



AUSTRALIAN  
INTERNATIONAL  
DEVELOPMENT  
ASSISTANCE  
BUREAU

# TONGA WATER SUPPLY MASTERPLAN PROJECT

NIUAFO'OU

MASTERPLAN

MARCH 1992



CONSULTANTS

In Association with Riedel & Byrne Pty Ltd

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## LIST OF ABBREVIATIONS

ASAS	Australian Staffing Assistance Scheme
ADB	Asian Development Bank
AIDAB	Australian International Development Assistance Bureau
CPD	Central Planning Department
DPV	Fifth Five Year Plan 1986–1990
GOA	Government of Australia
GOT	Government of The Kingdom of Tonga
MAF	Ministry of Agriculture & Forests
MLSNR	Ministry of Lands Survey and Natural Resources
MOF	Ministry of Finance
MOH	Ministry of Health
MOW	Ministry of Works
TEPB	Tonga Electric Power Board
TWB	Tonga Water Board
TWSMP	Tonga Water Supply Master Plan

## GLOSSARY OF TONGAN TERMS USED IN THIS REPORT

api uta	Allotments of rural land, usually 8 acres
fale koloa	Small shop selling mixed good

## Preamble to the Master Plan Reports

This preamble is a synopsis of the material contained in the Tonga Water Supply Master Plan Executive Summary Report. The Master Plan Team realises that many of the reports arising out of the Tonga Water Supply Master Plan Study will be read in isolation. There is also the danger that they may be read out of context of the framework from which they have all been produced. It is important that the information contained within each Master Plan be read in conjunction with the information and recommendations contained within the following reports;

- \* The Tonga Water Supply Master Plan Executive Summary
- \* The Tonga Water resources Development Master Plan.
- \* Tonga Water Supply Master Plan, Proposed Water Resources and Water Supply Legislation.
- \* Tonga Water Supply Master Plan, Institutional Strengthening and Community Development.

The Tonga Water Supply Master Plan Study has the role of providing Master Plans for the existing four 'urban' supplies of Nuku'alofa, Pangai, 'Eua and Neiafu. In addition, to create Master Plans for ten representative villages which are to be used as models for other future village supplies. These villages are; Vaini, Mu'a (Lapaha and Tatakamatonga), Te'ekiu, Haveluliku, Houma, Uiha, Felemea, Longomapu, and Tu'anuku. As well as Master Plans for Niuafu'ou and Niuatoputapu

The time frame selected is twenty years. This period is selected on the basis that beyond the twenty year period it is difficult to predict population growth, economic and legislative change, and directions of development beyond that time.

There is a growing desire to compete on world markets, especially in tourism, agriculture and in secondary industry 'value added' products. This increases the likelihood of environmental damage as a larger population attempts to maximise its use of existing resources. Of consequence larger amounts of waste will be produced which have to be dealt with in a rational manner. In relation to the Water Supply Master Plans the increased volume of wastewater generated as a consequence of increasing water use needs to be disposed of in an environmentally safe manner. It is extremely important that the resource, in this case the groundwater, is protected not only from unsustainable use but also from pollution from other sources such as agricultural chemicals or waste disposal. These are the subjects of the Tonga Water Resources Development Master Plan.

The essence of Master Planning is to retain as much flexibility as is possible given the unknowns of the future, but to provide firm solutions over the adopted timeframe. The Master Plans have an inherent flexibility to cater for variations both above and below predicted demands. This has been achieved through the use of a flexible design approach that has examined as many options as is reasonably practical in each case and to adopt the option that is most economic and sensible given the development evidence currently at hand. The Master Plans need to be seen as one part of a continuing development process over time and not as an isolated 'fix' for a utility under population or development pressure in rural or urban areas.

Dan T Raymond  
Project Manager

## 1 INTRODUCTION

### 1.1 Authorisation

The Master Plan for Niuafu'ou Island village water supplies is prepared as part of the Tonga Water Supply Master Plan Project under the Memorandum of Understanding between the Government of the Kingdom of Tonga and The Government of Australia. The executing agents for the Government of Tonga are the Central Planning Department, the Tonga Water Board, the Ministry of Lands Survey and Natural Resources, Ministry of Health, and the Ministry of Agriculture and Forests. For the Government of Australia the executing agents are PPK Consultants Pty Ltd.

