Water Supply and Sewerage Development.

(Cook Island, New Zeeland).

Assyment Report

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World Health Organization

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ASSIGNMENT REPORT

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by

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Title of project	:	Environmental health engineering advisory services
Geographical location	:	Rarotonga, Cook Islands
Participating agencies	:	Government of Cook Islands United Nations Development Programme World Health Organization
Subject	:	Water supply and sewerage development
Form of assistance	:	Advisory services
Staff	:	WHO Sanitary Engineer United Nations volunteers Government counterpart
Source of funds	:	UNDP
Duration of project	:	1973 - 1976

1. INTRODUCTION

1.1 General

The Government of the Cook Islands submitted a plan of operation for an environmental health engineering advisory services project to UNDP, with request for assistance. The proposal was approved on 28 February 1973 and WHO was appointed as Executing Agency. To meet the objectives of the plan of operation, WHO appointed a WHO sanitary engineer and the field work started on 29 July 1973. Two United Nations volunteers, a draftsman and a surveyor-technician, were included in the project.

1.2 Objectives

The objectives of the project were specified in the plan of operation approved in 1973, as follows:

1.2.1 Long-range objectives

The Government's long-range objectives are:

(a) to carry out a programme to improve the Rarotonga water supply system;

(b) to develop a storm drainage and sewerage system to serve Avarua;

(c) to carry out a programme to construct rural water supply facilities;

(d) to carry out a control programme to improve environmental health and the prevention of pollution.

1.2.2 Immediate objectives

The immediate objectives of the project are:

(a) to prepare engineering plans for a programme to improve the Rarotonga water supply system, so that it will meet accepted health standards and provide adequate water service, and to assist the Public Works Department to initiate implementation of the plans;

(b) to develop a plan for a sanitary sewerage system for the town of Avarua and contiguous areas;

(c) to prepare plans and/or give advice for the construction of water supply and sanitary systems for public and industrial/commercial facilities;

(d) to develop standards for sanitary facilities for public and private buildings;

(e) to develop surface drainage plans to ameliorate the flooding problem of the town of Avarua;

(f) to draw up plans for the development of water supply and excreta disposal facilities on the outer islands which may qualify for UNICEF assistance;

(g) to carry out other surveys and develop general programmes for the improvement of environmental health and the prevention of pollution.

1.3 Investment potential of the project

Based on the findings of the Tripartite Review Meeting on the project, at which United Nations Development Programme, World Health Organization and the Government of the Cook Islands were represented, a project revision form was approved on 11 December 1974. Some of the activities were extended and the project was expanded to include activities specifically defined as follows:

(a) preparation of plans for the improvement of Rarotonga water supply;

(b) preparation of plans for a sewerage scheme for Rarotonga;

(c) preparation of plans for sewage treatment and disposal;

(d) preparation of a storm drainage plan for Rarotonga;

(e) development of a rural water supply project and design;

(f) study of general environmental health and water pollution problems and development of a control programme;

(g) development of sanitary standards for physical facilities;

(h) provision of sanitary engineering services.

1.4 Methods

Engineering and hydrogeological survey was carried out, with collection of information for design, topographical mapping and surveying, to ascertain the existing position and to prepare proposals and plan designs for development and improvement of sanitary facilities and environmental health conditions.

Proposals with plan designs were submitted for the improvement of Rarotonga's water supply. Much has been accomplished in the preparation of proposals with plan designs for sewage collection, treatment and disposal and for a storm water drainage system. Plan designs were submitted for: (i) a cassion well for the Aitutaki water supply, which was also constructed; (ii) a sewage treatment and disposal plant for the Tepuka sewerage system. A proposal was submitted with regulations for construction of a public cemetery.

There was participation in different committee meetings when the State policy was formulated for development of water supplies, waste disposal and environmental protection.

Discussions were held in the Ministry of Foreign Affairs, Ministry of Works and Ministry of Health in New Zealand in connexion with the construction of the water supply for Rarotonga and improvement of other sanitary facilities of the Cook Islands.

Two plumber technicians were sent overseas to qualify for operation and maintenance of the future water supply and sewerage system.

2. ACTIVITIES

2.1 Preparation of report: plans on proposal for improvement of the Rarotonga water supply

Rarotonga's water supply system has been under construction for about 50 years. Put together in many stages and initially in different sections, it has been continuously extended. In 1961 the system consisted of three parts:

(a) the water supply of Avarua and Arorangi consisted of a distribution main connected simultaneously by feeding from three intakes: Takuvaine, Avatiu and Muriavai (Arorangi).

(b) The water system for Matavera, Ngatangiia and Muri consisted of a distribution main connected with a feeder main from the Turangi intake.

(c) The Titikaveka water supply consisted of a distribution main along the main road connected to the intake Totokoitu (Titikaveka) by a feeder main. During the last 15 years, the system was further developed on recommendations of different experts. At present it is composed of a distribution ring main with loops intermittently connected all around the island, fed by feeder mains from six intakes with different elevations supplying water of different quality and quantity.

In order to evaluate the existing system, a survey was carried out to locate the different parts and produce the required plan. The survey results were plotted on a non-topographical map in the scale of 1:7920.

2.1.1 Design criteria (Annexes 1 and 2)

The Government of the Cook Islands requested that the future water supply system should meet the demand of 25 years of economic development. The expected population, the development of communal facilities and services, the tourist, agricultural, transport and the industrial developments were determined (Annex 1).

