a much better success rate was achieved with 70% of the goal attained. Overall, evaluators found most gutter systems complete.

Regarding the goal of installing 91 water taps on existing water tanks, evaluators could find no instance where taps had been installed. This aspect of the project was apparently ignored.

Finally, the goal of providing proper covers and mosquito screening for all tanks as needed was partially achieved. This will be discussed in greater detail in the 'Evaluation' Section.

V. Work Achieved

The following figures summarize what has been accomplished by this project (June 30, 1981 through August 31, 1986):

- Number of Villages Assisted: 22
- Estimated Population Served[1]: 5,600
- Number of roof Catchment Areas Constructed 10 (585m²)
- Number of 1,000 ga Zincalume tanks Constructed 297 = 297,000 capacit
- Number of 2,500 ga Niuola Ferrocement tanks Constructed 477 = 1,192,500 ga capacity
- Number of 5,000 ga community ferrocement tanks Constructed 11 = 55,000 ga capacity
- Number of 1,000 ga WHO tanks Constructed 5 = 5,000 ga capacity
- Total Water Capacity of all tanks Constructed 1,549,500 ga

- Additional Water Storage Systems rehabilitated(2) 462,000 ga

- Additional Roof Catchment structures rehabilitated(2) 21 (420m²)

- Number of village groundwater pumping systems constructed 1

1. Based on latest Mini-Census

2. Refers to repair work completed by FSP to structures which were damaged in Cyclone Isaac in 1982.

VI. Evaluation

A. Evaluation Methodology

The six-member evaluation team visited the Ha'apai Islands during the time period September 15-24, 1986. (See Appendix I for schedule). Two of the six, Mr. Maka Vaipuna from MOW and Mr. Maunaloa Taufahema from FSP, had taken part in the evaluation in 1985. Their insights were especially useful as they had surveyed the water tanks before the repair project.

Where possible, village town officers assisted the evaluators with their survey. However, it must be noted that in a number of villages, town officers did not even bother to assist the evaluation team. This occurred in spite of the fact that messages had been announced over the radio station regarding the visit of the evaluation team.

Each tank was visited by all team members with each member recording his observations on an evaluation form. As much as possible, evaluators attempted to consult with actual tank owners as to the condition of their tanks.

All islands were surveyed except Tofua (8 zincalume tanks) and Mo'unga'one (35 Niuola ferrocement cement tanks) due to time limitations. Data on all tanks surveyed was collated at the end of the trip in Nuku'alofa by team members and it was agreed that each non-FSP evaluator would submit his own report to be included as part of the FSP evaluation (see Appendices 2, 3, 4, and 5).

Rains had been sufficient prior to the survey to insure that tanks surveyed should contain significant quantities of water if they had functional gutter systems and did not have major leaks.

B. Zincalume tanks

Of the 297 zincalume tanks constructed, 289 were surveyed. These tanks were constructed by a 5-man MOW work crew under the supervision of two Peace Corps Volunteers and one British VSO Volunteer during the time period June 1983 through February 1985. The final evaluation of April 1985 revealed that 80% of these tanks were leaking.

The FSP Evaluator noted that the leaking was most due to poor workmanship attributable to: 1. improper training of the MOW work crew by the tank suppliers (Lysaughts Fiji); and 2. poor supervision of the MOW work crew by the volunteer project managers.

Mr. John Borman, a Peace Corps Volunteer who had previously worked on a tank project in Fiji, began working on the repair of the zincalume tanks in December of 1985. He found that most leaks were occurring along the riveted seams of the tanks and devised a method of repairing the tanks from the outside which involved prying open the seams, inserting boat caulking, and then using cement to seal the length of the seam. Mr. Borman also advised tank owners on general maintenance of tanks and gutters and, as much as possible, involved actual tank owners in the repair of the tanks.

The condition of the zincalume tanks as determined by this survey is summarized in Table 2 . Total capacity of surveyed zincalume tanks is 289,000 gallons. Estimated quantity of water in tanks at the time of the survey was 136,750 gallons which means that approximately 47% of the total capacity was available to consumers, or 77 gallons per consumer.

As is shown in Table 2 , 80% of the tanks were found to be leaking in 1985 compared to 70% in 1986. Hence, there was no significant improvement in the number of non-leaking tanks. Of this 70% total, 59% were termed minor leaks while 11% were termed major leaks. Minor leaks were most commonly confined to slow seeping along the seams while major leaks were most frequently

found around the joint between the sides and bottom. In a number of cases, rusting was a major cause of leaking, especially around the taps and on the bottoms of the tanks.

Observations regarding the zincalume tank include the following:

1. Various attempts had been made to repair tanks. Most of the repairs were done on the outside of the tanks which in most cases appeared to be inadequate. It was clear that the only way to repair the tanks is caulking from the inside along the length of the seams.

2. Taps were a particular problem on most tanks. They were of poor quality and were the source of many leaks. In many cases, tap damage was due to pigs.

3. The problem with pigs was particularly evident on Nomuka. Since tap areas were not fenced off, areas around the tanks had become pig wallows. This exacerbated problems with taps as well as contributing to servere erosion around tanks causing many of them to be off level, especially in sloped areas of Nomuka.

4. There was a direct correlation between the general level of village neatness and the condition of the tanks. Conditions on Nomuka were the worst (primarily due to roaming livestock and poor maintenance of home and village areas) and zincalume tanks were in poor condition. In contrast, Kotu, Mango and Fonoifua were observed to be very clean and tanks were generally in good condition. Tank owners had clearly taken an interest in maintaining their own tanks. This was especially true on Mango and Fonoifua where all livestock is either pinned up or tied.

5. Guttering was a major problem, even though 90% of gutter systems were complete. Downpipes were frequently found to be missing and gutters were observed to be poorly positioned or falling apart at seams. Gutter problems in most cases appeared to be due to owners not having an interest in and/or knowledge of how to fit gutter systems back together. Because of this, many tanks were not full simply because of poor catchment efficiency. For example, a 20 foot section of

gutter might only have 6 feet of usable gutter, even though 30 minutes of effort on the part of the owner would render the whole gutter system usable. Also, many gutters were full of leaf debris.

6. Although strainers had been provided with tanks, many of them were missing or were not being maintained by tank owners. As a result, many tanks had refuse in them and also served as breeding habitats for mosquitos.

Overall, the repair of zincalume tanks was not successful even though the repairs necessary for most tanks are of a simple nature. Repairs of the tanks should have instead focused on sealing integral seams from the inside albeit this requires much more effort on the part of the repairers. This of course entails cooperation on the part of tank owners, which given the observations made in a number of villages, is questionable. Hence, many of the problems with the zincalume tanks relate more to attitudes of tank owners than strictly to technical aspects.

Still, it must be stated that zincalume tanks are only a short term solution for rural water supply. Given the problems of corrosion, most tanks will only provide a servicable life of 10-15 years at which time they will have to be replaced. They also tend to be very delicate insomuch as striking them with objects such as sticks or moving them tends to cause the seams to leak. Finally, there is the aspect of community participation which proved to be minimal given FSP's experience. Therefore, the decision to switch to building ferrocement tanks in 1984 was a proper one.

The approximate average cost to construct one zincalume tank in this project was T$290.00. This figure includes materials, labor, and freight, but does not include guttering.

C. Niuola Ferrocement tanks

Of the 477 Niuola tanks constructed, 447 were surveyed. The Niuola tank is of local design and has a capacity of 2,250 gallons. These tanks were constructed by the villagers themselves under the supervision of a work crew from the Niuola Women in Development Association during the time period of April 1984 through March 1985.

The Niuola supervisory crew would initally train a group of people in a village in building one or two tanks. This group would then be responsible for supervising the construction of tanks in the village. Each home was given the necessary materials (cement, wire, forms) to construct the tank with each household providing the labor.