### 1.2 Purpose and Scope

The purpose of the study is to assist in improving the health, living conditions and economic opportunities of the village populations of Niuafu'ou Island through the provision of an adequate, safe and reliable water supply. This will be achieved by the preparation of a Master Plan for the creation and expansion of a water supply system to accommodate predicted changes in water demands over the twenty year period from 1991 to 2011. This will be done in conjunction with an investigation of the overall Niuafu'ou Island groundwater resource by the Ministry of Lands Survey and Natural Resources which will enable an assessment of the potential of the resource and the determination of sustainable yields.

### 1.3 Associated Reports

This report is one of a series of reports comprising the Tonga Water Supply Master Plan Study. The following Figure 1.1 is a list of related reports which are variously referred to in this Master Plan.

### 1.4 Key People

The following key people were involved in the Tonga Water Supply Master Plan Project and contributed either to this and/or associated reports.

#### Full Time Staff

Danny Raymond      Project Manager

Steven Boyd          Water Engineer

#### Short Term Inputs

Ian Sharp             Project Director

Beth Mylius          Community Development Specialist

David Cole            Legislation Specialist

John Larcombe       Institutional Strengthening Advisor



Tony Falkland      Water Resources Expert

Greg Johnstone      Drafting Training Specialist

**Tonga Water Supply Master Plan**  
**List of Reports**  
**Table 1.1**

Report Name
Nuku'alofa Water Supply Master Plan
'Eua Water Supply Master Plan
Neiafu Water Supply Master Plan
Lifuka Water Supply Master Plan
Vaini Water Supply Master Plan
Mu'a Water Supply Master Plan
Houma Water Supply Master Plan
Te'ekiu Water Supply Master Plan
Haveluliku Water Supply Master Plan
'Uiha Water Supply Master Plan
Felemea Water Supply Master Plan
Longomapu Water Supply Master Plan
Tu'anuku Water Supply Master Plan
Niuatoputapu Water Supply Master Plan
Tonga Water Resources Development Master Plan
Tonga Water Supply Master Plan: Institutional Strengthening and Community Component
Tonga Water Supply Master Plan: Proposed Water Resources and Water Supply Legislation
Tonga Water Supply Master Plan Executive Summary

Acknowledgement

Many people helped in providing information and assistance in the preparation of the Master Plans. These included staff from CPD, MOH, MLSNR, TWB, MOF and AIDAB. Their assistance has been greatly appreciated.

## **2 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS**

### **2.1 General**

Niufo'ou is the North Western most island in the Tongan Archipelago. See Figure 2.1.

### **2.2 Study Area and Service Area**

The study area for the Niufo'ou Master Plan generally comprises the Niufo'ou village areas as shown on Figure 3.1

### **2.3 Demographic and Development Projections**

Niufo'ou had shown a large growth of 10.35% p.a. over the ten year period 1976–1986. However, this rate of growth is expected to stabilise at around 915 by the year 2011. The huge growth rates are due to a returning population mostly from 'Eua who had evacuated before the last volcanic eruption in 1947.

Development has been assumed stable to the extent that no major water consuming activities are likely to develop within the study period.

### **2.4 Water Demands**

Water consumption is solely from rainwater tanks. Current water consumption for Niufo'ou area is estimated at 38kL/d or an average of 50L/person/day.

Improvements in housing standards and the installation of a reticulated system are expected to raise domestic demand for water to around 100L/day. The proportion of the population served by the reticulated system is expected to be 100% by the year 1996. Non-domestic demand is expected to become 10% of domestic demand.

### **2.5 Existing Water Supply System**

#### **2.5.1 Existing Facilities**

The existing facilities in the Niufo'ou water supply consists of:

- \* Private and shared rainwater catchments and tanks and associated plumbing.

#### **2.5.2 Evaluation of the Capacity of the Existing System**

The current domestic consumption from the rainwater suppliers is estimated to be 50L/person/d.