Considering the estimated population, the national, cultural, economic, geographical, climatological and other factors, it was accepted that water demand for domestic needs would be 250 l/c/d with a maximum demand ratio factor for peak consumption of $K_o = 2.0$.

Seven fire-fighting hydrants, each with a capacity of 2.5 l/sec. and 15 m water pressure, were requested for Avarua.

For the cool store and the government freezer, the water consumption is variable. There is no water metering and it is difficult to make an estimate. The best guess is that about 11 500 m^3 per annum are used. It is proposed that the cool store and the freezer be supplied from the present Island Foods water supply which, it is envisaged, will be connected to the municipal system.

The electric power supply uses around 12 000 m^3 water per annum and the new plant is envisaged as an independent water supply.

The available data of the water sources were studied and in addition, brief observations were carried out to determine the required data. The available data were not sufficient for assessments, but the results from 1950-1951 could be accepted as being fairly applicable to most dry years. From the studies made on the water sources, it has been decided to construct five infiltration galleries in the terrace flats of the different streams dispersed around the Islands, at the following sites:

(a) Avana with yield about 3860 m^3/d;

(b) Avatiu which is expected to produce about 2730 m^3/d;

(c) three more galleries are envisaged in Takuvaine, Turangi and Papua Streams, each one expected to produce around 2730 m^3/d.

The quantitative balance for the expected production from the selected intake sites and the estimated water demand for the design period of 25 years for the ten districts is as follows:

	Intake yield m^3/d			Consumption m^3/d
1. Takuvaine	2730	I	Tutakimoa	963
2. Turangi	2730	II	Takuvaine	3 385
3. Avana	3860	III	Ngatipa	681
4. Papua	2730	IV	Tupapa	641
5. Avatiu	2730	V	Matavera	536
		VI	Ngatangiia	1 060
		VII	Titikaveka	1 167
		VIII	Arorangi	2 641
		IX	Nikao	1 050
		X	Ruatonga	1 700
Total	14 780 m^3/d	Total		13 824 m^3/d

The data on water quality in the distribution system are available as from 1961, showing contaminated water from the different test points and indicating the existence of secondary pollution in the reticulation system. There is not an established practice of routine periodic chemical and bacteriological examinations. With the exception of the areas supplied from Avana intake, the rest of Rarotonga is supplied with no potable water which is a potential danger for the spread of water-borne diseases.

Considering the data of water sources and distribution of water consumption, it is suggested that four independent functioning zones be established with the possibility of being inter-connected if necessary.

(a) The first zone includes all districts from Ruatonga clockwise to Avarua bridge with a total demand of 6524 m^3/d. This zone will be supplied from Takuvaine and Turangi intakes, providing a combined water quantity of 5460 m^3/d. The difference of 1037 m^3/d will be covered from the second zone which has higher pressure and excessive water quantities.

(b) In the next zone are included the consumers from Muri until Avaavaroa, demanding 1909 m^3/d water. This will be supplied from the remaining water flow of 2823 m^3/d from Avana intake. The excessive flow of 940 m^3/d is transmitted through this zone in order to be made available for the fourth zone when required.

(c) The third zone includes only the district of Arorangi demanding 2641 m^3/d and can be satisfied from Papua intake with expected quantity of 2730 m^3/d.

(d) The last zone includes the district of Nikao and Ruatonga, with a total estimated water consumption of 2750 m^3/d. It is expected that after the rehabilitation of the Avatiu intake it will produce 2730 m^3/d and principally supply the consumers from this zone. Considering the importance of the airport and the Avatiu harbour, an additional flow of 605 m^3/d is available if required. In such a way it will be possible to satisfy an additional demand in both directions around the island when required.

In the light of the estimated water demand and the expected yield from the selected intakes, the map from the survey on the existing water supply system was studied. It was concluded that for most of the sections, mainly along the Ara Metua Road, new distribution mains with adequate size are required to satisfy the consumers along the road and transmit the required quantities from the intake sites to the area with a higher demand.

2.1.2 Proposals

The improvement scheme goes no further than the distribution mains. Any local and private connexions have been disregarded as forming part of what could be called reticulation, which would be extended in relation to the future development of the communities and land settlement. The last mentioned factors were considered when the proposed new distribution mains were located (Annex 3). To better describe the required fittings, the type of junctions and all required data for the new pipelines, in the absence of a map in the appropriate scale, it was decided that the traverse of each section be plotted in one plan drawn in scale 1:2000, together with a profile of the same section in scale H/J = 1:2000/1:200. The above scale was selected as more suitable for the future works, when the expected new topographic map for Rarotonga in scale 1:2000 is completed. The parameters from the hydraulic calculation are also plotted on the profile plan for the respective sections.

(a) Feeding mains - The 8" fibrolite pipeline, recently completed, from Takuvaine intake to Ara Metua Road is of the required size. But in order to transmit a peak water flow for the respective area, where there is a connexion with the envisaged storage tanks, the size of the last portion of 328 m must be increased to 10". Hydraulic calculations for this reconstruction are made in a way to ensure flow from Takuvaine intake to the reservoirs in the period of low consumption and simultaneously to guarantee an excess pressure of 15m to the remotest parts of this zone (Napa's Store and Avarua harbour) during the period of peak consumption, plus fire flow.

The feeding main of 6" fibrolite from the present Takuvaine intake is not enough and another 8" fibrolite pipe must be installed parallel to it, in order to transmit the expected flow from the new gallery system with adequate water pressure to fill the storage take located above the Avarua bakery and cover the peak water flow demand for the area of Pue-Avarua.

