

**TECHNICAL ASSESSMENT AND SUPPORT
FOR WATERSHED MANAGEMENT, PLANNING AND TRAINING
FOR TONGA, COOK ISLANDS, SAMOA AND THE FEDERATED
STATES OF MICRONESIA, 25 JULY - 08 SEPTEMBER 2002**

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FOREWORD

Following the successful roving workshops on watershed management organized and sponsored by the UNDP/FAO South Pacific Forestry Development Program and the USDA Forest Service in 1993, the participating countries, i.e., Cook Islands, Tonga, Federated States of Micronesia and Palau have requested several follow-up missions and workshops.

With the continued support of the USDA Forest Service's Institute of Pacific Islands Forestry, several technical specialists have been detailed to this Programme since the initial 1993 workshops. We are most grateful for the efforts of these specialists, including Mr. Pradip Baisyet, Dr. James McKean, Mr. Kim Johansen and their respective employers.

The report of the 1993 workshops was published as Field Document No. 5. The report of the 1995 workshop was published as Working Paper No. 4. Additional workshops were conducted in 1996, 1998, and 1999.

The current mission was conducted by Mr. Jack Holcomb, Regional Hydrologist for Region 8 of the USDA Forest Service and James Denny Ward, forest health specialist also from Region 8. Mr. Ward has provided technical assistance to our Programme for several years.

Due to funding constraints, only three countries, viz. Tonga, Samoa and Cook Islands, were visited. Samoa was included in this mission to demonstrate what a Forestry Department can accomplish through a successful watershed programme. Also, Samoa graciously offered to help organize the regional training workshop held straight after the completion of the specialists' mission to the three countries. The Federated States of Micronesia and Palau were also invited to the workshop, but Palau was unable to participate because of travel difficulties.

There has been considerable progress made to improve the understanding and appreciation of the principles and processes of watershed management during the course of this and previous missions.

We would like to thank both Mr. Ward and Mr. Holcomb for their hard work and dedication, the USDAFS and the specialists' respective supervisors for releasing them for the assignment, the Heads of Forestry and other staff of the Forestry Departments and other agencies in the respective countries for their assistance. We hope that the information and recommendations made during these missions will result in improved management and supply of water resources in Pacific Island countries.

Sairusi Bulai
Forests and Trees Adviser
September 2003

PREFACE

This document summarizes the observations and recommendations of a mission to evaluate the status of watershed management in the Cook Islands, Tonga and Samoa. It also contains as a CD attachment the presentations made during the Workshop conducted in Apia, Samoa. In addition, the CD contains a wealth of information on watershed management as well as several presentations made at the Pacific Regional Consultation Meeting on Water in Small Island Countries held at the end of July 2002 in Sigatoka, Fiji Islands. It is hoped that this additional information and PowerPoint presentations will serve as a valuable resource for individuals involved in Watershed Management in the South Pacific.

ACKNOWLEDGMENTS

The authors sincerely thank the many people who supported and participated in this mission. Thanks are due to Mr. Kanawi Pouri, former Adviser to the SPC Forest & Trees Programme and to the Heads of Forestry and their representatives in the islands participating in the mission. Without their support this mission could not have been accomplished. Our thanks are also extended to Doctor Lloyd Swift and Doctor Richard Burns for sharing their excellent work on road drainage and to Jeff Moll, San Dimas Technology Development Center, for providing field guides on Water/Road Interaction for our workshop.

A special thanks is due to Mr. Malaki Iakopo, Director, Ministry of Agriculture, Forests Fisheries and Meteorology in Samoa for hosting the Workshop and providing the excellent facilities and services enjoyed by all the participants. We would like to especially thank and recognize the active participation and dedication of Mr. Maturu Paniani, Senior Forestry Officer and Watershed Management Specialist of the Samoa Forestry Department for his tremendous contribution to the Workshop. We also give special thanks to the employees and support staff at the Forestry Department for providing an excellent facility and food for the participants during the workshop. Additionally, the Institutional Strengthening Project for the Ministry of Agricultural was very gracious in lending us the use of their video projector that saved the day when our projector malfunctioned. We are very grateful for their assistance.

Finally the authors would like to thank the specialists who conducted the previous missions and workshops along with the USDA Forest Service's Institute of Pacific Islands Forestry for providing the background information and recommendations that served as a basis for the current mission.

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1.0 INTRODUCTION

Water is both vital and critical, especially in the small high islands and atoll countries in the Pacific. In this respect, management of forested watersheds has always been regarded as a high priority activity for both national and regional programmes by the Heads of Forestry.

In the atoll islands, water is largely supplied from rainwater or under-ground pits, which are sometimes intruded by saltwater during high tides. In the high island countries water from surface and underground streams is sometimes reticulated to supply urban and non-urban dwellings, and in the case of Samoa, water is abundant enough for both domestic use and to generate electricity. With increasing populations, threats of global climate change, rising sea levels, more land clearing for food production and increases in water consumption, the preservation and maintenance of healthy forests within water catchment areas is critical.

During the 90's various technical support programs and assistance were provided by two sister projects,; the UNDP/FAO South Pacific Forestry Development Programme (SPFDP), (RAS/92/361, 1992-1996) and SPC/UNDP/AusAID/FAO Pacific Forest and Trees Support Programme (PIF&TSP), (RAS/97/330, 1997-1999) to selected Polynesian states of Cook Islands, Samoa and Tonga and in the Micronesian states, the Federated States of Micronesia (Pohnpei) and Palau, with the assistance of the USDA Forest Service (Institute of Pacific Islands Forestry). Technical assistance missions were conducted in 1994, 1995, 1998 and 1999.

During these missions the potential and capacity of existing water sources were identified and various recommendations were made to improve both the quantity and quality of water from forested watersheds. Training in basic watershed management techniques was given through several roving watershed management workshops. From the initial mission in 1994 all subsequent missions attempted to build on the previous missions and measure the progress made in the respective island countries.

At the ninth Session of the Pacific Islands Heads of Forestry meeting in Nadi, Fiji in May of 2000, the small high islands countries identified watershed management and development as a continuing priority in the Cook Islands, Palau, Pohnpei (FSM), Samoa and Tonga.

In 2002, Terms of Reference were developed and the assistance of the USDA Forest Service was requested to conduct a follow-up mission to assess watershed management activities in these countries and determine if previous recommendations were implemented.

2.0 TERMS OF REFERENCE

Consultants on forest health and hydrology, able to undertake review of management plans, recommend policy and operational changes and train national staff in watershed management will be engaged to undertake the following specific activities.

Phase 1

The consultants will be required to visit Cook Islands (Mangaia), Tonga ('Eau/Vava'i) and Samoa (Upolu). They shall undertake the following duties:

- Undertake an analysis of on-going watershed management activities at national and community levels and consult with appropriate national institutions such as the water authority/board, environment services, local governments and any other institutions determined by the Head of Forestry in the respective countries.
- Assess the water quality and flow in selected community water systems.
- Identify and suggest policy and operational strategies/options for improving the watershed management plan and area and if necessary, recommend appropriate personnel to oversee watershed management responsibilities for consideration by the Head of Forestry and Ministry.
- Identify national training needs that relate to the overall management, protection, and rehabilitation of watershed areas, including mapping, testing of water quality, means and frequency of recording and monitoring, and any other related but relevant activity. The training needs identified will be the basis for a 4-5 day regional training workshop to be conducted immediately after the completion of the consultant's review and assessment visits to the three island countries.

Phase 2

- A 4-5 day regional training workshop will be conducted in Apia, Samoa by the consultants immediately after the review/assessment visits to Cook Islands, Samoa and Tonga. The regional workshop will include participants from the following countries; Cook Islands, Federated States of Micronesia, Palau, Samoa and Tonga. The participants will principally come from the national forest/agriculture services but may also include participants from the national water authority/boards, NGOs and CBO.
- Based on the training needs assessment undertaken at the national level and in consultation with the Heads of Forestry (during the visits), the consultants shall develop a training programme for the regional workshop and forward this to SPC Forests and Trees Advisor for endorsement.

- The training sessions shall include both classroom and field activities/demonstrations including but not limited to:
 1. Preparation of management plans including mapping.
 2. Best approaches and practices to minimize or integrate human activities within the watershed areas.
 3. Preventative and rehabilitative measures and options for erosion and land clearing.
 4. Water quality flow measurement, testing and recording.
 5. Development of strategies for post workshop community education and awareness programme to be conducted by the participants in their countries.

3.0 SUMMARY OF FINDINGS OF PREVIOUS MISSIONS

Earlier missions and workshops were conducted in these island countries in 1994,1995, 1998 and 1999. These earlier missions identified a variety of problems and recommendations were made to improve water delivery systems and watershed management. No previous missions in watershed management were conducted in Western Samoa because funding for a comprehensive watershed management project was being provided by FAO/UNDP.