### **2.6 Recommended Master Plan**

The Master Plan for the water supply for the Niufo'ou study has been developed to meet the present and projected water demands through 1991 to the year 2011

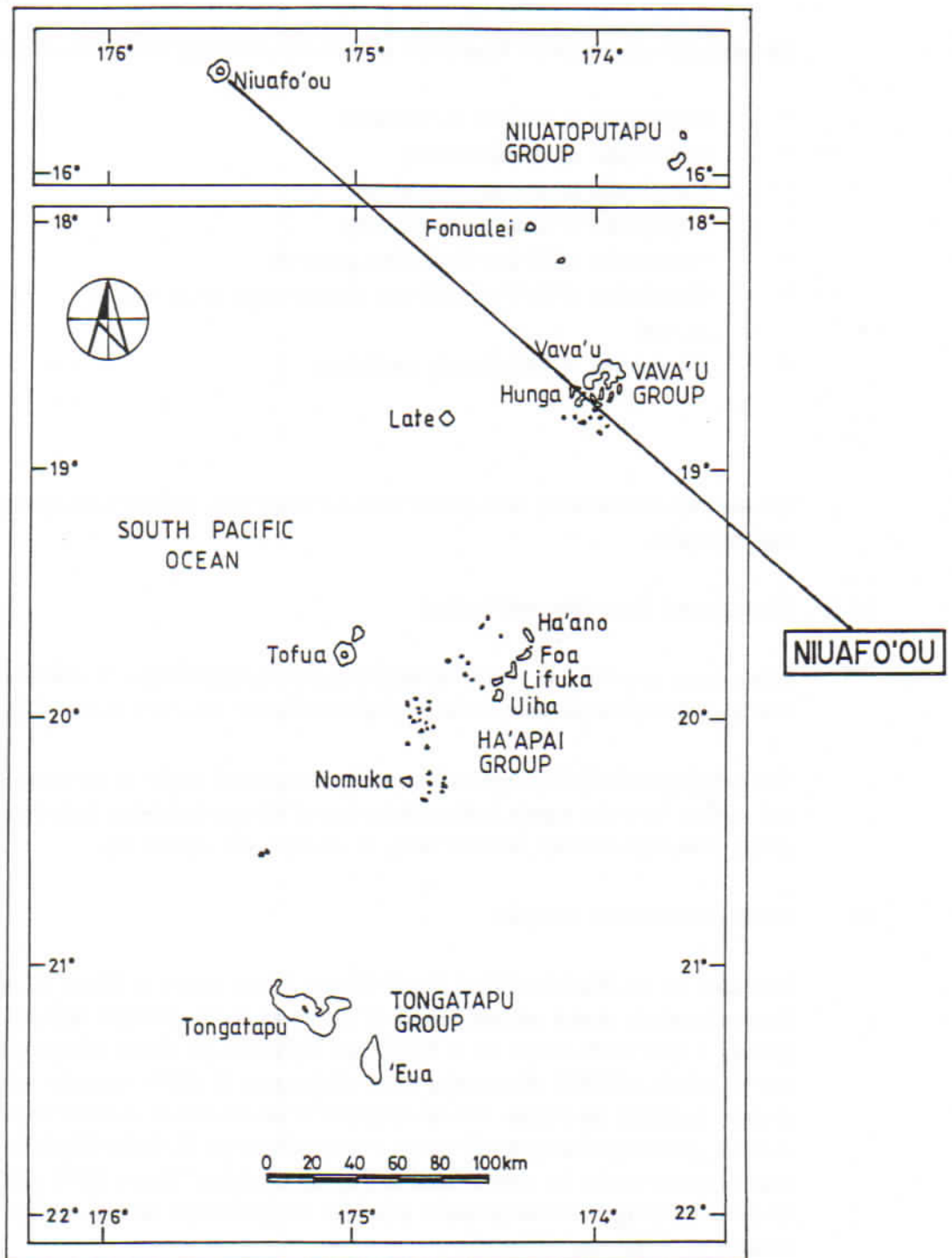
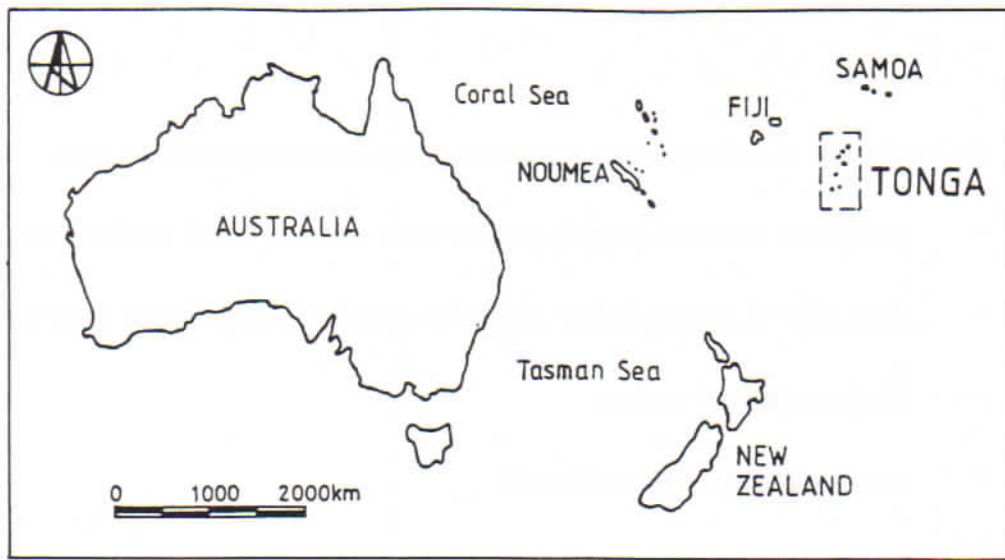