The existing feeding main (6" fibrolite) from Papua intake will be used only partially - from the intake to the location around 400m below the storage tank and pumping station. From the pumping station a 10" pressure main is required.

The Avatiu feeding main is relatively small (6" fibrolite), but there is enough head for transmission of the designed water flow. In the low part of the Avatiu Valley a storage tank is introduced and as a result another 675m long 8" fibrolite pipe must be installed in order to cover the adequate hydraulic parameters for the peak flow water demand.

At the lowest part of the old feeding mains, Venturi meters must be installed to enable better operation of the system.

All roads leading to the selected intake sites have to be improved to ensure better maintenance for the pipelines and the intakes. Special attention is required for the improvement of the road leading to Avana and Turangi intakes. In addition, some 150m downstream from Turangi intake, a bridge must be constructed.

(b) Distribution mains - The new distribution mains are located along the Ara Metua Road for two reasons. In the first place it offers a good hydraulic position and secondly expansion of the residential areas now and in the future will be mainly in this area.

In order to satisfy the demand along the road and to transmit the required water flow towards much more needed areas of Avarua, an 8" distribution main is designed along the Ara Metua Road beginning from the Three Stones in Ngatangiia leading up to Goldey's in Pue. At Vaenga, Matavera and F. Goodwin's along the road the distribution main is connected to the respective areas. At Avarua bakery an 8" fibrolite branch is designed to connect the storage tank.

Another distribution main is connected at I. Continuing, the same pipeline is enlarged to an 8" fibrolite pipe and connected to the distribution pipe in Titikaveka behind the church. From there after leaving the existing Ara Metua Road, the 8" pipeline continues to the storage tank at Papua.

The longest new distribution main begins at Papua pumping station, running all the way along Ara Metua traverse and Ara Metua Road to the storage tank at Pokoinu near the hospital.

In order to ensure convenient operation and normal functioning, a number of valves, air valves, etc., are to be installed as required. It was requested that screwdown hydrants, which have multiple purposes, be installed at wash-outs.

(c) Storage reservoirs - To meet the peak water consumption and to store the required fire reserve for Avarua, ten shortage tanks are proposed and located accordingly in the established zones to balance the water system. No studies are carried out for determination of daily peak consumption, but considering the characteristics of the envisaged future development, storage volume of 30 per cent. of the total daily demand is accepted. This requires a capacity of 4150 m^3 to be stored in ten storage tanks each with a volume of 455 m^3. Eight will be constructed to meet the requirements of the first stage of development and two later for the end of the design period.

The reservoir sites are selected to be as close as possible to the demand area and to ensure flow from two directions during the peak consumption. The elevations of the different storage tanks are calculated so that the tanks will be filled up when the supply exceeds the demand and emptied when the demand exceeds the supply, ensuring an excess of 15m water pressure to all points of the system.

Braithwaite's pressed steel tanks (UOFOD) are selected, each with a total volume of 457m^3, floor size 10.98 m x 8.54 m and depth cover of 4.88 m.

The number of the storage tanks for each zone is selected in accordance with accepted percentage of its total daily demand and distributed accordingly.

(d) Pumping - The site of the Papua infiltration gallery is very prospective and it is also at the closest possible source to Arorangi, the second most water-demanding zone after Avarua. The only disadvantage is that the elevation of the projected gallery will be only 35m above sea level, not enough to gravitate the required flow to the consumers of Arorangi. The required pumping station is not big, but will allow better flexibility in operation of the system in transmitting water flow around the island to the sites where additional water is required.

For selection of the required pumps, two regimes of work are recommended. First, during the hours of low consumption for filling up the storage reservoir at Pokoinu and, second, during the hours of peak flow in order to balance with the reservoir and to ensure the required existing water pressure of 15m in the selected consideration point. The required pumping data are as follows:

Q min. = 33.58 l/sec. - Pressure of P_1 = 45.57m

Q max. = 46.87 l/sec. - Pressure of P_2 = 44.08m

Three pumps are selected, two of them work in series, with one as reserve. They are from Southern Cross machinery catalogue, page 59, "N" series, centrifugal pump type NH-E, with 25 H.P., three-phase drip-proof induction motor, page 52 of the same catalogue. The required fittings for the installation and the requirements for the construction of the pumping station are included in the plan.

The required electrical equipment and installation has been coordinated for supply and installation with the Department of Electricity and Power Supply.

(e) Disinfection - For disinfection, liquified gas chlorine is recommended in respect of the present water supply. In order to safeguard against secondary contamination, a concentration of at least 0.2 p.m. free residual chlorine is required at the remotest position of the distribution system. Five chlorination points are introduced to the water supply system, located at easily accessible places along the feeding mains leading down from the intakes, designed to ensure an adequate contact period.

Considering the existing conditions for operation and maintenance and the supply and storage of the chlorine products, the Advance Gas Chlorinator System is recommended. The capacity of each chlorinator must be in the order of 3 - 6 kg/ 24 hours of chlorine feed in accordance with the expected water flow from the intakes. Model 201 Direct Cylinder Mounted General Purpose Unit will be adequate for this purpose. One chlorinator is envisaged for each of the feeding mains from Takuvaine, Turangi and Avatiu intakes. For Papua, three chlorinators of the same model are envisaged, but with the Advance Remote Control System.

2.1.3 General

Sanitary protective and fenced zones should be established to cover at least 15m radius around the intake construction. The area should be free from plants with deep roots. In addition, the larger area around should be marked off with warning signs to limit use.

An area of 15m around the storage tank structure must be equipped with wire fencing.