The first mission conducted in 1994 in five island countries identified eleven issues that were common to all of these small island countries and many specific problems in the individual countries. The current mission found that many of these same issues are still relevant today. The eleven common issues in watershed management in the South Pacific (McKean and Baisyet,1994) from the first mission were:

1. The level of public and government knowledge of the importance of watershed management and the consequences of poor management is generally not good and should be improved.
2. There is a general need for formal legislation requiring protection and management of watersheds
3. Watershed legislation should designate some agency within the national government in each country with the responsibility and authority for watershed management.
4. There is a need for better coordination of all the government and NGO groups involved in water supply, water quality, and watershed management issues.
5. There is a general lack of training and education of local people in the principles and techniques of watershed management, water monitoring, soil erosion measurements, and watershed rehabilitation.

6. There is a general lack of knowledge of the effects of fire on hillslope soil erosion and on sedimentation in streams.
7. In all four countries there is extensive erosion from roads.
8. On Atiu and Mangaia, Cook Islands, a large program is needed to correctly plan and conduct erosion control from abandoned agricultural fields and from roads.
9. In each country, there is an almost complete lack of information about the actual rates of stream flow, ground water recharge, ground water and surface water use, rainfall patterns, salt water intrusion, erosion from hillslopes, erosion from roads, deposition of sediment and other pollutants in mangroves, lagoons, and coral reefs, and acceleration of erosion due to fires.
10. In Tonga, a watershed management plan should be developed for 'Eua Island that includes specific land exchanges that are needed in the Saa, Matavai, and Heke Drainages to prevent agricultural and animal pollution from degrading these major domestic water sources.
11. There should be study tours, short training programs, traveling workshops, audiovisual training materials and conservation guides prepared and a South Pacific Regional Watershed Management Program established. (Summarized)

4.0 SUMMARY OF THE CURRENT MISSION

4.1 Joint Consultation Meeting-“ Water In Small Island Countries”

Prior to the mission one of the consultants and the Forest and Trees Advisor from SPC attended a special consultation meeting in Sigatoka, Fiji on “Water in Small Island Countries”. SOPAC and the Asian Development Bank sponsored this meeting to prepare for the 3rd World Water Forum in Kyoto, Japan in 2003. Approximately 150 people from 25 or more small island countries participated in the meeting.

The meeting was particularly relevant to the upcoming mission since all of the small island countries included in the mission were represented and gave presentations on the status of water in their respective countries.

The meeting was an excellent source of information to plan the activities for the upcoming mission. The most significant information revealed at the meeting was:

1. Most participants and attendees from the various countries did not understand or had not considered the role of forested watersheds in providing adequate supplies of clean water. The role of catchment areas was not discussed and there were no foresters other than the consultant and the Forest and Trees Advisor from SPC at the meeting to present the benefits of managing forested watersheds.

2. There was apparently little or no consultation with forestry agencies within the countries by water boards or other agencies responsible for water in the many island countries.
3. It became obvious that the upcoming mission must find a way to bring together forestry agencies and the many other agencies responsible for water in small island countries.
4. Before the meeting ended input was provided by the representatives of SPC on the resource needs to establish, improve and manage forested watersheds. This information will be considered part of the proposal to be presented at the 3rd World Water Forum in Kyoto, Japan in 2003 and may result in resources to manage forested watersheds in small island countries of the Pacific.
5. The concern for water is critical in small island countries of the South Pacific and may be the most serious problem they must face in this century.

4.2 Observations and Recommendations for Mangaia, Cook Islands

Background

The Cook Islands, located in the center of the Polynesian Triangle, are comprised of 15 islands covering some 237 square kilometers scattered over almost 2 million square kilometers. Approximately 18,000 people occupy the Cook Islands while another 60,000 Cook Islanders reside in New Zealand and Australia.

Topography varies from low lying and raised atolls to the high island of Rarotonga. The current evaluation was conducted on Mangaia, the second largest island, with an area of 52 square kilometers. A brief visit was also made to a watershed on Rarotonga, the largest of the Cook Islands.

Mangaia lies to the east-southeast of Rarotonga. The island is circled by a wall of coral (called the makatea), which forms around an inner volcanic core. The inner island area, underlain with reddish clayey soil, supports predominantly root crops, coconut trees and some pineapple plantations. The higher elevations have been planted in pine and acacia species. The most recent estimate (National Forest Policy, 1997) indicates that of 3350 hectares of forested area, 844 hectares are planted in *Pinus caribea* and *Acacia* species. The people obtain their water from a centralized water system and most of the individual households collect rainwater from roof tops where it is stored in cement storage tanks constructed adjacent to their homes.

Previous missions were conducted in the Cook Islands in 1994, 1996 and 1998 on the islands of Mangaia and Atiu. Specific problems found on the previous missions were related primarily to excessive erosion from abandoned agricultural fields, poorly constructed and maintained roads and poorly maintained water intake and delivery systems. Erosion in these areas was responsible for poor water quality and deposition of sediment in water intakes. Other noted problems were a lack of technical skills in watershed management and the lack of a watershed management plan.

Another issue that has hampered progress on the islands is that forestry has little or no influence on what happens on the outer islands such as Mangaia. This responsibility has been given to a much over-worked agency called the Ministry of Outer Islands Development (MOID). The CEO of MOID was aware of the problems identified during the 1998 evaluation (McKean, 1999).

Observations

Observations made during the current survey showed that a massive tree planting effort on Mangaia has significantly curtailed severe erosion. During the past fifteen years more than a million trees have been planted under the direction of Forestry. There are some remaining areas with erosion such as roadbeds, gullies, landslides and recently established pineapple fields but they are insignificant compared to the serious problems found in 1994.

Planting trees to reduce erosion has resulted in an additional benefit. Planted trees will eventually become commercial crops that could bring substantial income to the island. Currently, no forest management or harvesting plans have been developed. Unless precautions are taken, future harvesting could result in excessive erosion. This issue was discussed with the mayor of Mangaia and the Island Council and there was agreement that Mangaia did not want to repeat the mistakes of the past where improper land management resulted in severe erosion. The Pacific German Regional Forestry Project has provided consultation in this area with appropriate recommendations (Jahn, August, 2001).

It was also suggested that the people of Mangaia should consider setting up their own community-based timber harvesting operation using low impact harvesting and portable sawmills. This could provide jobs for local people and may reduce impact that could be caused by an independent contractor not living on the island.

The current mission also revealed that much work is needed to upgrade and maintain the island water intakes and delivery system. The intakes that were visited indicated that the previous recommendations to install geotextile filter cloth over the filter beds has not been done. Also there is no water monitoring plan or anyone routinely monitoring the water chemistry or flow. Water transfer from a storage tank on the Keia intake is inefficient and a great deal of water is being lost during the transfer process. Access roads for the water intakes have not been repaired making it difficult to monitor and maintain the intake structures.

Through discussions with the Mayor, Island Council and others on the island, it was noted that none of the other reports or recommendations made during previous visits by McKean and Johannsen (1998,1999) had been seen by anyone on the island. It was also pointed out that the people on the island directly responsible for water management, erosion control and forestry operations have not received needed training.

Recommendations

Based on our observations the following recommendation are made for Mangaia:

1. Develop plans for forest management, watershed management and low impact harvesting of the planted pine.
2. Clean water intakes on a scheduled basis and install geotextile filter fabric to improve filtration and remove sediment.
3. Continue planting trees to restore remaining eroded areas in the watersheds.
4. Develop and implement a local water monitoring plan for chemistry and streamflow.
5. Provide training in all areas of watershed management to local foresters and those responsible for water management.
6. Develop and implement a community awareness and participation program for maintaining healthy watersheds.
7. Gain support from MOID for improving water systems.
8. Investigate the feasibility of moving the upper water tanks on Keia to improve pump efficiency that will result in conservation of water by reducing overflow.
9. Because of the close proximity of the watersheds and agricultural fields where pesticides are applied it would be beneficial to conduct a pesticide use training course for the farmers.

4.3 Observations and Recommendations for ‘Eua, Tonga

Background

‘Eua, Tonga is one of 170 islands in the Kingdom of Tonga and lies southeast of the main island of Tongatapu. The island has a total area of 54 square kilometers and is comprised of two administrative districts made up of a total of 14 villages. It has a maximum elevation of 312 meters and slopes gently east to west in a series of three terraces and then plunging in a series of cliffs to the eastern side. The eastern ridge on Eua has not been divided into land parcels and large stands of secondary native forest existed there in the past. An area along the southeast cliffs has been allocated as a National Forest Preserve. Most of the accessible native hardwood forest resources have been logged and the cleared land is being encroached upon for farming.