FIGURE 2.1

The Master Plan is discussed in detail in Section 8 and includes the following works:

- \* Construction of a water pumping unit at a crater lake, Vai Fo and associated rising main
- \* construction of a storage facility comprising groundlevel tanks adjacent to Sapa'ata.
- \* Installation of water services.
- \* construction of distribution pipework.

#### 2.6.1 Immediate Improvement Programme

The Immediate Improvement Programme includes the following works and estimated capital costs:

* Construction of 3 No 22 kL reservoirs	\$27,000
* Construction of office/workshop	\$10,000
* Construction of lake pumping station	\$25,000
* Construction of rising mains (75 mm)	\$91,000
* Construction of 75 mm distribution pipework	\$68,000
* Construction of 1375 m of 50 mm diameter main to the west of the tank	\$45,000
* Construction of 110 domestic corrections	<u>\$2,500</u>
	<u>\$268,500</u>

It is assumed that the newly formed VWC with assistance from the MOH will be responsible for project implementation.

#### 2.7 Management Operation and Control

Management by a VWC to be established by the participating villages. It is assumed operational staff will be paid but consideration could be given to volunteer staff (see Section 2.8).

The pumping station will be operated manually with a diesel engine as the power source. To control and operate the water supply system monitoring of system parameters including water flow at key points, pumping hours and reservoir levels is required (see Section 10).

#### 2.8 Costs and Financial Analysis

The costs for the Niuafu'ou Water Supply Master Plan is shown in Tables 2.1 and 2.2 below. The financial analysis carried out (see Section 9) has shown that for a 4.00% IRR and assuming no grant funding a tariff of \$2.32 per kL or \$15.62 per household per month is required. This exceeds the cut-off criteria of 3.00% of estimated household incomes. It will be necessary to consider some form of grant funding if the scheme is to be affordable by the consumers over the 20 year planning period. A 100% grant funded scheme will require a tariff of \$1.60 per kL or \$10.74 per household if recurrent costs are to be met by the scheme itself on a continuous basis. This is 2.51% of household incomes. \$6.06 of this charge is for the proposed paid staff. With volunteer staff the household charge could be reduced to \$4.68/household/month.

**Table 2.1**

Program Phase	Total
Immediate Improvement (1991-1995)	\$300,720
Long Term Programme (1996-2011)	\$76,250
Totals	\$376,970

**Table 2.2**

**IMMEDIATE IMPROVEMENTS EXPENDITURE SUMMARY \$T at 1991 prices**

Year	Component		Totals	with 25% Contingency
	Materials/Equipment	Engineering		
1991	\$0	\$0	\$0	\$0
1992	\$98,000	\$11,760	\$109,760	\$137,200
1993	\$123,500	\$14,820	\$138,320	\$172,900
1994	\$31,500	\$3,780	\$35,280	\$44,100
1995	\$15,500	\$1,860	\$17,360	\$21,700
Totals	\$268,500	\$32,220	\$300,720	\$375,900

### 3 DESCRIPTION OF THE STUDY AREA

#### 3.1 General

The Kingdom of Tonga consists of 169 islands between latitudes 15° South and 23.5° South and longitudes 173° West to 177° West and extends over an ocean area of about 259,000 square kilometres. Total land area including major island reefs is 697 sq km. Only 36 islands are inhabited. There are three main groups of islands, the Tongatapu group in the south, the Ha'apai group in the centre and the Vava'u group in the north. There are two small islands in the far north, Niufo'ou and Niuatoputapu.