The final evaluation of April 1985 revealed that 81% of these tanks were leaking. The FSP Evaluator recommended that the Niuola group be asked to repair the tanks by doing the following: 1. Providing a 6-person supervisory crew to implement training of villagers in ferrocement tank repair and general maintenance of catchment systems, and 2. Replastering the inside of the tanks with an additional four bags of cement paying particular attention to the walls and floor. The Niuola completed its repair work early in 1986.

The condition of the Niuola ferrocement tanks as determined by this survey is summarized in Table 2 . Total capacity of the surveyed tanks is 1,005,750 gallons. Estimated quantity of water in tanks at the time of the survey was 533,812 gallons which means that approximately 53% of total capacity was available to consumers, or 206 gallons per consumer.

As the figures in Table 2 show, there was a marked improvement in the number of non-leaking tanks from 11% in 1985 to 42% in 1986. Of the total of 52% leaking tanks found in the 1986 survey, 42% were classified as minor leaks while 10% were classified as major leaks. Minor leaks were generally slow seeping leaks caused by fine cracking in the sides of the tanks. These leaks have a tendency to seal themselves over time. Major leaks were most frequently confined to leaks in the tank floor or the joint between the tank sides and floor. Figures for levels in the tanks were: 6% empty, 34% ¼ full, 23% ½ full, 15% 3/4 full, 22% full.

Interviews with tank owners revealed that the repair of many tanks was not carried out as originally set forth in the extension project. A number of tanks were in fact emptied, pried up off the ground, dry cement was poured underneath the tank, and the tank was reset. This practice did not alleviate leaking and in most cases caused leaking to become worse. In several cases, tanks were completely destroyed by this procedure.

Comments regarding the Niuola ferrocement tanks include

the following:

1. Workmanship varied widely from village to village and even from household to household. Some tanks were very well constructed while others were clearly substandard. This was undoubtedly due to the method of having tank owners construct tanks themselves with little technical supervision.

2. There appeared to be no set design for the tanks. Tank sizes varied with most of them being non-symmetrical in shape.

3. Floors and foundations of tanks were particularly a problem. No plastic moisture barriers were placed underneath the tanks and many tanks appeared to have inadequate foundations to support the total weight of a full tank of water (approximately 10 tons).

4. Some tanks were built into the ground a depth of 2 to 4 feet. In some cases, this was necessary because the catchment area on a house was very low to the ground. Such tanks did not have taps and water was dipped out of the opening on the top. This creates a situation where contamination of the water with debris is likely as well as allowing mosquitos to enter to lay eggs. Many such tanks were clearly a health nuisance.

5. Taps on tank were of poor quality and were often the source of leaking. As with the zincalume tanks, pigs were a problem around taps, but not to as great an extent.

6. Many tanks in the village of Ha'ano had flat roofs which were structurally flawed and caving into the tanks.

7. Few strainers were on tanks and many tanks were missing lids. Once again, this contributes to the problem of debris and mosquito larvae in water.

8. Gutters, as with the zincalume tanks, were generally complete. Problems, when observed, related to maintenance of gutter systems by tank owners.

Generally, the Niuola ferrocement tanks were in better condition than when the same tanks were surveyed in 1985. Once again, there was a direct correlation between the condition of tanks and village conditions as a whole. The

village of 'Uiha had the greatest number of tank problems while the best tanks were found in Ha'afeva, Koulo and, Holopeka.

In some ways, one must question the original wisdom of attempting to repair some of the worst Niuola ferrocement tanks in Ha'apai. A number of the tanks, especially in 'Uiha, were simply not repairable, their level of original workmanship being so poor. Other tanks which had been repaired were better in terms of water holding capacity. However, it was clear to evaluators that the original quality of construction was the single most important factor in determining whether or not a tank was servicable. As the WHO Engineer pointed out, carrying out major repairs of poorly constructed ferrocement tanks is exceedingly difficult because new cement will not adhere to old cement without proper cleaning and chemical treatment. Moreover, if there is not a substantial foundation and water barrier below the floor and sides, major bottom leaks will be a problem. Unfortunately, a number of the Niuola ferrocement tanks were simply not well built.

However, as was stated previously, the decision to begin the construction of ferrocement tanks was correct. Ferrocement tanks clearly are the best choice for individual household water storage and have the added advantage of long durability - up to 25 years. They also have the advantage of allowing more active community participation in water supply projects as was demonstrated with this scheme.

There is a caveat in emphasizing community participation and that is not to neglect the technical components of tank building. The construction quality of the Niuola ferrocement tanks could have been improved dramatically if supervision by knowledgable people had been provided for each tank. Granted, this may ultimately slow a project down, but project managers are expecting too much when they believe that outer islanders are capable of building durable ferrocement tanks without close supervision. This also means that the project manager should inspect project progress frequently (preferably as each village is finished) so that any problems encountered may be corrected early in the project and not attempted at the end.

Finally, the accomplishments of the Niuola group in building 477 tanks under difficult conditions in these remote outer islands should not be overlooked. The Niuola group should be complimented for this monumental task, even though their enthusiasm may have exceeded their technical expertise at times.

The approximate average cost to construct one Niuola ferrocement tank was T$160.00 which included materials, labor, and freight, but did not include guttering.

D. WHO Ferrocement tanks

Only five tanks of this type were constructed in this project. They were not included in the repair project.

As shown in Table 2 , four of the tanks were leaking - two with major leaks and two with minor leaks. Two tanks were empty, one tank was ¼ full, and two tanks were full bringing the total surveyed level to 2,250 gallons or 50% of total capacity when full. All tanks except one were being utilized as community tanks.

As was stated in the 1985 evaluation of the project, it was FSP's experience that these modular square ferrocement tanks of 1,000 gallon capacity were inappropriate for use in the Ha'apai group. The construction of the prefrabicated sections (approximately 5 feet by 5 feet) was carried out at the project workshop in Pangai and the tanks were then assembled in situ.

Comments on the WHO tanks include the following:

1. Construction of panels requires relatively sophisticated equipment - a vibrating table, imported high tensile steel, and steel fibre.

2. Transport of panels is difficult, especially if attempting to transport in small open boats as is the norm in Ha'apai. Each panel weighs 80 - 100 pounds.

3. More than one supervisor is required to efficiently construct tanks - one for panel production and one on site to assemble the tank. Also, a minimum of two 4-man crews are needed to run both operations simultaneously.

4. Because of the relatively high technology involved in producing the tanks, little to no participation of tank owners is possible during construction and assembly.

5. High overhead makes the tanks more expensive than alternative tanks. The WHO tanks produced by FSP in 1983 and 1984 were estimated to cost in excess of T$300.00.

Therefore, I would strongly advise against any future use of WHO modular tanks in water projects, even though the same construction methodology is currently being used quite effectively in building WHO pit latrines and bathhouses in Tonga. However, for water tank purposes, the WHO design is inappropriate.

E. 5,000 Gallon Ferrocement Community Water Tanks

Of the eleven tanks constructed by the project, six were actually surveyed. Five of the six tanks had no leaks while one tank had a broken off tap which had not been replaced. All five tanks with no leaks were completely full and were available for community use.

These tanks were built during the time period October, 1981 through May, 1983, prior to the construction of the zincalume tanks. Alongside these tanks were built roof catchment areas. The tanks surveyed were of excellent quality and gutters were also in excellent condition.

Whereas in the past villagers were dependent on community water tanks for year-round water supplies, the provision of private water tanks has dramatically decreased the dependence on community water tanks. Because water tanks located next to their homes are much more convenient, villagers naturally use them for water supplies.