The Public Health Department should determine the points required for bacteriological and chemical examination. At least 40 samples per month should be collected for bacteriological examination, for each of the established zones. At least one sample every six months should be carried out for short routine chemical examination. Complete chemical examination should be carried out once a year. For further information, see the WHO International Standards for Drinking Water.

2.1.4 Construction programme

In order to improve the existing conditions as soon as possible and satisfy first the most needy areas, the following stages are recommended.

(a) The first stage includes the 100 000 I.G. storage reservoir at Avatiu Valley and the 8" fibrolite pipeline 675m long, leading from the reservoir to the Ara Metua main. It could be constructed in three

months and this will increase immediately the pressure in the area of Nikao and Ruatonga which at present suffer very often from shortages of water. The capital cost for this stage is estimated at NZ$36 196.

(b) The second stage includes the pumping station at Papua, Papua storage tank, Pokoinu storage tank and the distribution main along the Ara Metua Road from the pumping station to Pokoinu storage tank. This stage should be completed as soon as possible because this section will supply the new Rarotonga Hotel at White Sands, which is under construction. In addition Arorangi is the second biggest consumer after Avarua and at present it is not adequately supplied in quality or quantity of water from Muriavai intake. Ten months will be enough to complete the construction work on this stage. The capital cost for this stage is estimated at NZ$194 968.

(c) The third stage includes the construction of the three storage tanks (each of 100 000 I.G.) at Takuvaine, the 10" fibrolite pipeline 328m long leading from the storage tanks to the distribution main in the Ara Metua, one storage tank of 100 000 I.G. at Avarua bakery, the distribution main along the Ara Metua Road from the Three Stones to the bakery storage tank and the second 8" fibrolite main from the Turangi intake to the feeding main at the Three Stones. For completing the construction of this section, around nine months will be required. The capital cost for this stage is estimated at NZ$247 502.

(d) The fourth stage includes the new distribution main running along the Ara Metua Road from Taakoka to the Titikaveka storage tank of 100 000 I.G., located near the Papua pumping station. Around four months will be required to complete the construction of this section. The capital cost for this stage is estimated at NZ$101 852.

The construction works are envisaged to start at the beginning of 1976, and with the existing capacity it will take around 2.5 years to accomplish and put in operation the projected reconstruction of the water supply of Rarotonga.

2.2 Preparation of plans for sewerage and storm drainage schemes for Rarotonga

Sewerage and drainage of part of the area, though satisfactory from the local viewpoint, may result in unsatisfactory conditions elsewhere. In general the sanitation of the country can only be regarded as satisfactory if all communities in a catchment area are sewered and drained to the same standard.

Under the original plan of operation for the project dated 1972, the proposed assistance shall include:

(a) preparation of plans for a sewerage scheme for Avarua;
(b) preparation of a storm drainage plan for Avarua.

When the objectives were prepared, some two years before the project began, most of the population was concentrated in Avarua and there were only scattered hotel developments and settlements around Rarotonga island. Hotels, schools, etc., have since multiplied to such an extent that planning for a drainage and sewerage system for the whole of Rarotonga (instead of for Avarua only, as originally planned) was then justified and with completion of the project revision form of 1974 the project objectives for this activity were expanded and extended as:

(a) preparation of plans for a sewerage scheme for Rarotonga;

(b) preparation of plans for sewerage treatment and disposal;

(c) preparation of a storm drainage plan for Rarotonga.

When the above activity started, the Cook Islands Government requested that the same design criteria be used as for the water supply design for Rarotonga, and that it be in accordance with the development plan for the year 2000. One of the prerequisites to carry on this activity efficiently was that prior to December 1974, the Government should provide a topographic map in scale 1:2000 for the island of Rarotonga. Unfortunately, the map was not available until August 1975. In order not to delay further the project activity, the emphasis was concentrated on the field of work of topographic mapping, boring for hydrogeological surveys and collecting of all required information for Avarua district.

The topography of the island is mountainous with steep, knife-edged ridges and sharp peaks rising to 653m above sea level. It is fringed by a narrow coastal plain around the island, intersected by a number of streams and most of the houses in the communities are located between 2m and 6m above sea level with only few exceptions.

Studying the preliminary data, it was recommended to design separate systems for sewerage and storm drainage for Rarotonga. The drainage system should cover mainly the areas that are subject to flooding during the rainy season, while the sewerage should serve the populated areas and the areas envisaged for development in the town plan. In the populated areas, additional open drains connected to the drainage system are envisaged to collect the surface run-off. The alignment of the streams crossing the populated areas have to be corrected to ensure adequate reception of the surface waters.

2.2.1 Sewerage

A large portion of the housing estate and most of the business and administrative buildings are concentrated in Avarua. The rest of the population and the new hotel developments are distributed along the coastal plain in and around the villages of Matavera, Ngatangiia, Muri, Titiveka and Arorangi. The proposed sewerage system consists

of a reticulation system of gravity sewers, of appropriate size according to the settled areas served and the gradients of the sewer lines. The tributary sewers are to merge progressively into larger ones. Considering the population distribution and the topography of the populated areas, a number of pumping stations along the main trunk sewer have to be constructed. The sewerage pumps must be automatically controlled so as to operate intermittently, at intervals determined by the fluctuation of the sewage flow. For the reasons mentioned above, it is not feasible to collect the sewage from all around the island into one system and to treat it in one sewage treatment plant prior to disposal. Therefore, it is recommended that the sewerage for Rarotonga be composed of five independent functioning sewerage systems. The biggest one, is for Avarua covering the area from Atupa to Pue. The second is for Matavera and Ngatangiia to Avana Stream. The next is for Muri and Titiveka. The fourth covers all of Arorangi and the fifth is for Nikao, covering the area from Black Rock to Puapuatu. The size of the sewers was calculated to carry only the dry weather flow from the existing estates and that expected from developments in the area in accordance with the development plan. According to the design criteria the sewage flow is equal to the water consumption. The smallest size of the street sewers should be 200mm, and the gradient chosen to ensure self-cleaning, at a minimal flow velocity of 0.8m/sec.