The main catchment management issue on ‘Eua is water quality degradation caused by activities within the catchment. The majority of the existing ‘Eua water quality problems are caused by impurities entering the water in the catchment area. The limestone covering most of ‘Eua contains interconnected cavities which allow rapid flow of water both horizontally and vertically. The surface soil horizons cover steep catchment surfaces and significant transport of eroded soil, vegetation and rock occur during heavy rainfall. The combination of limestone and soil produces rapid deterioration of water quality during wet weather periods. Clearing of trees and an increase in farming and stock raising has contributed to a

progressive reduction in the water quality. This is because loss of vegetation from farming activities and stock raising promotes soil erosion.

Currently, land ownership of the catchment lies with the Ministry of Lands, Survey and Natural Resources (MLSNR). Management of the catchment should be the responsibility of those who are operating the water supply system to ensure that they are well managed and that they are linked with the guidelines to be adopted by the proposed catchment management committee.

Originally, the source of water on 'Eua was from hand dug wells and springs. More recently rainwater collected and stored in ferrocement tanks has been the best source of drinking water. In the 1970's a centralized water system was established utilizing water from two streams flowing out of caves and the limestone rock. These sources of water suffered from contamination due to pollutants caused by human and animal wastes in the watershed. The water from the watershed and the centralized water system are not safe for human consumption.

Observations

The current mission to Tonga revealed that few changes have been made following the previous visits and associated recommendations. Forestry personnel and those responsible for watershed management have not seen the reports for these missions or the recommendations. There seemed to be a great deal of confusion on Tonga about the progress being made in fencing the watershed boundary on the island of 'Eua and determining who was responsible for activities within the watershed (i.e., growing of food crops). A fence has been constructed along a watershed divide to prevent pigs and animals from entering the watershed but crops continue to be grown within the fenced area. There are plans to relocate residents that currently live within the watershed boundary but there are problems with road access and a final decision has not been made on where to relocate the current residents.

Little progress has been made in correcting water supply and delivery problems on Tonga. Water intakes are subject to pollution and at times must be cut off due to heavy loads of sediment. There are also intakes that take water directly from a stream with no filtration. There is no regularly scheduled water testing for bacteria or streamflow. Road erosion is severe and consequently access to the water intakes is challenging.

Recommendations

Based on observations of the current mission the following recommendations should be implemented to protect forest resources and water quality:

1. Coordination must take place between the Tonga Water Board, Land Survey Office and the Forestry Department on 'Eua to develop a watershed management plan for 'Eua.
2. A full time watershed manager should be assigned to manage the 'Eua watersheds.

3. Water intakes must be improved by constructing sand/gravel filtration beds and installing geotextile filter cloth.
4. Water chemistry and streamflow testing should be done on a scheduled basis.
5. Road drainage should be improved and roads should be bladed and surfaced to provide better access to water intakes.
6. Watershed land being used for agricultural crops should be reforested.
7. The plan for relocation of farms within the watershed boundary should be implemented as soon as possible.
8. A training program should be implemented for personnel responsible for watershed management, monitoring and community awareness and participation.

The Tonga Water Board has been promised a grant of \$1.7 million from the government of New Zealand to implement a project to make the necessary improvements regarding the water supply but it is contingent on relocating homes and farms that are currently situated in the watershed.

The Project objectives are:

1. Develop appropriate catchment management guidelines to ensure the required quantity and quality of water available to the current and future reticulated system demands.
2. Develop a project management structure and provide an outline of management and administrative procedures appropriate for the 'Eua water supply.
3. Determine the potential economic, social, environmental and political benefits, costs, risks and constraints for project activities and outputs.
4. Provide a detailed design for the 'Eau Water Supply Improvement Project that will achieve the desired objectives, have a positive development impact and be consistent with NZODA Guiding Principles and Policy Statements.

4.4 Observations and Recommendations for Samoa (Upolu)

Background

Samoa lies in the southwest Pacific and is comprised of two main islands and seven smaller islands. The second largest island, Upolu, extends about 72 kilometers east to west and up to 24 kilometers across. Upolu goes from sea level to mountains rising 1,858 meters. Rainfall is abundant averaging from 2500mm to 6000mm in the highlands. About 70% of the population has access to water from surface sources. The major difficulty to providing an

adequate supply of clean water to the people of Upolu is the clearing of forest vegetation on natural watersheds.

Samoa is comprised of four inhabited and five un-inhabited islands containing 2,842 square kilometers. It has a population of about 175,000 people. Samoa has one of the most advanced watershed management programs in the South Pacific. Over 90% of the population has access to piped water. The abundance of water also provides about 50% of the electricity (SPREP, 1993). There are about 32,000 hectares of forested watersheds in Samoa.

Water resource management in Samoa is fragmented. The Ministry of Agriculture, Forestry, Fisheries and Meteorology deals with watershed management and hydrology while the Health Department monitors water quality standards. No agency is formally responsible for the regulation of water resources (Anonymous, 2002).

Observations

Observations from the current mission revealed that Samoa has the most progressive and well-planned watershed management program of all the small islands. The Forestry department has instituted an ambitious program to reforest the watersheds that provide drinking water and hydropower to the local communities. There have been up to 40 salaried and casual workers in the Watershed Management Unit. Samoa has a well-designed filtration system that consists of graded sand filter tanks with final chlorine treatment. Water chemistry testing is done on a scheduled basis for bacteria and the Samoa Water Authority does laboratory analysis in-house. The Forestry department has an excellent community awareness program that promotes reforestation and agroforestry. Reforestation on Samoa following recent cyclones has been designed for maximum erosion control and yet provides for agricultural crops for local farmers. Local farmers and landowners are supportive and pleased with the agroforestry approach to land management. Watershed areas are also being planted to stabilize steep slopes and landslide prone areas.

The relationship between the local farmers in the watersheds and the Forestry Department could serve as a model for the entire South Pacific. This is the result of a continuous awareness program implemented several years ago by Forestry. Numerous brochures and other training material have been prepared to enlist the help of the communities.

Road erosion and proper drainage is a concern on the island of Samoa. Roads in the headwaters of one watershed have little to no drainage. Landslides are common in the steep land and present considerable risk to water quality. Small landslides above the access road to the water filtration facility have been successfully stabilized. A local NGO group (METI) works closely with the forestry department and provides a vital link in community support and acceptance of watershed management and agroforestry.

Recommendations

Recommendations for Samoa include:

1. Assign a watershed manager to oversee the forestry program and provide training in watershed management.

2. Continue public education in watershed management and continue work with METI and other agencies in gaining public support.
3. Revise and reprint the excellent awareness materials prepared during the Watershed Management Education and Conservation Project.
4. Improve road drainage where needed.
5. Research and develop monitoring program for effects of reforestation on stream flow and water quality.
6. Use the highly trained watershed specialists in Samoa to provide training to other small island countries in the South Pacific.
7. Keep responsibilities for watersheds in the Forestry Department rather than reassign the activities to another agency.
8. Consider short-term training assignment for watershed specialists to the United States, New Zealand or Australia.

The Samoan government is currently reorganizing to consolidate 24 governmental departments to 16. There was some discussion as to having watershed management under the Department of Environment rather than Forestry. Based on our observations of the excellent program of Forestry it is recommended that the watershed program continue under Forestry with increased coordination with the Department of Environment.

5.0 WORKSHOP SUMMARY

Twenty-two people representing Cook Islands, Samoa, Tonga, Palau and the Federated States of Micronesia attended the workshop held on Samoa in August 2002. The objectives of the workshop were established to provide training on the management of forested watersheds in the South Pacific, especially for non-forestry personnel involved in managing water resources in small island countries. A secondary objective was to bring together forestry and nonforestry agencies or institutions responsible for water resources to encourage coordination and cooperation for the protection and restoration of forested watersheds. The workshop also collected information on the status of watershed problems in the small island countries and discussed training needs.

The workshop was very comprehensive and included two half-day field trips to local watersheds and water treatment facilities. Two field trips were made to demonstration areas to reinforce and illustrate concepts taught in the classroom. Members of the Samoan Forest Department, Samoa Water Board and the Director of METI also made presentations and representatives from each island country presented a country report. The following topics were covered in the classroom:

1. The hydrologic cycle (specifically on small island watersheds).
2. The role of forestry in the hydrologic cycle of small island watersheds.
3. Soil erosion principles and concepts including control and prevention.
4. Road construction techniques and principles.
5. The development and implementation of watershed management plans.
6. Water monitoring principles and techniques.
7. Impacts of land management on water quality, flow and timing.
8. Social and political influences on watershed management.
9. Multiple uses of forested watershed and low impact logging methods
10. Watershed restoration and streamside management principles

The workshop was well received and the participants indicated on the evaluation sheets that it was the best workshop they had attended. All participants indicated they would like to see future workshops developed with a similar format and would like even more detail presented. This would take more time but the islands would benefit by additional training. The workshop was interactive with a great deal of discussion with the students on their local island issues and concerns. Participants stated that they felt the objectives of the workshop were fulfilled. The participants agreed that providing water to the citizens of their respective countries must be a cooperative effort between government agencies, NGOs and the communities.