The important implications of this are that community water tanks may serve as backup sources of water during periods of drought and may also be sources of water after natural disasters such as cyclones. Every village surveyed by the team had at least one government community tank of at least 10,000 gallons capacity. By and large, FSP and government community tanks appeared to be well maintained.

It was clear that there is a role for both individual water tanks and community water tanks in outer island villages. With proper supervision and training in tank maintenance, individual water tanks clearly have the potential of improving overall health and sanitary conditions. Likewise, community tanks have an important

function in providing reserve fresh water sources.

F. Guttering

Plastic guttering was provided by UNICEF for every tank constructed in this project. Gutter materials provided included 2 gutters, 1 downpipe, 1 rainhead, 2 stopends, 1 joint, 5 brackets, and 2 bends. Some houses had a little more, and some less, depending on the size of the house.

Overall, the survey found that 94% of the gutter systems were complete. Common problems encountered with gutter systems were missing stop ends, too few hanging brackets, and poor maintenance by owners. There is a great need to improve existing guttering by training tank owners in hanging guttering properly so water catchment is maximized, as well as keeping gutters clean.

Another observation made by the survey is the importance of catching water from all available roof space on a house. A number of houses had gutters on both sides of the roof and tanks connected to such systems were generally 3/4 full or full. This is especially true with the hurricane houses which are the most common house type in the Ha'apai group. Roof areas on these houses are not very large and catchment efficiency could be doubled if guttering was provided for both sides of the roof. Future programs should seriously consider providing double gutters on hurricane houses if funding is available.

G. Groundwater Pumping System

One pumping system was constructed by this project in the village of Fangale'ounga on the island of Foa. It was constructed by the MOW work crew in 1982. A 15 feet deep well was hand dug by villagers about ½ mile to the east of the village. A 3½ h.p. diesel motor and centrifugal pump were installed at the well site and a small building was constructed to house this equipment. Water is pumped to a 3,000 gallon metal tank (provided by UNICEF) standing on a 22' tank stand. Water is piped to eleven taps in the village. A village water committee is in charge of maintaining the system and raising and collecting funds for the

purchase of diesel fuel and oil. Overall, the system is functioning very well. Water from the well is used primarily for agricultural purpose.

It was reported that occasionally, the water level in the well falls below the intake pipe. The WHO Engineer felt that this was most probably due to tidal fluctuations of the water lens and not to overpumping. It was observed that the system could be improved by the provision of a test valve outlet so that pump output could be measured. Also, bore holes need to be covered.

The system serves a population of approximately 220.

VII. Summary and Recommendations

A. Summary

Over a period of five years, this project has constructed and repaired 790 water tanks and one groundwater pumping system. Approximately 5,600 people in 22 villages on 16 islands have directly benefitted from this project. The total direct and indirect costs for the project were US$372,113.00 which translates into a cost/benefit ratio of US$66.45 per beneficiary. Total fresh water storage capacity was increased by approximately 1.5 million gallons at an approximate cost of US$.25 per gallon.

The initial goals of the project have clearly been achieved in that fresh water supplies in Ha'apai have been increased significantly with the concomitant effects on improved health and sanitation. Overall, living conditions have been improved in Ha'apai over the past five years because of this project and the Government Hurricane Housing Program.

The history of this project and the lessons learned in the process point to certain shortcomings in its design and implementation. There is no question that round ferrocement tanks are the best choice for use in rural water supply projects. The main advantages of ferrocement over other tank construction materials, such as zincalume, are its cheapness and common availability of materials, easy working using a minimum of expensive equipment, and durability. Moreover, the users of the ferrocement tank can help in collecting sand for the mortar and in doing most of the heavy construction work; in this way they can contribute

work instead of capital which they may find difficult to provide. Hence, the experiences of this project demonstrate that round ferrocement tanks are the best choice for this type of project.

It is indeed unfortunate that the initial phases of the project experimented with various tank types before it was realized that round ferrocement tanks represented the best and most appropriate technology.

The leadership provided by the Niuola group is admirable. They totally involved tank recipients in the construction of tanks. Community participation was outstanding. However, their construction methods tended to be substandard. Closer consultations with engineering consultants on initiation of ferrocement tank construction to establish a standard design, much closer supervision of actual construction, and closer attention to quality control would have resulted in much higher quality tanks.

As the last fifteen month repair phase of the project demonstrated, repairing ferrocement tanks with serious flows is very difficult. On the other hand, smaller leaks often seal themselves or can be easily repaired. Still, it is important to do the job right the first time. This means starting with a proven design and supervising work closely.

The most critical aspect that needs to be addressed more closely with regard to water projects in the outer islands is the human element. It must be remembered that tanks are used by people. Without close consultations and involvement with tank recipients as to what is expected from them in terms of taking responsibility for maintaining tanks, the negative public health implications are clear. This was very evident on Nomuka as mentioned earlier. In some ways, one must wonder if certain villages in the Ha'apai group are suffering from an "aid overload". Yet in those villages where people take obvious pride in the general upkeep of their homes and community areas as was observed in Kotu, Ha'afeva, Mango, and Fonoifua, the demonstrable positive effects of the water tank program are clear.

Hence, to insure better upkeep of water tank systems, project implementors need to pay more attention to training tank owners in total system maintenance.

Attempts should also be made to include in the program design incentives to insure owner cooperation with program expectations. This might best be achieved by the requirement of an actual cash contribution towards the cost of the tank. Finally, closer co-ordination with the Ministry of Health is imperative. Project implementors need strong support from Public Health Officers, as well as Town Officers, to effectively impress upon tank owners the need to maintain tanks. Training and enforcement must be improved.

Regarding the issue of individual versus community tanks, I believe there is a place for both types of tanks in the outer islands. Programs should not ignore one tank system at the expense of the other.

B. Recommendations regarding existing water tank systems in Ha'apai

1. Public health issues must be tackled. This means that Health Inspectors, with the cooperation of Town Officers, must work with villagers in improving overall community sanitation levels. This not only includes improving tank maintenance but addressing the problem of roaming livestock, particularly pigs.

2. Engineering advice should be sought on how best to repair metal tanks which are still leaking. Tank owners should be trained in how to carry out repairs themselves.

3. Niuola ferrocement tanks still in need of repairs should be the responsibility of the Niuola group. However, before they initiate any repairs, they should be thoroughly trained in proper methods of repairing tanks.

4. Even though the repair phase of this project was not 100% effective, given the increase in overall fresh water supply capacity made possible by the program, further funding for the Ha'apai Water Supply Project by USAID is not recommended at this time.

C. Recommendations for future water supply programs

1. The current policy of providing individual water tanks should be continued. However, existing community tanks should be maintained and renovated as necessary so that reserve fresh capacity is available in each rural village.

2. Future programs should build round ferrocement tanks. Construction design should be reviewed in detail by a competent engineer familiar with water tank design in the South Pacific. A standard design should be adopted so minimum quality standards may be measured upon completion of the tank.

3. Prior to the initiation of the program, a thorough survey of all recipient households should be made by project implementors and Ministry of Health personnel to:

   a. determine location of the tank on each 'api along with necessary gutterings;

   b. thoroughly explain to tank recipients the implementation methodology of the program and to make clear their responsibilities of participating in the program and maintaining tanks after construction. Those individuals who do not want to accept these responsibilities should be excluded from receiving a tank.

4. Care should be taken by the implementing agency in choosing a competent and experienced construction supervisory team. Such a team should have a demonstrated record of constructing high quality tanks and should also have the ability to work with villagers and involve them in the actual construction process.

5. Serious consideration should be given to the possibility of having villagers contribute not only labor, but also capital, in the form of materials or cash. This would increase the incentives for tank owners to maintain their own tanks.

6. Each tank constructed should be directly supervised by the construction supervisory team to insure proper mixing of cement and proper building techniques.