2.2.2 Sewage treatment and disposal

Sewage and other water-borne wastes can be disposed of directly into the receiving water, without treatment, if the dilution rate is big. However, considering the availability of recipient, the hydrogeology, areas of land, climatical factors, future development and the existing treatment methods, it was recommended to introduce a scheme for mechanical treatment of the sewage, and a dispersed marine outlet at least at 10m depth beyond the reef. Arrangements for distribution of the effluent should be made and used in case of epidemics. The separated sludge should be digested and the gas collected and utilized.

The treatment scheme should consist of:

- bar screen
- two-storey tanks
- disinfection - chlorination
- dispersed marine outlet.

The digested sludge will be utilized as fertilizer. The collected gas will be stored in a gas holder and utilized.

Five sites have been selected for treatment plants, with the above-described schematic process.

(a) The treatment plant for Avarua (7300 m^3/d) shall be located at Kaikaveka near the cemetery where the effluent could be disposed of very conveniently into the sea with a short outlet.

(b) The second treatment plant, to serve Matavera and Ngatangiia (920 m^3/d), shall be located at Vaenga nearby the SDA church where the effluent could be disposed of conveniently with a short outlet.

(c) The treatment plant for Muri and Titikaveka (1909 m^3/d) shall be located at Taakoka in a suitable site but the outlet must be of considerable length (around 200m) to cross the lagoon. There is not a better alternative for this area.

(d) The fourth treatment plant to serve Arorangi (2641 m^3/d), shall be located at Akaoa. An outlet 150m long is required; but the lagoon at this place is shallow and it should be easy to construct the outlet.

(e) The fifth treatment plant (1050 m^3/d) is for Nikao and shall be located between the end of Tepuka Road and the runway of the airport. The outlet for the effluent initially runs along the drainage ditch of the airport and after that crosses the lagoon at a length of around 150m.

The sites for construction of the outlets have been selected to ensure good anchoring at a suitable depth and to guarantee appropriate dilution.

2.2.3 Drainage

From the hydrogeological surveys carried out under the project, it was clear that the flooding in the subjected sites occurs mainly because of surface run-off during rain and not because of rising of the ground water table. Most of the bore-hole samples for these areas, located in the coastal plain, show that the top layer down to about 0.5m depth consists of humic soils. Below that there are sands down to 7 - 10m depth. The ground water table in the coastal plain is almost at sea level. The selected areas for construction of the drainage systems are Tutakimoa in Avarua, a section in Ngatipa, around Matavera, a small section in Ngatangiia, Akaoa in Arorangi and part of Nikao. For these areas it is envisaged that mainly surface drains will be used, covered in populated areas with perforated concrete. Culverts are required as outlets for crossing the main roads and the coastal part on the way to the lagoon.

2.3 Tepuka sewage treatment plant

Following the alarming report of the Director for Public Health on the sanitary conditions of the existing partial sewerage system of Tepuka, the Government requested the writer to accelerate the design of the sewage treatment plant for this area.

The equivalent present population for this area is around 800, but the following design criteria were specified for a future 25 years.

		Av. daily cons. in m^3/day	Peak flow in l/sec.
Inhabitants	2412	603.07	13.96
Fountains	1	50.60	0.59
Nikao School	1000 pup	15.00	0.69
Kindergarten	30 chil.	1.50	0.07
Golf Club	120 memb.	0.72	0.02
Public toilets	2	40.58	0.46
Motor cars	402	13.82	0.32
Trucks	80	5.18	0.12
Tractors	10	1.30	0.03
Visitors	64	9.50	0.22
Olympic swimming pool	1	286.25	3.31
Tereora College	1500 pup.	22.50	1.04
		1050.02 m^3/d	20.83 l/sec.

In addition, the topographical and hydrogeological surveys were carried out on the basis of the above-mentioned data. It was estimated that the areas served will have equivalent population of 3560. The accepted treatment plant scheme is composed of bar screens, grit chambers, Imhoff tanks, disinfection and a dispersed marine outlet.

It was recommended as a temporary arrangement that the treated effluent be disposed of by absorption trenches instead of marine outlet. The tests from the soil survey showed that the absorption capacity was was more than satisfactory - the average absorption time for the water to fall 2.5 cm was 10 seconds.

Three bar screens (clear opening 25 mm) built into the entrance of three grit chambers (clear opening 25 mm) are envisaged, these will be built into the entrance square (2.50m long and 0.42m wide) with two of them working in parallel and one on standby.

Four units of Imhoff tanks, each one with a capacity of 16.4m^3, were designed to ensure 1.5 hours detention time of the average daily flow. The digestion part of the units is calculated with a capacity of 13.0m^3 each. In addition, it is envisaged to collect the developed gas for utilization by means of domes built on the two-storey tanks. Digested sludge will be extracted after six months' detention and utilized in wet condition by direct spraying in the field for fertilization.