Digital photographs were taken on each island prior to the workshop and presented in Power Point slides to illustrate the individual topics that related the principles directly to the small island environment. Field trips provided an excellent opportunity for students to observe and discuss erosion problems, landslide prone areas, agroforestry practices and water treatment facilities. (The workshop plus additional training materials will be included as a CD and will be attached to this report. The USDA Forest Service will produce the CD at no cost to the Programme. These materials can be used for conducting future training sessions). Two of the island countries participating in the workshop made presentations but did not provide written country reports for the proceedings.

6.0 RECOMMENDATIONS TO HEADS OF FORESTRY AND THE SPC FOREST & TREES SUPPORT PROGRAMME FOR WATERSHED MANAGEMENT IN THE SOUTH PACIFIC

During this mission it became evident that there were issues that had hampered the implementation of recommendations made during the previous missions. Some of the problems had resulted from changes in personnel, changes in organizational structure, lack of human and monetary resources and a lack of communication. Observations with suggestions on some of these issues are as follows:

1. As far as could be determined there have been no formal follow-up (progress reports) to monitor the status of recommendations made on the previous watershed missions. It is recommended that the Programme request an annual progress report from each island documenting the progress or lack thereof in carrying out the recommendations made during the missions sponsored by the Programme. The reports should indicate reasons for lack of progress (such as the availability of funds or other obstacles). This procedure could be used for any type of mission where recommendations are made. Monitoring of progress is vital to watershed management.
2. There is a lot of expertise in watershed management in the member countries. It would be more cost effective to use consultants within the Programme rather than bring consultants from other parts of the world. The Programme should identify key individuals from member countries that can serve as specialists (consultants) in watershed management to conduct missions within the member countries. In some cases additional training or apprenticeships may be needed to prepare individuals to be Programme consultants. We recommend the development of a database for the Programme to identify the knowledge, skills and backgrounds of personnel in member countries of SPC. This database could serve as a source of consultants for future missions in watershed management as well as other Programme areas. The USDA Forest Service will assist in developing this database if requested.
3. The Programme should continue to train the staff of member countries in the technical aspects of watershed management. Use of materials presented during the current workshop as well as information from previous missions could be beneficial in planning a training program. Training modules could be prepared as Power Point presentations and made available on the Programme website or on CDs.
4. The Programme should encourage activities to create public awareness on the importance of watershed management in all small island countries. Making the government aware of the importance of watersheds and the role that government should play may be necessary in some island countries. The island of Samoa has an excellent example of a public awareness and education program that could be used as a model or prototype.
5. The responsibility for providing an abundance of clean water usually involves at least four government agencies in each island country. Often there is no one agency responsible for water. In no country is that role delegated to a government forestry organization. Many countries have water boards that are comprised of representatives from several agencies. Therefore it is important that forestry organizations have a seat on the water boards so that they can speak for managing healthy forested watersheds.

Heads of forestry should do all that is possible to make sure they have representation on these water boards in their respective countries.

6. Often forestry organizations in the member countries are not given high priority. This may reduce the capability to obtain funding and other resources to complete their missions. If possible the SPC Forests and Trees Programme should develop a plan to elevate the status of forestry in the respective island countries. It would be beneficial for the Heads of Forestry to assess their role and status and to advise SPC on a plan to assist in making their organizations more effective.

7.0 REFERENCES

- Anonymous 2002**, Country Briefing Paper on Samoa. Presented at the Pacific Consultation Meeting on “Water in Small Island Countries. Sigatoga, Fiji. 32 pages
- Baisyet, P. 1990**, Vaisigano Pilot Watershed Management Project. Government of Western Samoa Food and Agriculture Organization of the United Nations. FO:TCP/SAM/8851(A) Field Document No. 2.
- Burns, R.G. and Swift, L.W. Jr. 2000**, Reducing Low Traffic Road/Stream Impacts. USDA Forest Service (PowerPoint presentation).
- Fielea, Quddus. 2002**, Integrated Catchment Management in ‘Eua, Kingdom of Tonga. Paper presented at the Pacific Consultation Meeting on “Water in Small Island Countries” Sigatoga, Fiji. 17 pages
- Holcomb J. and Ward J. 2002**, Technical Workshop Presentations and References. Apia, Samoa, August 2002. (CD Format).
- Jahn, Hans Christoph, 2001**, Short Term Consultancy Assignment To The Island of Mangaia, Cook Islands. SPC/GTZ Pacific German Regional Forestry Project. Unpublished Report. 28 pages
- Johansen, K. 1999**, A Report on Technical Support for Watershed Management, Eua, Tonga- March-April 1999. RAS/97/330 Occasional Paper No. 2. November 1999.
- McKean, J. and Baisyet, P. 1996**, Watershed Management Workshops on Islands of the South Pacific, Tonga, Cook Islands, Pohnpei (Federated States of Micronesia) Palau. South Pacific Forestry Development Programme RAS /92/361.
- McKean, J. 1999**, Watershed Management Support Mission Mangaia, Cook Islands & ‘Eua, Tonga, 22 August-23 September 1998. RAS/97/330 Occasional Paper #1, November 1999.
- McKean, J. 1994**, Watershed Management Workshops on Islands of the South Pacific, Tonga, Cook Islands, Pohnpei (Federated States of Micronesia) Palau. South Pacific Forestry Development Programme RAS /92/361. Field Document # 5, November 1994.
- Maidment, D.**, Handbook of Hydrology 1993. McGraw-Hill. ISBN 0-07-039732-5.
- STREP - 1993**, Western Samoa. National Environment and Development Management Strategies. United Nations Development Program. Report prepared for the South Pacific Regional Environment Programme. Apia, Western Samoa. 100 pages

US Department of Agriculture, Forest Service 2000, Water/Road Interaction Field Guide. Technology and Development Program. 0077 1803- SDTDC

US Department of Agriculture, Forest Service 2002, Forest Roads: A Synthesis of Scientific Information. PNW-GTR-526.

Salafsky, Nick 1997, Eleven Steps for Setting up Community-Based Timber Harvesting Enterprises. An Overview of the IRECDP Experience in the Islands Region, Papua New Guinea. Biodiversity Support Programme. Islands Region Environment and Community Development Programme. European Union.

SOPAC - 2002, From Vision to Action Towards Sustainable Water Management In The Pacific. Sigatoka, Fiji Islands 29th July- 3 August 2002. (CD Format)

Solloway, C. 2001, National Management Measures to Control Nonpoint Source Pollution from Forestry. U.S. EPA contract No. 68-C7-0014.

Quddus F. 2002, Integrated Catchment Management in 'Eua, Kingdom of Tonga. Pacific Consultants Meeting on "Water in Small Island Countries, Sigatoka, Fiji. July 29-August 3, 2002.

Appendix A

MISSION BACKGROUND, FIELD NOTES AND OBSERVATIONS (Report Details of Mission during August, 2002)

1.0 Cook Islands

No one agency in the Cook Islands is specifically responsible for the management of island watersheds. The Ministry of Agriculture (Forestry) has, however, provided technical assistance in the areas of restoration of watersheds and reforestation on Mangaia, Atiu and Rarotonga islands.

1.1 Background And Previous Recommendations

Specific Observations and recommendations for Cook Islands (Mangaia) are described in Dr. McKean's reports (1994, 1996 and 1998). These reports were reviewed prior to visiting Mangaia and used as a benchmark to evaluate whether or not the recommendations had been implemented. The recommendations are summarized below.

Recommendations For Mangaia From Previous Reports

1994 Report

1. There should be an integrated watershed management plan that considers the entire watershed from uppermost watershed boundary (catchment) to lagoons.
2. The program should focus on erosion control, revegetation, soil loss monitoring, water quality measurements and monitoring, water supplies and public awareness.
3. A watershed management program should be formally established through legislation and a review should be done to see if existing watershed management is required but not being carried out.
4. A study should be done on all islands to identify and map watersheds that are source areas for water and human consumption.
5. Special guidelines and regulations should be established for land use in "source" watersheds to protect quality and quantity of water.
6. Public awareness programs are needed to provide education on water pollution, soil erosion, effects of fire, sewage, etc. The environmental linkages between environmental conditions and quality of water must be conveyed to island inhabitants.
7. Training in watershed management for personnel responsible for watershed management should be provided

8. A new watershed management program should begin the following:
 - a. Revegetate to slow or prevent erosion in abandoned pineapple fields.
 - b. Begin a basic long term monitoring program for rainfall, erosion, stream flows and water quality.
 - c. Use monitoring information to design rehabilitation programs and evaluate the impact of land use such as revegetation.
9. Monitor and control use of agricultural chemicals, sewage disposal, and trash disposal.
10. Ministry of Marine Resources should begin a study of existing conditions of lagoons and reefs and their tolerance to sediment.
11. Evaluate condition of roads on Atiu and close unneeded roads.
12. Begin a program to repair and stop erosion and damage on existing roads.
13. All new roads should be carefully planned, constructed and maintained.
14. Maintenance of ground cover during planting of pines should be an integral part of reforestation.
15. Reforestation on Atiu, Mangaia and Rarotonga should be planned for maximum soil conservation.