7. If funding is available, smaller roof areas should be provided with double gutters to maximize catchment efficiency.

8. Tanks should be inspected soon after completion to assure quality standards. At this time, clear instructions should be provided to owners regarding maintenance of the catchment system.

9. Coordination and cooperation between the implementing agency, the Ministry of Health, and town officers is very important. Ministry of Health should dispatch Health Inspectors to villages on a scheduled basis to make sure that tanks are being maintained as well as to enforce minimum sanitary levels in villages.

10. Training in tank maintenance should be provided to villagers in an ongoing basis by community-based groups.

Appendix I Table 2

Tank Type: Number (%)	April 1985 Survey				September 1986 Survey			
	1,000 ga zincalume	2,250 ga Niuola ferrocement	5,000 ga ferrocement	1,000 ga WHO	1,000 ga zincalume	3,250 ga Niuola ferrocement	5,000 ga ferrocement	1,000 ga WHO
Tanks surveyed	289	471	11	5	289	447	6	5
Gutters complete	266 (90%)	338 (72%)	11 (100%)	5 (100%)	267)92%)	421 (94%)	6 (100%)	5 (100%)
Gutters incomplete	31 (10%)	135 (28%)	0	0	22 (89%)	26 (6%)	0	0
Major leak tanks					32 (11%)	44 (10%)	1 (17%)	2 (40%)
Minor leak tanks	237 (80%) *	382 (81%) *	6 (55%) *	5 (100%)*	170 (59%)	190 (42%)	0	2 (40%)
Uncertain if leaks	16 (5%)	40 (8%)	0	0	34 (12%)	24 (6%)	0	1 (20%)
No leaks	44 (15%)	51 (11%)	5 (45%)	0 (0%)	53 (18%)	189 (42%)	5 (83%)	0 (0%)
Tanks empty	22 (8%)	35 (7%)	0	1 (20%)	24 (8%)	26 (6%)	1 (17%)	2 (40%)
Tanks ¼ full	78 (27%)	171 (36%)	1 (9%)	4 (80%)	103 (36%)	154 (34%)	0	1 (20%)
Tanks ½ full	86 (23%)	101 (21%)	1 (9%)	0	83 (29%)	103 (23%)	0	0
Tanks 3/4 full	61 (16%)	88 (19%)	0	0	38 (13%)	67 (15%)	0	0
Tanks full	42 (26%)	76 (17%)	9 (82%)	0	41 (14%)	97 (22%)	5 (93%)	2 (40%)

* Leaks not classified as major or minor in 1985 survey

Appendix I Table 2

Tank Type: Number (%)	April 1985 Survey				September 1986 Survey			
	1,000 ga zincalume	2,250 ga Niuola ferrocement	5,000 ga ferrocement	1,000 ga WHO	1,000 ga zincalume	3,250 ga Niuola ferrocement	5,000 ga ferrocement	1,000 ga WHO
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* Leaks not classified as major or minor in 1985 survey

ITINERARY FOR FINAL EVALUATION TRIP
FOR HA'APAI WATER SUPPLY PROJECT

SEPTEMBER 15 - 24, 1986

Mon.	September	15th	Leave Tongatapu 6:00AM Part of Nomuka, overnight Nomuka
Tues.	"	16th	Complete Nomuka, 'O'ua, overnight Ha'afeva
Weds.	"	17th	Tungua, Ha'afeva (one group); Kotu, Matuku (other group) overnight Ha'afeva
Thurs.	"	18th	Fotuha'a, Lofanga, overnight Pangai
Fri.	"	19th	Fakakakai, Pukotala, Ha'ano, Muitoa, overnight Pangai
Sat.	"	20th	'Uiha, Felemea, overnight Pangai
Sunday	"	21st	Pangai
Mon.	"	22nd	Pangai (Koulo, Holopeka)
Tues.	"	23rd	Fonoifua, Mango
Weds.	"	24th	Return to Tongatapu

APPENDIX II

REPORT ON FINAL EVALUATION SURVEY OF HA'APAI WATER SUPPLY
PROJECT 15th - 24th SEPTEMBER 1986

INTRODUCTION:

As we all know, water is one of our most important and most useful necessity in everyday life and we do not always remember its importance when it's plentiful, but when it is scarce and very little available, then we realise how to use it thoughtfully and how to save it from wasting and leaking.

All over the islands of Ha'apai Group, the first time in history that they ever possessed water tanks for individual homes granted by F.S.P. It was observed during the survey, that the community tanks especially in Kauvai District were all full of water clean and locked up for later use. Because of F.S.P. Tanks, no one wants to take water from community tanks because it's too far while F.S.P. tanks are stood by each house, but when F.S.P. tanks run dry then they will have to use the community tanks.

ZINCALUME WATER TANKS:

Generally speaking these tanks were not soldering type, because zincalume does not react to soldering processes so it was recommended to use adhesive sealant. As you can see the table, most tanks leak. The sealant did not adhere to zincalume properly due to oily residue from manufacturing. Then the repair work was not done properly due to tanks still contain water, surface dirty, and most of all should have been done from inside not outside.

FERROCEMENT WATER TANKS:

As I observed most tanks of this type although they were not professionally done individually, each one of them, it seemed from last year report that the bottom and sides are prime weaknesses. It will cost more to put these tanks right but despite that, I am referring to 1st construction and repair stages.

Collection of information stated that construction were done by each group of villagers and it was obvious that professional hands and technical supervision were lack.

Again, we heard that the repair work was worse. Most people with almost no leak tanks were forced participate in the repair work. So what they did, was priced the tank up on one side, cleaned the floor underside then lower down on to a layer of dry sand mixed with dry cement. It turned out that these almost no leak tanks were leaking 75% more.

Finally I congratulate F.S.P. Niuola and everyone taking part on the whole project, despite a few pitfalls, like the saying we learn from our mistakes.

We should look forward for any future project similar to this one to decide a better workmanship better supervision and should have a better results.

MAKA VAIPUNA
Building Services Supervisor

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FERROCEMENT TANKS 2250 GALS.

VILLAGE/ISLANDS -	HA'AFEVA	TUNGUA	HOLOPEKA	KOULO	MUITOA	FELEMEA	'UIHA	PUKOTALA	HA'ANO	HAKAKAHAI
tanks surveyed	64	62	29	34	18	61	83	20	41	35
gutters complete	61	59	28	31	17	55	77	19	40	34
gutters incomplete	3	3	1	3	1	6	6	1	1	1
major leak tanks	8	1	2	4	0	7	14	2	3	3
minor leak tanks	33	35	5	10	8	26	34	8	19	12
tanks no leak	15	16	22	18	9	24	32	9	14	17
tanks uncertain	8	10	0	2	1	4	3	1	4	2
tanks empty	1	2	2	1	1	3	14	0	0	2
tanks ¼ full	24	20	8	16	1	28	32	6	10	9
tanks ½ full	18	11	10	3	5	18	23	4	7	4
TANKS ¾ full	10	15	3	8	0	6	6	1	8	10
tanks full	11	14	6	5	11	6	8	9	16	10
consumers	417	368	147	276	110	265	431	151	248	180
tanks abandoned	2	3	0	0	0	2	6	0	1	1
small roof area	2	1	0	4	2	3	7	1	4	4
bad gutters	2	3	3	5	1	7	11	2	3	2

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ZINCALUME TANKS 600 GALS.