Niufo'ou is the most northerly island in the Kingdom Of Tonga and is located at latitude 15° 35' south and longitude 175° 40' west. It has an area of approximately 35km and a maximum elevation of 260m.

#### 3.2 Study Area Definition

The study area for the Niufo'ou Master Plan is illustrated in Figure 3.1.

#### 3.3 Geomorphology

##### 3.3.1 Topography and Geology

The Tongan islands lie on the north–northwest to south–southeast oriented Tonga–Kermandec Ridge, which forms a major underwater feature extending over 1300 km from New Zealand to Samoa. The Tongan archipelago consists of three types of islands running in two chains parallel to each other and to the Tonga trench.

(i) An eastern chain of islands, (Tongatapu, Ha'apai and Vava'u) sitting on the relatively shallow platform of the Tongan Frontal Arc, consist of limestone derived from coral reefs, underlaid by older volcanics. In some areas such as Nomuka and 'Eua the volcanic rocks are exposed.

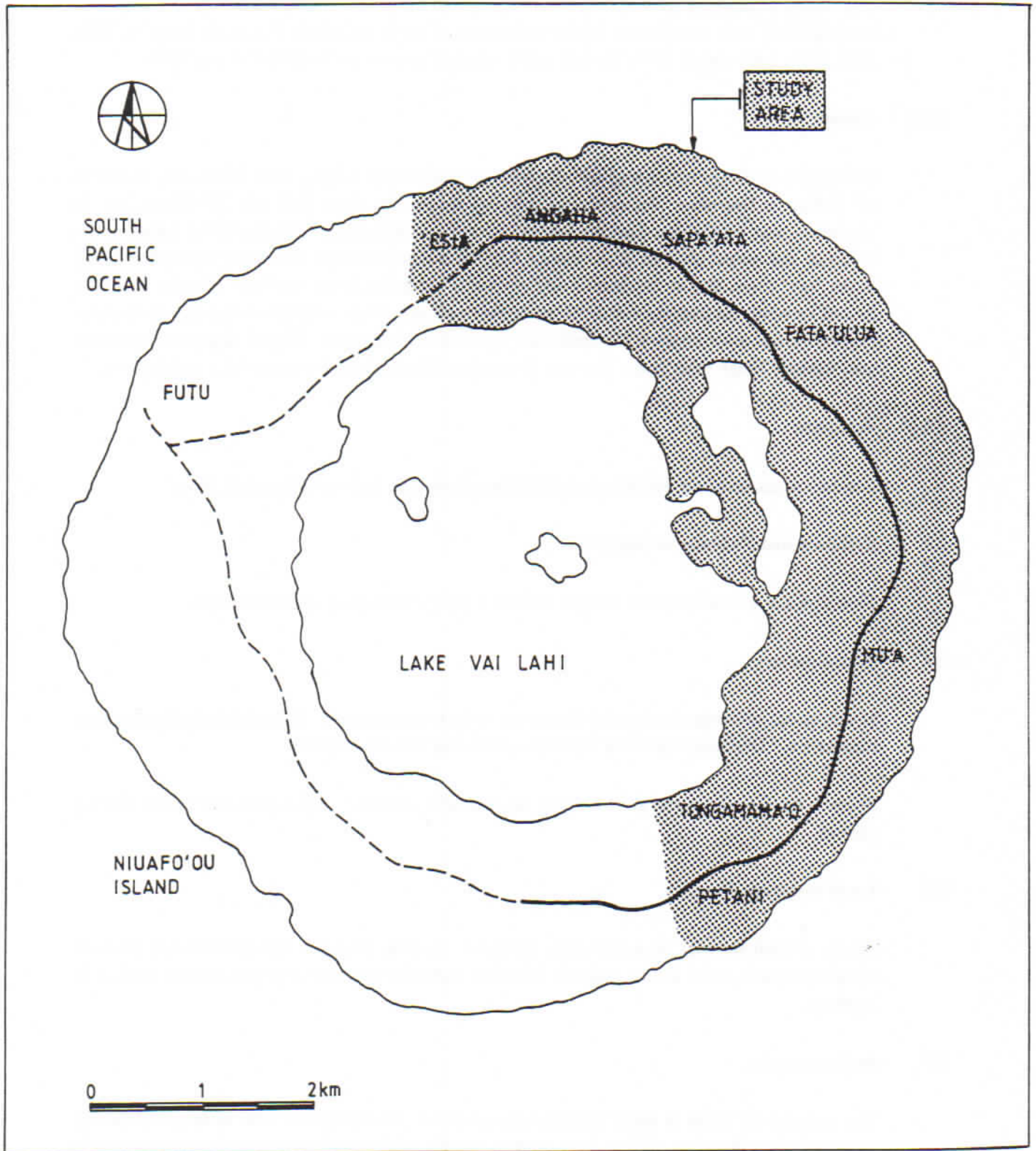
(ii) A western chain of active volcanoes, (Tofua, Late and Kao), sit on the Tofua ridge and are separated from the chain of coral limestone islands by a trough up to 1,800 m deep.