1996 Report Summary

1. Forestry should concentrate their efforts on lands where owners agree to pine reforestation as well as gully control.
2. Establish control and managed slopes to measure erosion and measure cross sections of streams to measure sediment input.
3. Provide training to Forestry Tech Staff in areas of erosion, sediment concentration, stream flows, rainfall, gully erosion and control.
4. Develop information on pine plantations to determine harvest levels to minimize soil erosion.
5. Develop a map of extent and severity of erosion on island of Mangaia.
6. Fine tune gully stabilization efforts by including the following:
 - a. Construct spillways in check dams to focus water in the middle of the dam.

- b. Plant clumps of vetiver grass just downstream of check dams to slow velocity.
 - c. Plant vetiver grass on slide slopes just upstream of the dams and along the gully bottom at the bottom edge of the gully wall.
 - d. Divert water away from gullies with diversion ditches.
 - e. Stabilize head cuts by sloping back to angle of 45 degrees- plant with vetiver grass.
 - f. Test feasibility of using only vetiver grass in gullies.
7. Make fire management a high priority for forestry and monitor plantations for outbreaks of disease.
 8. Plant local ferns in open areas where rill erosion is occurring.

1998 Report observations and recommendations

1. Wire installed to protect water source intakes has been trampled and fences need repair.
2. Metal pipes from cisterns are corroded and should be replaced with plastic. Plastic and gravel should be wrapped with geotextile fabric.
3. When pipes are replaced evaluate the possibility of moving the pipes to collect more water or improve pressure. Pipes should be 35-40 meters higher than village use point for 30 psi at outlet of pipe.
4. Tests for nitrates, phosphates and turbidity should be done in all watersheds.
5. Planting of pines should be done on remaining gaps (around 50 hectares). Seeds and equipment are available.
6. Vetiver grass should be planted along the base of the walls of the gullies and deep-rooted trees should be planted in sediment deposits in the gullies and also outside the hillslope areas.
7. Closely spaced pine trees should be planted in old pineapple plantations to prevent rill erosion from developing into gullies.
8. There is a need for a strong fire management plan and public education regarding fire prevention.
9. If logging is resumed when plantations are mature the logging should be done to control erosion (i.e. limit clear cutting).
10. It is recommended that a paired hill slope study be done to monitor erosion.

11. A public education program should be instituted to train people to properly clean and maintain their catchment tanks.
12. Monitoring should be done on a regular basis for rainfall, runoff, bacterial contamination, nitrates, phosphates, chlorides (salts) and turbidity.

1.2 Field Notes and Observations From Current Mission

8-10-02

We arrived at the airport where we were met Mr. Jan Christianson, owner of Ara Moana Bungalows, one of the two hotels on the island. Christianson has a great deal of knowledge about the location of the water intakes on the island, as well as historical knowledge on maintenance and water supply problems. Due to the absence of any government officials we decided to accept Christianson's offer to show us the water supply intakes on the island. In addition to showing us the water intakes he provided a local residents perspective on land management, water intake problems and watershed issues.

8-11-02

On August 11, 2002, Mr. Christianson reviewed the previous reports from 1998 and 1996 by Dr. McKean and agreed with most of the information in the reports but indicated that elevations for the intakes may not be accurate. For example, the Karanga intake was estimated at 95 meters and Mr. Christianson believes it to be around 70 meters. We did not have a GPS unit to confirm.

Our first field stop was the Oneroa (Keia stream) lower water intake. The intake was designed with a filter bed of gravel, fine sand and an upper layer of gravel as a filter bed that covered perforated pipes. The lower intake was, however, using surface water that was going straight into the delivery pipe. The intake surface was covered in thick silt and red clay. The sides were lined with well-placed gabions, which protected the intake structure. The McKean (1998) report indicated that this lower intake was around 80 meters. A priority for this intake should be to clean the filter beds. For all the intakes we visited on Mangaia we discussed the benefits of installing a layer of filter cloth (geotextile fabric) over the coarse gravel to protect the filter bed from accumulations of silt and clay. The filter cloth would allow water to pass through and help keep the filter beds clean requiring less maintenance. It would also be easier to clean the silt off of a smooth layer of filter cloth than from the top of coarse gravel.



Figure 1. Lower Keia Intake Oneroa

We next visited the upper Keia (Oneroa) intake. The intake cover was removed which revealed a great deal of sediment and red slime covering the overflow pipe. The stream just above the intake was rust colored indicating a great deal of sediment had been flushed down to the intake. This was probably due to continued erosion of the stream banks since a major storm that had occurred in December.

The intake filter beds should be replaced with clean sand and gravel and covered with a filter fabric as recommended for the lower intake. The water from the intake at the upper intake was flowing through the filter bed.



Figure 2. Keia upper intake cover removed showing poor water quality.



Figure 3. Keia upper intake filter bed showing poor water quality

Water from the two Oneroa intakes (Keia stream) flow by gravity to a tank located downstream and above the taro fields. From here the water is pumped to a storage tank on the ridge top above to provide head to the village below. An additional tank that collects rainwater is adjacent to the collection tank. The storage tank below the intakes was filled to capacity and overflowing in a nearby taro field. A new pump that had been recently installed was running at the time of our visit. The two tanks above had a vertical capacity of approximately 2.4 meters and the tanks were just over a meter full. We believe that a higher capacity pump would deliver more water to the tank and prevent observed overflow losses from the lower tank.



Figure 4. Upper Keia storage tanks (red tank is secondary storage)



Figure 5. Keia lower storage tank and pump house

We also discussed improving efficiency of the pump by moving the upper storage tanks to a lower elevation. This could be done without a significant loss in hydraulic head.



Figure 6. New pump near lower storage tank

After the visit to Keia we traveled to the Veitatei intake site (Tipitaru stream). This intake serves the village of Tanarua even though it is in the Oneroa District. The road had been cleared for access (small slides that had blocked the road had been cleared (Figure 7).



Figure 7. Recently cleared road to Veitatei

The Veitatei intake could not be located. We later found through discussions with the Mayor that it had been completely buried during the December storms. The intake was functioning at low pressure even though it had been buried. The water district manager indicated there were plans to clear the material from Veitatei and clean the other intakes by the end of October. Next, we drove the road that accessed the Karanga Intake (Vao Roa) water supply. The road was not passable due to the December storm that washed out a large culvert (1.2 meters) and severed the water pipe. The water pipe had been replaced but a new culvert will not be installed until October of 2002 (Figure 8).



Figure 8. Road to Karanga intake showing where culvert washed out.



Figure 9. Recent pineapple field planted vertically above road is already showing signs of erosion.



Figure 10. Typical taro field on Mangaia

The Karanga intake is inspected 2-3 times a month by walking the access road. The remainder of the afternoon was spent looking at pineapple fields, taro fields (Figure 10) and roads on the islands. Some recent pineapple fields are still being planted vertically instead of on the contour as shown in Figure 9 above. It was mentioned that the pesticide Paraquat was being used on the taro fields to treat competing vegetation and the farmers indicated it was a safe chemical to use. Paraquat is very poisonous and could be lethal if ingested.

8-12-02

Meeting with the Mayor of Mangaia

We arranged to meet with Mayor Taata Tangatakinu to discuss the purpose of our visit and hear from the Mayor, the Chiefs and his council. The Mayor invited others from the Island Council, Agricultural Office, and Administration to participate in the meeting.

After a welcome and introduction of the Island Council the Mayor mentioned a previous meeting where the council and people were encouraged by a consultant to be more responsible for watershed management. They indicated that they had not read nor received the reports or recommendations that had been made by the earlier consultants. When asked about the intake that had been buried during the December storm, Ora Harry, who oversees the water intakes and also other infrastructure on the island, mentioned that Veitatei intake was still functioning but with very low water pressure. There are plans to clear the intake in the next couple of months along with additional work on all water intakes. Ora described the road crossing that had been washed out and reaffirmed that the crossing on the road to Karanga was destroyed and would be replaced with a new culvert as planned. The pipe that was lost was approximately 1.2 meters in diameter. The new pipe will be larger and consist of a stainless steel arch type culvert. The new culvert has already arrived on the island and will be installed soon.