VILLAGE/ISLAND -	FONOIFUA	MANGO	PANGAI	MATUKU	KOTU	FOTUHA'A	'O'UA	NOMUKA	LOPANGA
tanks surveyd	20	16	3	21	35	20	24	99	51
gutters complete	20	16	3	19	30	19	21	90	49
gutters incomplete	0	0	0	2	5	1	3	9	2
major leak tanks	2	1	0	1	4	3	5	15	3
minor leak tanks	10	6	2	19	9	14	9	64	37
tanks no leak	8	8	1	0	7	3	6	10	10
tanks uncertain	0	1	0	1	10	0	2	0	1
tanks empty	0	0	0	2	7	1	2	10	2
tanks ¼ full	4	5	0	16	14	12	7	33	12
tanks ½ full	3	7	3	3	8	4	8	30	17
tanks ¾ full	8	2	0	0	4	1	4	14	5
tanks full	5	2	0	0	2	2	5	12	13
consumers	116	86	9	139	192	107	131	655	311
tanks abandoned	0	0	0	0	0	0	0	7	1
small roof area	2	2	0	1	7	3	1	3	0
bad gutters	0	[illegible]	0	[illegible]	6	0	0	5	2

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F.S.P. 5000 gal. Community Who

Village/Island	Muitoa	Ha'ano	Fakakakai	Pangai	Holopeka
tanks surveyed	2	2	2	4	1
gutters complete	2	2	2	4	1
gutters incomplete	0	0	0	0	0
major leak tanks	0	0	1 broken tap	3	0
minor leak tanks	0	0	0	1	0
tanks no leak	2	2	2	0	1
tanks uncertain	0	0	0	0	0
tanks empty	0	0	0	2	0
tanks $\frac{1}{4}$ full	0	0	0	1	0
tanks $\frac{1}{2}$ full	0	0	0	0	0
tanks $\frac{3}{4}$ full	0	0	0	0	0
tanks full	2	2	2	1	1
consumers	all community	all community	all community	community	6
tanks abandoned	0	0	0	0	0
small roof	0	0	0	0	0
[illegible]	0	0	0	0	0

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APPENDIX III

CENTRAL PLANNING DEPARTMENT

Cable: "CEPLAN" Phone: 21-366

P.O. Box 827 *Nuku'alofa* *Tonga*

Our Ref: 39/4/1-L520 9 October 1986

Mr Jon D Lindbong
Country Director
FSP
NUKU'ALOFA

Dear Jon

Please find attached a copy of my report on the final evaluation of the Ha'apai Water Supply project conducted from the 15-24 September 1986.

Yours sincerely

M Kaufusi
for/ACTING DIRECTOR OF PLANNING

Att

MK/lt

FINAL EVALUATION: HA'APAI WATER SUPPLY PROJECT

INTRODUCTION

During the period between July 1st, 1981 and May 31, 1985 F.S.P. with the assistance of Niuola Women in Development Association constructed 786 Water tanks in 21 villages on 15 Islands in the Ha'apai Islands. A final evaluation completed by F.S.P. and the Tongan Government in April 1985 found 630 of the total leak, 156 of the total with incomplete guttering, and a majority of tanks without proper taps and or covers to protect them from mosquitoes and contamination.

A project to maintain these tanks and other shortcomings of the water supply project was funded through a USAID Grant administered by the F.S.P. The final evaluation of the maintenance project was conducted from 15-24 September 1986 by representatives from F.S.P., the Ministry of Health, the Ministry of Works and Central Planning Department.

All the inhabited islands of Ha'apai Group were visited in the course of the evaluation with the exception of Mo'unga'one due to shortage of time. Good use was made of the Fisheries Division Vessel the M.V. Alhacore. By using this vessel it was possible for the evaluation team to move from island to island. Appendix I outlines the schedule followed in term of islands visited and number/type of tanks surveyed.

This report covers only the islands I visited except Kotu and Lotuhu where other members of the evaluation team visited. A total of 688 tanks were surveyed which included 230. 1000 gallons Zincalume tanks and 447 2250 gallon Niuola ferro cement tanks and 6 5000 gallon ferro cement community tanks.

Last heavy rain was in the early week of September 1986 for all the islands of Ha'apai.

Table I provides the comparative data obtained during the evaluation. It is noted that a number of tanks had incompleted gutterings. At the time of the evaluation, a number of tanks did not hold much water because they had small roof area and

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TABLE I: NUMBER OF WATER TANKS SURVEYED

	Niuola Ferro Cement Tank 2250 Gallons	Zincalume Tank 1000 Gallons	W.V.O. Modular Tanks	5000 Gallons Community Tanks
1. Number of Tank surveyed	447	230	5	6
2. Number of Gutters completed	421	215	5	5
3. Number of Gutters incompleted	26	15	0	1
4. Number of major leak tanks	44	29	3	0
5. Number of minor leak tanks	190	140	2	2
6. Number of tanks uncertain	37	16	0	0
7. Number of tanks no leaks	176	45	0	4
8. Number of consumers	2,593	1,436		
WATER LEVEL OBSERVED IN TANKS				
1. Number of tanks empty	27	15	2	0
2. Number of tanks ¼ full	154	73	1	0
3. Number of tanks ½ full	103	69	0	0
4. Number of tanks ¾ full	67	34	0	0
5. Number of tanks full	96	39	2	6
1. Number of tanks abandoned	15	8		
2. Number of tanks have small roof area	33	11		
3. Number of tanks have no good gu gutter	39	8		

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APPENDIX I

ISLANDS VISITED AND TANK SURVEYED

15 September 1986

Nomuka Island - 53 Zincalume tanks

16 September 1986

Nomuka Island - 4[illegible] Zincalume Tanks
'O'ua Island - 24 Zincalume tanks

17 September 1986

Mungua Island - 62 Mwola Ferro Cement tanks
Ha'afeva Island - 64 Mwola Ferro Cement tanks

18 September 1986

Fotuha'a Island - 20 Zincalume tanks
Lofanga - 51 Zincalume tanks

19 September 1986

Pakakakai Village - 35 Mwola Ferro Cement tanks
2×5000 gallon cement tanks

Fukotala Village - 20 Mwola Ferro Cement tanks

Ha'ano Village - 41 Mwola Ferro Cement tanks
2×5000 gallon community tanks

Muitoa Village - 19 Mwola Ferro Cement tanks
2×5000 gallon community tanks

20 September 1986

'Utula Village - 53 Mwola Ferro Cement tanks
Pelenea Village - 61 Mwola Ferro Cement tanks

22 September 1986

Koulo Village - 34 Mwola Ferro Cement tanks
Holopeka Village - 29 Mwola Ferro Cement tanks
1 WWC Modular tank

Fangai Village - 3 Zincalume tanks
4 WWC Modular tanks

23 September 1986

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Despite the fact that more tanks of both the Niuola and the Zincalume tanks were found to be leaking, a majority of both these types were observed to hold between a quarter to a completely full tank of water.

Attempts by Niuola to patch the leaking tanks were observed. In general attempts to patch the Niuola ferro cement tanks and Zincalume tanks appeared to be unsuccessful. The reason for this unsuccessfulness is due to their maintenance procedure. It was reported by the people that the maintenance procedure for Niuola ferro cement tanks was to dig up the tank and spray it with dry cement and then put back the tank. The placing of the tanks caused cracks at the bottom and the sides. At Koulo the tanks were emptied and the insides were plastered. It is obvious that the maintenance procedure done in Koulo is better than the other villages as the number of tanks there were full and not much leaking occurred.

In the case of Zincalume tanks the majority of leaks were on the side seams and the bottom edges of the tanks. Their maintenance were done by each households. This job was not properly carried out because they did not have enough skill to repair the tanks and the other materials they used like cement etc. could not adhere properly to the metal tank.

Regarding the W.H.O. designed tanks, five of them were surveyed. Three of them were found to have major leaks and the other two with minor leaks at the bottom joint seams. These faults indicate insufficient tension steel application and the concrete was not well mixed with sand.