(iii) A chain of active sub–marine volcanoes (Fonuafo'ou and Metis Shoal) forming unstable islands made up of volcanic ash and pumice.

The Tongan Frontal Arc can be subdivided into five tectonic blocks. These are Vava'u, northern Ha'apai, southern Ha'apai, Nomuka and Tongatapu. Each of these has a different and distinct history.

The island of Niufo'ou is a basalt shield volcano surmounted by an andersitic cove which has collapsed to a large water filled caldera about 4km across (Vai Lahi). Other smaller lakes have also formed including Vai Si'i, Vai Fo, Vai Inu and Vai Sulphur.

The highest section of the crater ranges from 100m to 1km from the edge of Vai Lahi and the remaining 2km wide concentric landmass slopes down to the ocean.



NIUAFO'OU STUDY AREA  
FIGURE 3.1

### 3.3.2 Seismic Activity

The Tongan archipelago is one of the most active seismic areas in the world. Tremors of 3–4 magnitude on the Richter scale are frequent. Major earthquakes of above magnitude 7 have hit Tonga in 1853, 1865, 1881, 1908 and in 1977. The last major volcanic eruption in Niuafu'ou was in 1946.

### 3.3.3 Climate

The climate of Tonga is sub-tropical with average temperatures ranging from 15° Celsius in June to 27° Celsius in December. The maximum recorded temperature since 1949 was 32° Celsius and the minimum was 10° Celsius. Rainfall patterns are mostly convectional with more rain falling on the southeast and central portions of the islands. Rainfall is highly variable with heavy rains often falling in the "dry" (from May to September) and dry spells occurring during the "wet" (October to April). Prevailing winds are from the east to the south-east with an average velocity between 10 and 15 knots. Hurricanes can occur between November and April but are infrequent. Tropical depressions however pass through Tonga most years. The area is considered for design purposes to be a cyclone area.

### 3.3.4 Vegetation

Coconut palms dominate the island of Niuafu'ou, along with fruit and ornamental trees.

## 3.4 Economy and Function of Niuafu'ou

Niuafu'ou has a series of small villages and has a slowly developing agriculture area.

## 3.5 Infrastructure

Niuafu'ou has minimum developed infrastructure with no bitumen roads. The area has no electric power reticulation. Telecommunications facilities are limited to radio telephone.

Water is not reticulated and all consumers use rainwater. There is a high school and several primary schools.

## 3.6 Local Materials Supply

Supply of local material for construction is limited. A small scale saw mill was recently installed. Crushed volcanic rocks is also available. All other materials for waterworks construction need to be imported.

## 3.7 Socioeconomics

The economy of Tonga is based primarily on agriculture, which together with forestry and fishing, accounted for 45% of the GDP in 1985. Seventy percent of the population depend on these areas for their livelihood. Principle export crops are copra, desiccated coconut, coconut oil, vanilla, bananas, and other fruit and vegetables. The manufacturing sector though small is growing. Tourism is an important foreign exchange earner, second only to private remittances.