2.4 Design and construction of a casing for water supply well in Aitutaki

Aitutaki is the second largest community after Rarotonga in the Cook Islands. The volcanic main island lies on the northern section of a large and reasonably deep lagoon, the eastern reef of which is studded with eleven atoll islets. Since the beginning of internal self-government in the Cook Islands in 1965, Aitutaki has moved forward in the development of agriculture as a major producer of bananas (over 200 acres), citrus and copra as well as a wide range of subsistence crops. The population of the island is around 2600 and most live in the central west coast in the villages of Nikaupara, Reureu, Arutanga, Ureia and Amuri. Three other villages are located on the eastern side of the island, Tautu, Vaipe, and Avanui. The island has an airport with daily flights to Rarotonga. The water supply system of the island has been developed under the supervision of the engineers from the South Pacific Commission. It consists of (i) three bore hole wells each furnished with a deep well pump having a capacity of 400 I.G. per hour, connected to ten storage tanks assembled from reinforced concrete with a capacity of 10 000 I.G. each, and (ii) a dug well 32 feet deep, furnished with a "Grundfos" submersible pump with a capacity of 100 I.G. per minute, connected to one 100 000 I.G. storage tank. The water distribution system is made of galvanized, PVC and fibrolite pipes and is already extended along the main road to all villages except those in Avanui district. The pipelines in the village areas are provided with standpipes. Along the western coast, house connexions are installed.

The writer was requested to assist in the rehabilitation of the well at Teruiporoiti. The first ten feet of the well were excavated with a cross-section of 18 feet square and the second portion of 22 feet depth in 10 feet square. Originally, the well was to be 40 feet deep but during the construction it caved in at 32 feet and endangered the lives of the labourers. In this condition, very rough timber lining was carried out and the submersible pump installed and connected to the 100 000 I.G. storage reservoir. Open to contamination and the surface waters, the well caved in again and the water supplied from it got increasingly turbid. The Government requested urgently that a new permanent casing be constructed, which would allow safe cleaning of the caved-in soil and make it possible in the future to deepen the well if required. Because this is the only well that provides a satisfactory quantity of water to the island, it was requested that the construction of the new casing be completed in the shortest possible time. Therefore, it was decided the casing should be made of perforated, prefabricated, reinforced culverts with internal diameter of 4 1/2". The well is constructed in weathered sandy soils requiring that a filter of three different sizes of crushed basalt aggregate be constructed, in the space between the excavation and the culverts. There was no time or technical capacity to construct a special mould and so for the casting of the required culverts an existing mould was used. The lowest culvert was constructed

with a special edge of timber and iron to enable easy and safe installation in the caved-in and not uniform bottom of the well. In future, this edge will be useful if further deepening of the well is intended. After the completion of the well, the submersible pump was installed; and tests show that there was no decreasing of the well's capacity and the water quality was improved.

2.5 Miscellaneous

As a result of the report of the Minister of Social Services, the Cabinet of the Cook Islands Government appointed a committee, of which the writer was a member, to study and prepare a proposal for construction of a public cemetery and to recommend sanitary regulations for burial practice. The existing practice is that graves are located all around the island in different areas on land that the family decides on. The writer made a study of the local customs and the factors dictating the sanitary requirements, and submitted to the Government through the committee a proposal with regulations for planning of a public cemetery and burial practices (Annex 4).

Island Foods is a factory for processing mainly citrus fruits and pineapples and at present has an independent water supply. The water supply belongs to the Government but is loaned to the factory and consists of an open intake, two pressure rapid sand filters, chlorinator, and one 50 000 I.G. storage tank. One of the filters was non-functioning and the writer was asked to advise on its rehabilitation. The filter was cleaned, refilled with suitable ingredients of sand and gravel, and put again into operation.

During the dry season of 1975, the same factory was running short of water for processing. All alternatives were studied and it was proposed to construct a new dug well, furnished with an electrical pump directly connected to the factory water supply system.

In connexion with implementation of the plan for improvement of Rarotonga water supply, the writer visited New Zealand. He attended different meetings at the Ministry of Foreign Affairs, Ministry of Works and Ministry of Health. The plans, implementation stages, the supply and the financing of the scheme were discussed. The writer met complete understanding and cooperation in all instances. In addition, the office of the Surveyor General was visited where the possibilities for earlier production of the required topographic map of Rarotonga in scale 1:2000, for the sewerage designs, was discussed.

Through the Cook Islands Government, the writer was requested to assist the airport authority to prepare plans for sewage disposal for the airport. The sewage system was very often clogged as a result of overflowing of the septic tank. It was found that the absorption trench following the septic tank was constructed originally in layers with very low permeability. Corrective measures were proposed and implemented.

In view of the rapid development of the tourist and other industries, shipping, the intensified agricultural activities, and other developments which contribute towards pollution and rapid changes of the environment, the Cook Islands Government considered and studied the arising problems and experience and legislation of different countries. On 15 October 1975, a Law for Conservation of the Environment was brought into force.

Recently there was established an independent Ministry of Supportive Services division concerned with water and sewerage works, which is fully in line with the requirements and the increased demand for these services.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusion

The writer's assessment of the project is that about 65 per cent. of the proposed project activities are accomplished. In particular the most important one, the preparation of the proposal and plan designs for improvement of Rarotonga water supply, has been fully completed and approved for implementation.

Preliminary work has been accomplished for preparation of the plan design for the sewerage system, sewage treatment and disposal, and the drainage system for Avarua.

The plan design for the sewage treatment and disposal plant for Tepuka will be a good example and experience for the design of the other sewage treatment plants required for Rarotonga.