A major concern relative to both Niuola and Zincalume tanks was the missing nuts from the tap. It was reported that pigs rubbed them so these taps are patched with rags and water are collected from the top of these tanks. Some of these tanks also lack lids to seal the hole at the top to prevent animals and insects etc. from polluting the water.

Another problem relating to both types of tank was the lack of air vents which prevent [illegible] from the conditions of

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guttering. Many tanks could have held more water if greater attention had been given to guttering and providing a big water catchment area.

5000 gallons community ferro cement tanks. Six of these tanks were surveyed and four of them were forward to be full with complete guttering. One of them has minor leaks and the other one was not able to hold water. These tanks appeared to be providing a good back up of water supply to the village in which they are located.

CONCLUSION

Overall, it is felt that the Ha'apai Water tank construction project has substantially improved the rain water supply storage capacity in the Ha'apai Island and the goal of maintaining Niuola ferro cement tanks, Zincalume tanks and W.H.O. Modular tanks has therefore been well surpassed. However, the major problem faced is that the maintenance lacked proper supervision, so the people did not have enough skill to repair their tanks.

Therefore, despite the efforts made to correct the faults of the water project it can be seen that a majority of the repaired/maintenanced tanks still have the same problems as before eg. leaking, incomplete guttering. Lastly, eventhough the maintenance project is not satisfactory, water tanks should not be viewed as a discrete activity which is now complete. There is a need to follow up to ensure tanks are properly repaired if possible.

RECOMMENDATION:

1) That further investigation be carried out to determine the best means of repairing tanks (Zincalume, Niuola and W.H.O.)

2) An appropriate technician be provided to visit Ha'apai

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3) For further similar water projects, the choice of the implementing agency should be carefully done in order to avoid similar problems faced by the Ha'apai Water Supply Project.

APPENDIX IV

REPORT OF THE FINAL EVALUATION OF HA'APAI RAINWATER SUPPLY PROJECT: September 15-23/, 1986.

******

Sepeti.A.Kauvaka
Public Health Inspector
Environmental Health Section
MINISTRY OF HEALTH.

"""""""

Introduction

The purpose of the Ha'apai visit was to view first-hand each rainwater tank that has been constructed by N iucla Group under US Aid through FSP, so it could then be accurately assessed how effective the project had been.It also provided an opportunity for the evaluators to seewhat the situation was on each island in terms of availability of fresh water.

Methodology.

1.The Fisheries Department's fishing vessel, MV Albacore, was hired by the FSP as the means of conveyance to the islands.
2.Town officers ,District officers and the Ha'apai Group, in general, were notified of this visit over the air.
3.Each and every tank constructed under the FSP Project was visited by the team including the Fangale'ounga Well Water Scheme.
4.Special attention was given to:
- number of tanks per island or village.
- number of consumers.
- condition of gutterings.
- amount of water present in tanks on date of inspection.
- size of catchment area.

5. Informations were obtained from householders and tank owners regarding the project and local experiences.
6. In order to catch up with the programme scheduled it was necessary to split the team into two groups when inspecting Kotu-Matuku and Tungua-Ha'afeva.
7. Data collection, analysis and report writing.

Result

(Presented in table form as attached).

Discussion:

The eva luators were consisted of 6 representatives from various government departments and organizations, that is , Ministries of Health and Works(1 from each), Central Planning Department (1),Foundation of the Pe ople of the South Pacific (2) and The World Health Organiz ation Sanitary Engineer.

Villages/Is lands visited were :

Nomuka	
'O'ua	Kot u
'Uiha	Matuku
Fe lemea	Fakakai
Kolo	Pukotala
Holopeka	Ha'ano
Pangai	Muitoa
Hihifo	Mango
Lofanga	Fonoifua
Fotuha'a	

Mo'unga'one and Tofua were not visited by the team because of the problems of accessibility.

There were 747 rainwater tanks examined of which 280 were made of Zinc-alum (corrugated iron sheets) each of about 2 000 litres , 447 Niuola ferrocement tanks each of about 3 000 litres , 6 community ferrocement tanks each of about 5 000 litres and 5 WHO square tanks which were built at the beginning of the programme but due to the high technological knowledge required for their construction they were ruled out of the program e.

The conditions of the tanks varied from one island to another owing to (1) the level of technical knowledge available,
(2) community participation,
(3) and good tank keeping after the construction.

Technical know ledge available were supplied only by the construction group-- The Niuola.

Community participation differed from one island to another and various status of tanks existed , that is, some tanks were riddled with minor leaks but others either had major leaks or waterright that they were full.

1. ZINC-ALUM RAINWATER TANKS:

The average number of consumers for each tank was about 6.1 . The estimated total amount of water present in the tanks during the visit was about 60 000 Impe rial gallons but if all the 280

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tanks were full they would have held a total quantity of 130 000 Imp. gallons. Therefore only 46.2% of the total capacity of the 289 tanks were available on the dates of inspection. It should be remembered that there are other tanks privately built by some homes and most of them are better than the zinc-alum tanks and therefore they are more frequently used by the householders, respectively.

The problems met with were as follows;

(1) Leakages were due to weaknesses or insufficient glue applied at the seams, both on the side and the base.

(2) Strainers and downpipes are not easily removed for cleaning purposes.

((3) Some gutterings were either incomplete (7.6%) or marked "bad" (3.8%) due to the non-existent of glue on the edges of the gutterings therefore they could not fully their purposes.

(4) Some taps were broken either by carelessness of the owners or damaged by roaming livestocks, pigs for instance.

(5) Most tanks had no drainage system(Pit) under the tap in which spilled water could collect at and seep into the soil.

(6) Most of the tanks had no fence around the tap to keep away roaming livestocks which account for many damages done to taps and mud pools which are environmental health hazards.

(7) No tank had any mosquito net to cover the inlet opening (strainer seat) to prevent the entrance of adult mosquitoes and the exit of newly developed adult mosquitoes. A health hazard.

(8) Some people don't seem to give any extra care or do any improvement to faulty tanks.

(9) Most homes never clean out the leaves and dirts from the gutterings.

2. 'NIHOLA' FERROCEMENT RAINWATER TANKS:

The average number of consumers for each tank was about 5.8. The estimated total amount of water present in the 447 tanks upon inspection was about 150 000 Imp. gallons in which if

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Therefore , on the dates of inspection only 50% of the total tanks capacity was available in tanks for use. Once again , other tanks privately constructed in homes were also in use.

The problems found concerning ferrocement tanks were as follows :

1. Bad gutterings, that is, brackets were not glued together in some homes (8.7%) and some were just incomplete(65.1%).
2. Only a small number of tanks had mosquito screens on the strainers in which to prevent the access of mosquitoes.
3. Some tanks had no covers for the inspection hole at all, thus allowing leaves and dusts into it.
4. Some had broken taps and some had no taps at all but draw water by using ropes-buckets through the top inspection hole, however, this is a very insanitary method of drawing water. A health hazard.
5. About 2 tanks , as in 'Uiha, had large holes on the side that they could not hold any water and are totally rejected. Wall was too thin for such a large tank to hold a large amount of water.
6. Suspected leaks (major) at the bases which is proved by the quick loss of water from them just after heavy rains.
7. Most gutterings were cleaned of leaves , dust and dirts.
8. Some tank owners never seem to improve minor faults in tanks.
9. Some tanks are not levelled and/or symmetrical.

In general , both zinc-alum and ferrocement tanks had been by far poorly constructed and poorly maintained.

Therefore I recommend the followings:

1. That future aid programmes should be carried out by a more reliable and higher technological construction enterprise.
2. That FSP officials hold village meetings with local formal and informal leaders prior to any aid programme of such type.
3. A Public Health Inspector would play a major role in organizing the people, technical advisory, maintenance and environmental health inspection.
4. Other than providing part of the labour the people should be given a portion of the total expenses to pay it themselves so that they would feel that they have earned it on their own thus very carefull in construction and maintenance.