In discussing the pine plantations, Mayor Tangatakinu mentioned that the reforestation efforts were to prevent soil erosion with a secondary objective to harvest the pines as a commercial crop sometime in the future. Some areas could be thinned now but the major harvest should occur within five to ten years. Figure 11 shows the typical size of pines that have been thinned (approximate 40 cm in diameter).



Figure 11. Pine plantation on Mangaia Island after thinning

We then asked about management of the watershed area and if activities are controlled or restricted to protect water quality. The council mentioned that animals are not allowed beyond the water intakes but if animals are found beyond the water intakes court action will be taken by the Council. Fire is also prohibited above the water intakes. We saw numerous “No Burning” signs during our field visits. We asked what the Council’s priority was for their watersheds and the Mayor indicated it was to keep up the maintenance of the water intake systems. There are also no settlements in the watersheds.

We asked about water testing and how it was conducted. Water samples are taken and sent to Rarotonga for testing. This takes a long time and there is no equipment available on the island to do the testing. On the field trip the following day we spoke to Ora Harry about getting some sample test kits for the islands to demonstrate that water tests could be done more quickly. No chemical tests are being done at this time (i.e. nitrates, ph).

There is a concern by the council that if water-testing equipment was purchased for the island of Mangaia it may be diverted to Rarotonga and never reach Mangaia. Even though this has been a problem in the past, the Mayor mentioned they still must go through the proper protocols to get equipment. Because of this problem, Canada is now bypassing the government agencies in Rarotonga to get equipment to Mangaia. When asked about training needs the Council summarized training needs as follows:

1. Biological testing conducted on the island.
2. Rainfall and stream flow measurements.
3. Training on how to measure water consumption and track water availability.
4. Training in water conservation and education. Television is now being used in addition to one-on-one awareness training.
5. Training in timber harvesting and road building. Harvesting will be done in the future but no harvest plans or guidelines have been developed.

We suggested that before harvesting is done the island should develop a set of standards for harvesting to insure that logging is done in a manner to protect the resources on the island. They agreed that they do not want to end up with other erosion problem like the one that occurred in the pineapple plantations. We discussed the use of a portable mill and how it could be set up on site to avoid some of the environmental damage from logging. The mayor was told that a portable mill could cost in the range of \$25-\$30 thousand dollars (New Zealand currency). There is a good reference available for setting up a community-based timber harvesting enterprise (Salafsky, 1997). Pruning of the pines is currently underway. Pruning is labor intensive but will greatly increase the value of the trees (Figure 12).



Figure 12. Recently thinned pine plantation on Mangaia

Critical needs for the island include guidelines for forestry, road building, and timber harvesting. In the interim, example guidelines developed in Fiji can be sent to Mangaia. We agreed to meet again with the chiefs and Council after we had a chance to do a further field review.

The Mayor mentioned that in the past tourism was not encouraged because there was a fear that they would lose their traditional values. However, they now see the value of limited tourism as long as impacts on their cultural values and the environment were minimized.

Following the meeting with the Mayor and Council members, Ora Harry, Island Construction Supervisor and Unlucky Tungata, Agricultural Officer, accompanied us on a field tour of the water intakes and upper watershed areas. Our first stop was to walk the road past the section where it was washed out by the December storm to observe the Karanga Intake structure. The road was well vegetated and grass was growing on most of the surface with little or no erosion (Figure 13).



Figure 13. Road to Karanga Intake stabilized by planting grass

The cut banks were also well vegetated. The forest floor above intakes was covered with dense ferns under the planted pines. Some areas under the hibiscus trees were barren but there seemed to be little surface erosion from these areas. The major sedimentation in the stream seemed to originate from bank erosion and recent slides along the road (Figure14). The road will need to be bladed and stabilized and the banks will eventually heal themselves. This seems to be a natural process. The people are concerned about the Eucalyptus trees planted along the road to help stabilize the stream banks. They have heard that these trees use a lot of water thereby reducing the amount of water in the stream (Figure 15).



Figure 14. Slide on road to Karanga water intake



Figure 15. Eucalyptus Trees planted on Karanga Road

The Karanga intake was similar to the previous intakes we had observed earlier. There was silt deposition on the surface and the intake needed cleaning. Gabions placed on the sides of the intake were providing erosion control at the intake (Figure 16).



Figure 16. Karanga intake filled with silt from erosion

After leaving the Karanga water intake road we traveled to the town where we observed a recording rain gage designed to transmit data to Rarotonga. Ora indicated he has not seen the records and it is questionable if the rain gage is operational. We then visited the upper pine plantations (old pineapple plantations). The pine and fern have been successful in controlling erosion. Some of the old furrows were barely visible and groundcover is excellent as shown along the road in Figure 17.



Figure 17. Road through old stabilized pine plantation



Figure 18. Large gully below road in process of stabilization

Most erosion problems occur on the roads that traverse the ridge tops. Much of this erosion could be corrected with proper drainage (dips and water bars) and some surfacing with rock in the through cuts. The pine and vetiver are working very well in the gullies.



Figure 19. Vetiver grass and ferns in gully are slowing erosion

Erosion was controlled in the largest gully observed as indicated by the outlet onto a field of fern so there was no soil moving further down slope to a field of ferns as shown in Figures 19 and 20.



Figure 20. Outlet of large gully showing successful stabilization

8-13-02

The following day we met with the Mayor, chiefs and members of the Island Council to discuss our field findings and recommendations. The Mayor introduced the chiefs and Island Council members and thanked us for meeting with them. He was very cordial and gave us an overview of the different districts on the islands and the villages.

The Mayor explained there was no court on the island of Mangaia to handle land issues. No judge, no lawyers, no jail. There was a jail in town but he tore it down. Small crimes are punishable by community service. If a problem is not resolved by the chiefs it is dealt with in New Zealand. The people of the island respect the chief's decisions and they have the respect of the people. A 1996 law transferred the responsibility for central government to the local island governments.

There are 3 villages and 6 districts on Mangaia. There are 44 sub chiefs and a population of just under 700 people. The island is losing people as the young ones move away to New Zealand and do not return.

We discussed the importance of using low impact harvesting to minimize the damage to soil and water in the watershed. We also briefly discussed the use of sodium borate to protect milled logs and lumber. It is being used successfully in the U.S. and much safer than many other preservatives.

We also discussed training needs for monitoring and water testing and the need for a fire plan and a plan to treat logging slash to prevent wildfires. Other issues included the use of geotextile filter cloth to protect the water intakes and filter beds and the need to establish priorities to correct water intake problems. The intakes should be cleaned out and the road should be repaired. The council also mentioned that some water leakage may be a problem but they do not know the extent.

We discussed training needs with Mayor Taata. He was concerned about who would receive the training. Taata felt the local people that deal with the water problems should be sent to the training. He indicated that the people that are usually trained are not the people that are responsible on the island so the benefits of training may not be realized on the island. We agreed that training at the local level would be in our report recommendation.

They questioned whether or not the pine that was thinned could be treated and used for posts and construction. There was also much discussion about how the island planned to use the harvested pine. For example, how much would be used on the island and how much would be exported. There is no current plan in place. The island also needs to develop an island forestry guide on practices that will protect the soil and water during harvesting. If the pine were used to make furniture on the island they would need training and machinery. The island has no facility to do that at the present time.

One of the chiefs asked if the geotextile material for the water intakes could be used on the sides of the intakes for erosion control. We explained that the material is often used to contain erosion and the fencing could be used for this purpose.

There were discussions about treatment of water to prevent bacterial contamination. The idea has been explored and Rarotonga responded that it would be too expensive. I found out when we visited Rarotonga that they have no chemical treatment of their 8 large water intakes. The sand/gravel/ intake filters seems to work well and there has been no water contamination. Taata is concerned that a water contamination problem could wipe out his people because the catchment area is so small and felt it should not be that expensive to treat the water chemically.

We talked about getting support from SPC for Geotextile filter cloth and also information on portable saw mills, test equipment, and the preservative sodium borate. We also discussed the need to have a watershed management plan. The mayor and council indicated that they would like someone to assist in preparing forest harvesting and watershed management plans.

We found that no one on Mangaia or Rarotonga had seen any of the four previous mission reports. This is astounding since we are reviewing how previous recommendations have been carried out and no one knows about them. The ministries we talked to in Rarotonga said they had no jurisdiction or influence on any outer islands and that island watershed management issues are handled by the Ministry of Outer Islands. We were told this office is overworked and understaffed. Consequently, funding to assist Mangaia would not go through forestry (agriculture) in Rarotonga but must come from the MOI.