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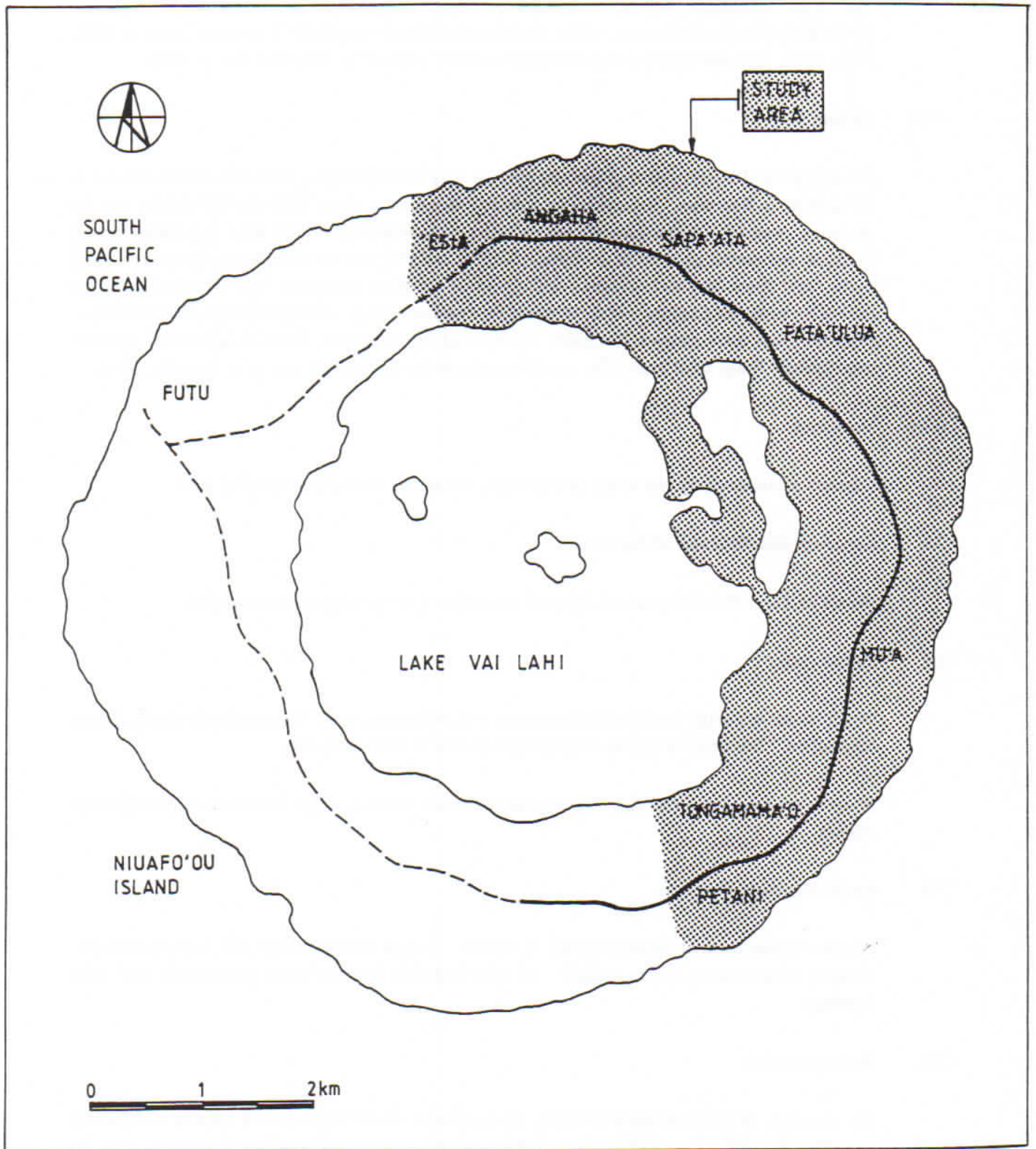
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NIUAFO'OU STUDY AREA  
FIGURE 3.1

annum per employed person, with about 1.4 workforce members per household (household size is estimated to be 6.4 persons). Overseas remittances are estimated to be in the order of T\$350 per person per annum or T\$2205 per household (based on 1986 figures). Household incomes are therefore about T\$4445 per household or T\$705 per person per annum. Additional information from the 1984 Household survey indicate this may be upto \$5500 (1991) per Household.

### **3.8 Public Health**

The health of the community is generally good with few records of disease which could be attributable to water-borne vectors or water quality. The available water quality data indicates that the proposed water source will be for non-potable use.

Sanitation, wastewater and environmental aspects are considered in Section 8.9.