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5. The existing faulty tanks should be repaired before further aid project begin.

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TABLE: FINAL EVALUATION OF THE HA'APAI RAINWATER SUPPLY.

Type of tank	Consumers	tanks surveyed	Consumers per tank	LEAKAGES Major No.	Major %	Minor No.	Minor %	None No.	None %	Uncertain No.	Uncertain %
Zinc-alum	1776	289	6	38	13.1	175	60.6	57	19.7	19	6.6
Niuola ferro-cement.	2593	447	6	44	9.8	192	42.9	176	39.4	35	7.9
5 000 comm.	open to public.	6	open	nil	0	nil	0	6	100	nil	0
WHO	open to public.	5	open	3	60	2	40	nil	0	nil	0

Type of tank	QUANTITY Empty No.	Empty %	1/4 No.	1/4 %	1/2 No.	1/2 %	3/4 No.	3/4 %	Full. No.	Full. %
Zincalum	24	8.3	103	35.6	83	28.7	38	13.1	41	14.3
Niuola ferro-cement.	26	5.8	154	34.5	103	23.0	68	15.2	96	21.5
5000 comm.	1	16.7	nil	0	nil	0	nil	0	5	83.3
WHO	2	40	1	20	nil	0	nil	0	2	40

Type of tank	GUTTERING Complete No.	Complete %	Incomplete No.	Incomplete %	Bad guttering No.	Bad guttering %	Small catchment No.	Small catchment %	Tanks abandoned. No.	Tanks abandoned. %
Zincalum	267	92.4	22	7.6	11	3.8	19	6.6	8	2.8
Niuola ferro-cement	21	94.2	26	5.8	39	8.7	33	7.4	15	3.4
5 000 comm.	6	100	nil	0	nil	0	nil	0	nil	0
WHO	5	100	nil	0	nil	0	nil	0	nil	0

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APPENDIX V

EVALUATION OF THE HA'APAI WATER SUPPLY PROGRAMME

14 - 23 September, 1986.

By

Richard Stoll
WHO Engineer

26 September, 1986

Evaluation of Ha'apai Water Supply Programme

1. Introduction

An Evaluation of the F.S.P. water tank programme was conducted from 14 to 23 September, 1986. The purpose of the evaluation was multiphasic. It was a final evaluation of the construction of more than 700 tanks to determine effectiveness of water supply increase to local island populations, the state of repair of individual tanks and gutters, and the integrity of individual tanks after construction.

The survey team included representatives from FSP, MOW, Central Planning, MOH and the WHO engineer as a technical resource. The villages visited specifically by the WHO engineer were as follows:

- Nomuka
- O'ua
- Kotu
- Matuku
- Lofanga
- Fakakakai
- Pukotala
- Ha'ano
- Muitoa
- 'Uiha
- Felemea
- Koulo
- Holopeka
- Pangai - Mihifo

Islands and villages not surveyed by the WHO Engineer included:

- Mango
- Fonoifua
- Moungaone
- Fotuha'a
- Tofua

Of these latter islands only Tofua and Moungaone were not visited by any members of the team because of access problems. The reason the WHO engineer was not able to visit the remaining 3 village was that it was necessary to split the team in order to complete the survey. Nevertheless, the WHO engineer was able to personally inspect over 500 tanks on 15 villages spread throughout the Ha'apai islands.

The survey was very useful and informative. Not only did it afford a close look at water supply problems throughout a large portion of Tonga, but it afforded a first hand look at environmental health conditions, an opportunity very few aid agency expatriots have had.

In this regard the information gained was striking and at times unexpected. Therefore, this report will encompass somewhat more than water tank evaluation information. Included will be considerations, factors and opinions as to the state of individual villages with regard to both environmental health and past and potential aid projects. Such information is enhanced by the fact that the WHO engineer did surveys of the same islands and villages some 8 year ago. Comparisons can be made.

II. Water Tank Evaluation

Two types of tanks were built under the programme. A zinc-alum corregated tank of about 750 imperial gallon capacity and a ferrocement tank of about 2250 imperial gallon capacity. These were all installed on individual homes taking advantage of available roof catchment for rainwater. At the beginning of the programme 8 WHO square tanks were built but these proved impractical due to the high level of technology needed and the logistics of transporting prefabricated panels.

The physical state of the tanks varied from village to village. The state of the tanks in any particular village depended on two factors; First, the adequacy of construction by the construction group assigned in a particular village; Second, leadership in the village with regard to tank maintenance and environmental health matters in general. Since construction groups consisted mostly of village people from each village where construction took place, adequacy of construction and maintenance were usually corollary.

Where construction was exceedingly poor maintenance was nearly non-existant. Those groups that were usually more careful in tank construction appeared also to have the incentive to maintain their tanks to the best of their ability.

The tanks will be discussed by construction type rather than by village although individual villages will be mentioned as appropriate.

A. Zinc-Alum corregated tanks.

Over 300 of these tanks were observed. Of these tanks more than half had significant problems related to either water catchment areas or their ability to hold water.

These tanks were constructed out of semi-circular corregated iron pieces galvanized with a zinc-alum coating. Construction was done on site by riviting the pieces together with calking between the rivited joints. The bottoms were crimped on with a calked seal and the tops were also crimped on. Guttering with downpipe was installed for each tank and strainers were installed on the top of each tank.

Although the riviting and crimping appeared adequate, most tanks had inadequate calking to make integral water seals. As a result most had at least some minor leaking and many would not hold water.

Attempts had been made to repair many tanks but repairs were done on the outside. The only way to adequately repair these tanks is calking from the inside.

Other problems frequently encountered included the following:

1. Strainers were not a self-cleaning and type easily removable. As a result many of the tanks were open, dirty inside and nursuries for thousands of mosquito larvae. Proper strainer maintenance was nearly non-existant in most locations.

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2. Gutters and downpipes, of a PVC type, were not glued together. As a result many had come apart and downpipes had fallen off. It became apparent also that the majority of individual owners did not bave the incentive or knowledge of how to adequately fit the downpipes and gutters back together. This resulted in many tanks being nearly empty.

3. A good number of tanks were misplaced. Either they were attached to roof areas so small as to provide inadequate catchment or they were installed on houses with good pre-existing tanks already in place. In a number of cases, provided gutters were re-routed to an old tank even though the new tank was good.

4. The water taps at the base were of poor design and many were broken. Although these are easily fixed, many owners did not care to do so or did not have the simple technical knowledge to repair them.

5. Practically no taps had drain pits below them. As a result many tap areas were very dirty and a severe environmental health hazard.

6. Most tanks were not level. Since these tanks hold nearly 4 tonnes of water when full the stresses on a non-level tank are enormous. This in itself can either cause leaking or exascerbate existing leaks.

7. Most tap areas were not fenced against animals and many tanks harboured populations of pigs around the tap areas in particular. Pig damage to tanks because of this was very great in places. Pig rooting had pushed many tanks off level and made the immediate area a pig wallow. This was particularly true with tanks that had leaks or had overflowed. Particularly on Nomuka, a large number of tanks were rendered useless and a severe health hazard because of pig damage alone.

8. Most individual owners appeared not to understand the need for cleaning gutters. As a result many were clogged and non-functional.

In general, it must be considered that metal tanks can only provide a very temporary solution to water supply. The lifespan of such tanks rarely exceeds 10 years. Many tanks, installed 4 and 5 years ago, were already coming to the end of their useful life. Rust had started. On Kotu, several tanks were observed with the bottoms completely rusted out. The extent of such rusting is unknown as it was not possible to observe the bottoms of most tanks.