For most of the period, the project was understaffed and much time was lost due to recruitment difficulties with the draftsman and surveyor-technician, both United Nations volunteers included in the project. The idea of the United Nations volunteers is good and there is in the beginning much enthusiasm for work.

The Government policy of establishing a strong organization for water and sewerage works and the enforcement of a law on environmental protection shows an understanding of the encountered problems and they are taking measure in the correct direction.

The completed design proposals and recommendations have been submitted to the Director of the Water and Sewerage Division.

3.2 Recommendations

To be able to construct and maintain successfully the new water supply system for Rarotonga, the Water and Sewerage Division must be reinforced with equipment. At least one more overseer with experience on construction of bigger water schemes must be recruited.

The sites of the five dispersed marine outlets have been selected, but some more observations should be carried out to ensure better anchorage.

The reticulation of Aitutaki water supply should be studied further and proposals should be submitted for balancing the existing system and for further extension to the areas that are not centrally supplied yet.

Some more regulations should be introduced for the water supply, sewerage and waste disposal practices.

The extent to which the United Nations volunteers can be used and relied on should be reconsidered especially for projects where production is required straight away for practical applications.

4. ACKNOWLEDGEMENTS

Grateful acknowledgement is made of the courtesy and consideration shown by the Premier of the Cook Islands, Sir Albert Henry C.B.E. and his Government, and of all the assistance rendered towards achievement of the project objectives.

The writer also wishes to thank in particular, Mr Vahua Vahua, Director of Water and Sewerage Division for his continuous, inspiring assistance which enabled the team to carry out successfully the required field work.

Special thanks are extended to the project counterpart, Mr Hugh Henry, the Secretary to the Ministry of Supportive Services, for his prompt assistance and enthusiastic support which enabled successful development of the project.

PERSONS INTERVIEWED IN CONNEXION WITH THE PROJECT

1. Sir Albert R. Henry, C.B.E., Premier
2. Mr Apenera Short, Deputy Premier
3. Mr Inatio Avaruru, Minister of Supportive Services
4. Mr William Estall, Minister of Economic Services
5. Mr Trupui Henry, Minister of Internal Affairs
6. Mr Jefry Henry, Minister of Finance
7. Mr Joorg Alis, Minister of Trade and Shipping
8. Mr J. Williams, Minister of Health and Culture
9. Mr Hugh Henry, Secretary of the Ministry of Supportive Services
10. Mr Vahua Vahua, Director for Water and Sewerage Division
11. Mr Harverd Henry, Acting Director for External Affairs

ESTIMATED WATER DEMAND FOR THE ISLAND OF RAROTONGA IN YEAR 2000

No.	Consumer	Number	Units per number	Unit demand in l	Dimension	Total no. of units	Total demand in l/day	Factor of peak consumption	Consumers peak water demand qmax in l/sec	Total peak water demand in l/sec
+1	Population	30 000	1	250	l/cap/day	30 000	7 500 000	Ko=2.0	0.005787	173.61
2	Laundry	1	2 580	60	l/kg/dry wt	2 580	154 800	8 hours	5.38	5.38
3	a. Hotel swimming pools b. Olympic sw. pools	10 2	505 500 2 862 500	10 10	% of the total volume	5 055 000 5 725 000	505 500 572 500	24 hours 24 hours	0.59 3.31	5.90 6.62
4	Fountains - for recovery of water loss	3	253 000	20	% of the total volume	759 000	151 800	24 hours	0.59	1.77
5	Hospitals	1	200	300	l/bed	200	60 000	Ko=2.0	1.39	1.39
6	Outpatient clinic	1	150	12	l/patient/12h	150	1 800	12 hours	0.04	0.06
7	Bakeries	3	283	200	l/ton of bread	849	1 698	8 hours	0.02	0.06
8	Schools	9	described	15	l/student/6h	8 500	127 000	6 hours	described	5.90
9	Kindergartens	10	30	50	l/infant	300	15 000	6 hours	0.07	0.70
10	Clubs	3	120	6	l/visitor	360	2 160	12 hours	0.02	0.06
11	Public toilets	12	1	20 290	l/unit	12	243 480	24 hours	0.23	2.76
+12	Motor cars	5 000	1	200	l/car	5 000	166 666	12 hours	0.00077	3.86
+13	Trucks	1 000	1	400	l/truck	1 000	66 666	12 hours	0.00154	1.54
14	Hotels	15	described	400	l/bed	2 580	1 032 000	Ko=2.0	described	23.86
15	a. Avarua market b. Avatiu market	1 1	50 800	15 15	l/m^2	50 800	750 12 000	12 hours 12 hours	0.02 0.28	0.02 0.28
16	Avatiu harbour				l/day		272 760	24 hours		3.16
17	Avarua harbour				l/day		18 180	24 hours		0.21
18	Island foods	1	121 920	20	l/kg/tins	121 920	2 438 400	24 hours	28.22	28.22
19	Service stations	4	20	700	l/vehicle	80	56 000	8 hours	0.49	1.96
+20	Tractors	130	1	120	l/tractor	130	15 600	12 hours	0.002769	0.36
21	The airport	1	500	400	l/passenger	500	200 000	Ko=2.0	4.63	4.63
+22	Visitors	800	1	150	l/visitor/day	800	120 000	Ko=2.0	0.003475	2.78
23	Prison	1	100	60	l/prisoner	100	6 000	Ko=2.0	0.14	0.14
24	Packing sheds	10	1	2 273	l/shed	10	22 730	8 hours	0.08	0.80
25	Soft drink plant	3	3 000	5	l/soft drink	9 000	45 000	8 hours	0.52	1.56
26	Abattoirs	1	50	300	l/beast/day	50	15 000	8 hours	0.52	0.52

+ Distributed water demand

Σ 13 823 490 l/d

Σ 278.09 l/sec

- 21/22 -

ANNEX 1

Annex 4

SOME REGULATIONS FOR THE PLANNING OF A PUBLIC CEMETERY

1. The size of the plot to be used for a cemetery is determined in the town plan for the community. The location of the cemetery must be determined with a view to its future use as a public park, after the cemetery has been closed.