1.3 Parting Comments on Mangaia

The mayor of Mangaia, his tribal chiefs, and forestry personnel are to be commended for their excellent work in planting trees and effective erosion control. Much of the erosion from abandoned pineapple fields has been significantly curtailed and the island is actively working on upgrades and maintenance of their water intakes and delivery system. Recommendations are presented earlier in this report.

1.4 Summary of Visit to Rarotonga

Although the mission did not include a review of the water systems and watershed management on the Island of Rarotonga, we asked for an island overview of water intake structures and delivery systems since we would be addressing watershed management in the workshop and Cook Islands would be sending participants to the workshop.

On 8-14-02 we left the island of Mangaia and flew to Rarotonga (via Auckland) where we were met by Sabati Solomone and others from the ministry of works. Daryl Rairi and Sabati Solomone gave us an afternoon field tour and explained the basic filtration process on Rarotonga, which consists of filter beds on the 6 intakes that serve the island (Figure 21).

We visited the Tupapa intake that has been improved with a filtration system made of a series of ring filters (Figure 22). The system is on a trial basis and there are problems with sufficient pressure to backwash the filters so it is done manually.



Figure 21. Typical filter bed intake on Rarotonga (Tupapa Intake)

There had been an attempt to move the filters down slope to get more hydraulic head but there was resistance from the downstream property owner to having the filters on her property. Bacteria and chemical tests are done approximately every 3 months. We discussed training needs and concerns about water contamination.



Figure 22. Ring Filter system for Tupapa water system

We then met with Nga Mataio, Secretary, Ministry of Agriculture. Nga provided some historical background on the pineapple industry on Mangaia. In the 80's Mangaia and Atiu were major producers of pineapple and they had a closed market and preferential trade agreements with Australia and New Zealand. The markets were then opened to other countries and the pineapple business began to slump with lowered prices and higher costs for production. When the fields were abandoned the erosion process began. It was then decided to plant pines and vetiver to arrest the erosion.

Now forestry is under the island council and there is no forestry department and no commercial business. The total area planted in pine is just over 1000 hectares. We discussed the need for a forest management plan and talked about the use of sodium borate to treat lumber and the idea of using a portable mill. Nga said they do have a portable sawmill on Rarotonga that operates on an as-needed basis. Nga mentioned that there was concern from the people about the uptake of water by the pines. The elders in the town claim there was more water before the pines grew. I explained that the pines do take up water but more water is actually available over the long period because the vegetation regulates the infiltration of water into the groundwater that provides streamflow on a regular basis. Without the groundcover and interception by the trees the water runs off more quickly and is lost to the ocean. It is always better to have the vegetation to naturally retain runoff and regulate streamflow with the added benefit of erosion control. There may be a reduction from the Eucalyptus planted directly along the streams and this could be remedied by partial removal now that the stream banks are stabilized.

Nga asked how long it would be before the pines are ready for harvest. We estimated it would be in the next 5-15 years. After visiting TUPAPA we discussed maintenance of the water intakes on Rarotonga. The Ministry of Works has been focusing their effort on fixing leakage problems in their delivery system and replacing old pipe with PVC pipe. Once this is done the ring filters will be installed below the other intakes.

It was explained that MOID is responsible for the outer islands such as Mangaia and not the Ministry of Agriculture. The MOID has only one engineer working on all projects including water and with a full workload there is little time to devote to specific water issues. This seems to be a major obstacle in obtaining support to improve the existing water systems. We see this as a major obstacle in completing some of the needed recommendations.

2.0 Kingdom of Tonga - Description

Fresh water is a scarce resource for the small-scattered islands of the country. The main sources of water for the population are either rainwater or well water from a lens of fresh ground water overlying salt water beneath the islands. The island of 'Eau is the second largest island and is located 40 km southeast of Tongatapu. It is a high limestone island covering about 8900 hectares and contains one of the few watersheds in the country.

It is riddled with limestone caves and sinkholes from which water is collected and distributed through a water system to the population. Unfortunately the water is unclean because it is contaminated by human activities in the areas that drain into the limestone caves.

A report by Fielea (2002) presented at the Pacific Consultation on “Water in Small Island Countries” summarizes the water issues as follows: “ The main catchment management issue on ‘Eua is water quality degradation caused by activities within the catchment. The majority of the existing ‘Eua water quality problems are caused by impurities entering the water in the catchment area. The limestone covering most of ‘Eua contains interconnected cavities which allow rapid flow of water both horizontally and vertically. The surface soil horizons cover steep catchment surfaces and significant transport of eroded soil, vegetation and rock occurs during heavy rainfall. The combination of limestone and soil produces rapid deterioration of water quality during wet weather periods. Clearing of trees and increase in farming and stock raising has contributed to a progressive reduction in the water quality. This is because loss of vegetation from farming activities and stock raising promotes soil erosion”.

2.1 Previous Recommendations

Reports from visits to ‘Eua in 1993, 1995 and 1999 made specific recommendations to improve water delivery and provide protection for water quality. The summary of the recommendations is cited below.

Report 1993

1. Protect upland portions of the water supply watersheds. (Ministry of Agriculture). Manage and protect areas immediately around the water intakes in the caves and streams. (Tonga Water Board “TWB”).
2. There should be forestry representation on the TWB.
3. Water Intake structure should be made more efficient through improvements.
4. Begin a water quality monitoring program with sampling and testing at Heke, Saa, and Matavai watersheds.
5. Convert farming leases back to government with management by Forestry for watershed protection (114.5 ha in Saa and Matavai watershed and 39 ha in Heke).
6. Do not allow further land allocations for farming or other uses within the watersheds listed in recommendation 5 above.
7. Train forestry personnel in principles and techniques of watershed management.
8. Forestry Department should begin a public awareness and extension program that addresses measuring techniques and cooperation with the public.

Report 1995

1. Install central storage tank capable of holding 150,000 gallons of water to be used during periods of heavy rain when the stream water is muddy.

2. Specific improvements recommended:
 - a. Install pump for water delivery from lower cave to storage tank.
 - b. Enlarge damn at Shower-Cave intake point.
 - c. Construct new dam at Matavai intake.
 - d. Construct new dam at Shower-Cave intake.
 - e. Install diversion valves at each intake (for heavy rains and muddy water).
 - f. Install a chlorinator system for water storage tank.
3. Improve system of screening leaves from the TWB water intakes.
4. Extend fence to protect water supply areas for Matavai and Saa.
5. Continue forestry extension program and provide training in West Samoa for Technical Staff of Agriculture and Forestry.

Long-term recommendations

1. Testing of water quality in source areas should be done cooperatively with the Ministry of Agriculture and Forestry and the Ministry of Health.
2. Forestry should begin a program to measure rainfall and stream flow on 'Eua.
3. Tonga Water Board should obtain a conductivity meter to test salt in water from boreholes.
4. Finalize proposed land exchange and manage land by Ministry of Agriculture and Forestry.

Report 1999

1. Assign a full time watershed manager with ability to monitor, manage and maintain watersheds.
 - a. Reforest farms that were in the watershed
 - b. Construct fences and gates to prevent entry into the watershed
 - c. Remove pigs from the watershed by hunting
 - d. Continue investigation of water pollution sources
 - e. Test for water pollution
 - f. Obtain rainfall and stream gauges and record data daily
 - g. Monitor and track changes in watershed (rainfall, stream flow and water quality)
 - h. Monitor and report erosion in unstable areas
 - i. Plan and oversee road improvements
 - j. Maintain forest roads

2. Perform a multiple-use forest planning watershed analysis on the watershed using an interdisciplinary team.
3. Improve portions of road with rock surfacing and improve drainage.
4. Map soil erosion and sedimentation sources. (Focus on cave joints, secondary tunnels, drip areas or side channels within Fern Gully and up stream of Ana Peka Peka and Matavai weirs).

2.2 Field Notes and Observations from Current Mission

8-8-2002

Mr. Taniela Hoponoa, Officer In Charge, Tonga Division of Forestry met us at the airport. We explained our mission to Mr. Hoponoa and asked for assistance in meeting with a representative from the Tonga Water Board. We explained to Mr. Hoponoa that our mission was to assess improvements that have been made on 'Eua since the recommendations from the previous visits.

Our discussions with Mr. Hoponoa revealed that the watershed boundaries have not been completely established and the people now living within the drinking water supply watershed will need to be moved. He was not sure when this would happen. New Zealand had funded the watershed program since 1996 but has pulled out because the watershed boundaries had not been established and trees that were planted within and beyond the watershed boundaries had been harvested to plant agricultural crops.

The land near and within the watershed was split up and given to Tonga people to continue farming. New Zealand demanded that the catchment areas be defined before they provide additional monetary support. There is apparently no clear legislation to accomplish this task.