It should be noted that most leaking tanks and gutters are easily repairable. Things could be done to extend their lifespan more than 10 more years. However, this would take funds, infrastructure, and close supervision. Most important, it would take village cooperation. Such cooperation, from observations made, could not be expected from many villages.

Of particular note is the island of Nomuka. Maintenance, and particularly owner responsibility was so poor that a great percentage of the tanks represent a severe public health hazard. They are much more of a liability than an asset. Many are degraded pig wallows and totally unsanitary. Many are dirty inside and are breeding areas for literally thousands of mosquitos. Although, Nomuka has an exceptional problem with their water tanks, such problems exist to some extent on all islands.

The island with the best tank maintenance is Kotu. This island is very clean and well governed. The people are, in general, highly conscientious and responsible with respect to their village surroundings and material possessions.

B. <u>Ferrocement Tanks</u>

Over 200 ferrocement tanks were observed. Approximately three-quarters of these had severe structural problems.

These tanks were constructed on-site without the use of forms by local village labour groups. More so than the metal tanks, the integrity of construction varied greatly from village to village. However, in no case were any individual group of tanks well constructed. They were very rough indeed. Ferrocement tanks were in villages on Lifuka, 'Uiha and Ha'ano.

All tanks were constructed with water taps at the bottom with the exception of those in Koulo and Holopeka. These had no water taps and were designed to be dipped from openings in the top.

Attempts had been made to repair many of the leaking tanks but repairs were inadequate. It is very difficult to adequately repair a tank of this type as they leak at stress points where cracks will also appear in repairs. In addition, without proper cleaning and chemical treatment new ferrocement will not stick to old.

Some of the problems frequently encountered with these ferrocement tanks were as follows:

1. Symmetrical and non-leveled construction. Round tanks depend on a very symmetrical shape and good levelling in order to withstand stresses. In the case of these tanks, they must withstand pressures of up to 10 tonnes of water contained within. Consistent shape was never maintained as levels and forms were not used in construction.

2. Many taps were broken and not repaired.

3. In many cases the tank roofs were flat and caving into tank. This was particularly evident on the island of Ha'ano.

4. Many gutters were misplaced on roofs, were broken or were non-functional for other reasons. In most cases there had been no owner attempts to repair these gutters. Gutters were in particularly bad shape on the island of 'Uiha.

5. Many tanks were placed on inadequate catchment areas and on houses with pre-existing good tanks.

6. Very few sieves or strainess were emplaced on the tops and the top openings mostly were not covered. Mosquito problems were a severe health hazard as a result.

7. Drains and fences were not placed around the tap areas. However, pig problems were not so great as with the metal tanks.

The island with the greatest ferrocement tank problems was 'Uiha. This was reflected in general village conditions as a whole. The best tanks were in Koulo and Holopeka, close to Pangai, the center of construction operations.

c. Ministry of Health Ferrocement tanks

As a comparison, and for interest, the WHO engineer did sample viewings of these tanks in the Pangai - Hihifo area. Generally, these tanks looked very good as they were constructed symmetrically with forms. However, there appears to be two major problems associated with them.

First, no straining devices were included and most downpipe empty direct into the tanks. Rubbish, dirt and leaves directly enter these tanks from the roofs. Second, and more severe, there appears to have been a design flaw with regard to the wall-to-foundation connection. The walls appear to extend down around the base rather than being adequately tied into it. As a result, unremirable leaking was discovered at wall-base joints, the places that are subject to heaviest stresses. The extent of this leaking is not known at this time. However, with such design leaking could appear at any time in previously integral construction. Further evaluation will need to be done regarding this as it may be a very serious problem indeed.

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III. General Comments regarding individual 'api Water Tanks in Ha'apai and Recommendations.

First, it must be said that this programme has not been successful. In fact, on some islands including 'Uiha, Nomuka, Matuku and others, the tanks are more of a liability in environmental health terms than an asset. They are infected with pigs and are ideal large mosquito breeding areas. The water recepticle areas are unsanitary and places for easy transmission of parasites and diseases.

The reasons for this can not be attributed to any one agency or group. There were inadequacies on all sides, extremely exascerbated by the attitudes of local people regarding maintenance and sanitary conditions.

Although the programme is now irretrievable there is much to be learned from it. Some of the things that the WHO engineer thinks are most important are as follows:

A. Rectification of existing problems

1. If funds and infrastructure can be found, repairs particularly on the metal tanks should be made. In this eventuality the WHO engineer will be glad to make specific recommendations as to how these repairs should be conducted.

2. Health inspectors should be dispatched to these islands as soon as possible to strongly tackle the environmental health problems associated with these. Bi-weekly follow up should be made to make sure these problems are taken care of post-haste.

3. Where tanks are unrepairable or owners uncooperative, the tanks should emptied, sealed and quaranteened Otherwise they should be destroyed to the point where there no longer hold any water and present no further health hazards.

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4. Pigs were the biggest single problem related to metal tanks. Particularly on Nomuka, but not only this island, the conditions related to pigs and water were untolerable. Immediate steps should be taken to control pigs for this and other reasons.

5. Individual owners should be absolutely required to do the following:

   - Seal the tank tops
   - Keep integral sieves always in place
   - Put drains below the tap areas
   - Fence the tap areas
   - Use only taps for water retrieval, not open tops and buckets.
   - Keep their tanks and gutters in good repair.

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B. <u>Consideration for future programmes</u>

1. It does not appear that individual owners on outer islands may be responsible enough to maintain their own water tanks in a healthy and functional condition. Additionally, it was noted that with these tanks water reserve and conservation considerations were non-existant in most cases. Therefore, MOH should strongly re-consider initiated community water supply programmes with community rather than individual water tanks. This has both very strong health implications as well as water supply for dry period considerations.

2. Before any more water tank programmes are initiated, thorough 'api by 'api surveys should be conducted by both the project coordinators and MOH to determine exactly where to put each tank and how to install it.

3. An educational programme of some sort should accompany any water tank installation and clear sets of instructions should be required to be posted in the 'api as to use procedures and [illegible]

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4. All construction design should be reviewed in detail by a person exceedingly familiar with water tank construction and operation in Tonga.

5. Every tank constructed should be thoroughly inspected by a qualified individual before it is released for use. This should include HOH. Inadequate tanks should be destroyed as they cause severe health hazards.

6. All water tank construction should be done by individuals or construction groups with demonstrated ability in water tank construction.

7. All tanks and supplies such as guttering should be of standard design and specifications and all materials should be locally available. This will make potential repairs much more possible.

IV. General Comments regarding aid projects in outer islands in general

One of the notable things on the islands visited was the profusion of aid projects. Nearly every family was a recipient. Included were hurricane houses, fences, stoves, bathroom improvements, kitchens and water tanks.

Even with all of this, it was obvious to the WHO engineer that environmental health conditions on many of the Ha'apai island have severely deteriorated over the past 8 years. The reasons for this are not entirely clear but may have to do with such things as emmigration to urban centers of the more ambitious individuals as well as the expectation of the remainder that government and aid programmes will take care of their needs. Of notable exception were Kotu and Lifuka.

It is natural then, that aid individuals observing this would have doubts about the nature and conduct of aid programmes in such areas. Somehow attempts to help people should include expectations that incentives are increased for the recipients to help themselves to a greater degree. It is not obvious that this is happening on some of the Ha'apai outer islands, rather, the converse.

Many of the people the WHO engineer came in contact with had definite expectations of more gifts and had no hesitation in asking for such.

There is no question that needs are real and apparent. Approaches to have these problems rectified, however, need some serious reconsideration and new approaches need to be taken.

It is the opinion of the WHO engineer that possibly much aid should be directed from strictly physical appurtenances to educational and self-help programmes. In many ways, the quality of life and environmental health on the outer islands can only be accomplished through the local people, not in spite of them.

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