2. The size of the cemetery plot is derived from the population of the community at the end of the period of the town plan; for each person 1.2 square metres is required. The distance from the cemetery to the first dwelling or communal buildings must be further than 300 metres.

3. Every cemetery plot must respond to the following requirements:

3.1 The gradient of the terrain should be away from populated areas or water resources used for irrigation or communal needs.

3.2 The site to be chosen should be on stable soil.

3.3 The site should not be flooded during heavy rains.

3.4 The underground water in the region should not be higher than 2.0 metres below the surface. In the absence of such, adequate drainage of the area is to be provided.

3.5 The soil is to be dry and porous, ensuring enough air circulation for easy drying.

3.6 The site is to be accessible to transport.

4. For every cemetery, a plan must be prepared in which must be determined:

4.1 All burial plots and the sequence for their use.

4.2 The direction and size of the roads and the large and small passages.

4.3 The location and characteristics of the green areas in and around the cemetery.

4.4 Location of all required cemetery buildings and equipment. The plan for the cemetery and the project's buildings and equipment must be approved by the Health Department.

5. The operation of the cemetery may commence only after approval of the Health Department.

6. The burial of the dead must be in separate graves. The distance between the graves should not be less than 1.0 metres on the long side and 0.5 metres on the short side of the grave.

7. Every adult grave should have the following minimal size:

- Length, 2.0 metres; width, 1.0 metre; depth, 1.5 metres. When burying infants, this size could be reduced, but the depth must be not less than 1.2 metres. The earth embankment for every grave must be 0.5 metres above the terrain to avoid flooding and water retention above the grave. Later, it shall be allowed to place some stone or concrete borders around the grave.

8. In the event of disaster or epidemic, where it is deemed necessary, it shall be allowed, with the approval of the Health Department, to bury many bodies in a common grave with the following requirements:

8.1 The distance between the coffins shall be 0.5 metre.

8.2 The second layer must be separated from the first by 0.5 metre.

8.3 The coffins between the first and second layer shall be placed in "chess" order.

8.4 The depth of the common grave, when it is in two layers, must be deeper than 2.5 metres and the bottom shall be at least 0.5 metre above the ground water.

9. Re-use of graves shall be permitted only eight or more years after burial. Disinterring of a body before eight years have passed may be done only at the request of the Justice Department or by the relatives of the dead person in order to move the body to a different place for burial, and after permission has been obtained from the Health Department.

10. Special precautions shall be taken by the labourers, as follows:

- All labourers digging the grave must wear a mask, gloves and apron. A disinfectant shall be used for washing the gloves.

11. Disinterment of the common grave shall be allowed if all bodies from the grave are to be re-buried in another place.

12. Digging of graves is allowed only during the day and with the approval of the Health Department.

13. The soil taken from the grave and the grave walls and bottom, after the body has been removed, must be sprinkled with a lime solution. On refilling of the grave each layers (20 centimeters) must be sprinkled with the lime solution.

14. The cemetery plot which will not be used in the future will be planted with trees and arranged as a public park, but only after all grave signs have been removed.

The use of the cemetery site for any other purpose must be with the prior approval of the Health Department.

15. The Public Health Department is invested with the authority to enforce these regulations.

Requirements for transportation, burial and digging of graves

1. The dead from every community are buried in a previously determined cemetery. The burying of the dead outside the cemetery is allowed only in special cases which shall be authorized by the Government and approved by the Health Department.

2. A certificate for the dead to be buried shall be issued by the Health Department and be prepared by a medically authorized person. In such certificates shall appear the name of the dead person, the date and hour of his death (if known), the names of the witnesses and the cause of death (if known).

3. The burial shall take place at least 24 hours but not more than 48 hours after death. The burial could be delayed if special precautions are taken to preserve the body.

4. Transportation of the body from the house to the cemetery shall be made in a sealed coffin. It is forbidden to transport the dead in an open coffin.

5. The dead from infectious disease and tuberculosis, before transportation from the hospital or the house where they died, must be covered in a linen sheet which has been fumigated with disinfectant and the body put into a coffin with the lid nailed shut. In the absence of disinfectant, the dead must be sprinkled with a chlorine and powdered lime. In such cases, the dead must be transported directly from the hospital or house to the cemetery.

6. The vehicles, in which those who have died of infectious disease or tuberculosis are transported, are to be disinfected immediately after use.

7. Transportation of the dead out of the state to another state, and the reverse is allowed only with the approval of the Health Department. In such cases transportation must be carried on in a sealed wooden coffin which shall be placed within another coffin made of zinc-coated tin. On the bottom of the wooden coffin there must be placed sawdust which has been sprinkled with chlorine disinfectant and powdered lime. The zinc coffin shall be welded shut and must possess a seal.

8. The vehicles for the transportation of the dead are used according to the regulations of the transport authority.

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