No full time watershed manager has been assigned responsibility for the watershed program as previously recommended. A watershed analysis or watershed plan has not been completed. However, the current Minister of Lands has completed a survey of the boundary.

Mr. Hoponoa mentioned there is a problem keeping wild pigs out of the watershed. Some fencing has been done on the western edge by the outlet of the watershed. Fencing and maintaining the entire watershed would be difficult, but given its small size it could be done.

The outlet of the watershed has not been reforested and trees are still being harvested for local use. There is no control of land use in this area because it is out of the catchment area proper. Once landowners in the watershed are relocated – about 62 people which occupy 100 hectares- the land will be managed by the 'Eua Forestry Division (The Tonga Timber Limited).

Mr. Hoponoa believes there has been some attempt to fence the watershed. We found out in a later discussion with the head surveyor in the Ministry of Lands that only the stream on the western edge had been fenced and not the entire watershed.

Meeting with Simone Helu- General Manager of the Tonga Water Board

Mr. Taniela arranged a meeting with Mr. Simone Helu, General Manager of the Tonga Water Board. We explained our mission as one of conducting a follow-up on previous recommendations and that we would be presenting a comprehensive workshop in Samoa. Mr. Helu indicated that he strongly supports the role of Forestry in watershed management and said he has been trying to encourage others to plant trees and conserve the watershed areas. He said there was around 150 acres on Tongatapu that should be planted and maintained as well to improve the watersheds.

Mr. Helu indicated that when legislation was developed he encouraged and stressed the importance of watershed protection. We mentioned concern from people about water pollution from the settlements in the watershed and it was Mr. Helu's understanding that the forestry people had fenced the watershed. However, he confirmed that a watershed manager has not been assigned to 'Eua.

Water testing is done every 30 days and they have found that the water does get contaminated from animals with high fecal coliform counts being detected. He also said that the sand filter beds regularly become clogged and need to be cleaned out. I talked about using geotextile filter cloth to improve the intakes and he said that could be done later.

Meeting with Mr. David Alatini

We later visited the Land and Survey Office and met with Mr. David Alatini and Seli Tafua, Deputy Chief Draftsman and Assistant Senior Draftsman respectively. David indicated the watershed boundary had been completely mapped and the final work would be presented to the Minister of Land Surveys within in a couple of weeks. The survey will also be provided to Mr. Simone Helu. David Alatini again indicated that approximately 62 landowners would need to be moved.

Reports were made that people employed by the Tonga Water Board were actually cultivating crops just within the watershed boundary. Crops can now be successfully grown since the pigs have been fenced out of this area around the Western boundary. The fence removes the pigs but then farmers can cause more damage as they remove trees for their crops. It was claimed that the pigs root around and cause little erosion but they can also pollute the water by entering the stream directly.

Alatini had visited the area and noticed for himself that the lands being sectioned off from the pigs was now being cultivated.

We arrived in 'Eua in the early afternoon and met with Maloni Havea, Technical Officer and Sitiveni Hamani, Officer in Charge for Forestry. A volunteer from Japan (similar to U.S. Peace Corp) also accompanied us in the field. We were taken to the lower and upper water

intake sites by driving the east side divide of the watershed boundary. Both intakes took water directly from the stream without the benefit of a filter bed of gravel and sand.



Figure 23. 'Eua upper water intake coming out of a cave

The upper intake however was deep inside a cave to avoid water contamination from bats (Figures 23 and 24). We were told that when it rains the water becomes so muddy that a valve must be shut off to avoid the water going into the town of 'Eua. We visited the site where the watershed boundary had been fenced and taro crops were planted within the fenced watershed boundary (Figure 25).



Figure 24. Discussion between James Ward and Sitiveni Hamani



Figure 25. Taro crops grown within the fenced watershed boundary

2.3 Recommendations for ‘Eua

The current mission to Tonga (‘Eua) revealed that few changes have been made following the previous visits and associated recommendations. Forestry personnel and those responsible for watershed management have not seen the reports from the previous missions and were not aware of the recommendations. There seemed to be a great deal of confusion on Tonga about the progress being made in fencing the watershed boundary on the island of Eua and who was responsible for activities within the watershed (i.e. growing of food crops). A fence has been constructed along a watershed divide to prevent pigs and animals from entering the watershed but crops are being grown within the fenced area. There are plans to relocate residents that currently live within the watershed boundary but there are problems with road access and a final decision has not been made to where the residents would be moved.

Little progress has been made in correcting water supply and delivery problems on Tonga. Water intakes are subject to pollution and at times must be cut off to due to heavy loads of sediment. There are also intakes that take water directly from a stream with no filtration. There is no regularly scheduled water testing for bacteria or streamflow. Road erosion is severe and consequently access to the water intakes is challenging. Specific recommendations were made earlier in the report to protect forest resources and water quality.

A project has been designed by the Tonga Water Board to improve the watershed, the distribution system and to chemically treat the water to make it safe for human consumption. Funding is contingent however on the government’s promise to move the farms and homes and animals out of the watersheds. (See Workshop CD for more information on Tonga)

3.0 SAMOA

Description

Western Samoa is comprised of four inhabited and five un-inhabited islands containing 2,842 square kilometers. It has a population of about 175,000 people. There are extensive forested watersheds that receive an annual rainfall of 2926 millimeters. Water is so abundant that hydropower is produced. Samoa has one of the most advanced watershed management programs in the South Pacific.

3.1 Field Notes and Observations

We arrived in Samoa where Maturu Paniani, Senior Forestry Officer, Samoa Ministry of Agriculture and Forestry met us at the airport. Mr. Paniani introduced us to Sami Lemalu, the Assistant Director. We spoke very briefly with Mr. Lemalu about the purpose of our trip and what we planned to do in Samoa. We agreed to spend Thursday and Friday in the field with Maturu Paniani to review sites for the workshop field visits. We would spend the weekend in preparation for the workshop.

During our conversation with Sami Lemalu he briefly mentioned there were currently 24 Governmental Departments with a reorganization plan to consolidate these into 16 departments. There was some speculation that watershed management may be moved from the Forestry Department to the Department of the Environment.

In the afternoon we met with Toni Leutele acting assistant director for Sami Lemalu. We asked Mr. Leutele what he thought would happen with the reorganization. He was unsure but thought there was a move to put forestry, watershed management and the water board under the Department of the Environment. Maturu Paniani then took us to the site where the workshop would be held. He showed us the nursery where trees (Poumuli) were being grown for posts. Most of the private homes in Samoa within the 50 villages are open post homes so there is a good market for the pole trees.

8-24-02

We met with the Assistant Director of the Environment, Faumuina Sailimalo Pati Lu. He indicated there was a need on Samoa to look at things more holistically and to put agencies under more central authority. For example there is little information available on the supply or quantity of water before it is distributed. One agency should have responsibility for insuring that water is available and sustainable with more of a focus on the source of water. He said there is a need to rethink the Agricultural/Forestry benefits and a need to come up with a balanced approach for food, stable land and clean water.

In the afternoon we met with Dr. Walter Vermeulen, Director of Matuaileoo Environment Trust Inc (METI). METI is a non-government organization that helps local people by educating them and teaching self-reliance. Dr. Vermeulen briefed us on a current watershed management project funded by the University of Holland and Belgium where a flume is being constructed that will measure runoff, erosion, and other hydrologic parameters. The

objective of the project is to identify source areas of erosion to determine where agricultural crops occur.

Dr. Vermeulen explained METI helps people understand the consequences of their actions. He said it is important that people develop an understanding of farming and effects on water quality but there are also other issues. For example, there is tension between people that live in the upper part of a watershed and other village citizens and many have health problems. People must deal with these communication and health problems before they will listen to your concerns about the environment and water quality. Many Samoans also suffer from sleep apnea and Dr. Vermeulen has opened a clinic to help people deal with these and other health problems.

We asked Dr. Vermeulen if he would consider speaking at our workshop about the NGO activities and he agreed to make a presentation.

We later met with Mr. Malaki Iakopo, Director, Department of AFF&M, (Ministry of Agriculture, Fisheries Forestry and Meteorology) where we discussed the importance of watershed management and protection including cultivation/reforestation. The villages depend on good watershed management for their livelihood and it is especially important that very steep areas be reserved for watershed protection. Mr. Iakopo indicated that the government needs legislation to reinforce the attitudes and perceptions about the protection of watersheds.

3.2 Field Trip and Class Demonstrations

We chose the upper water intake of the Vaisigano Watershed, the water storage and treatment area, and the headwaters of the “Falefa” watershed for the field trip. These areas were selected to demonstrate water sampling by the Samoa Water District, discuss landslide processes, illustrate road drainage/erosion problems, and the concept of disconnecting streams from roads.

We first visited water intakes on the Vaisigano watershed, the water supply for the city of Apia (Figure 26). Three main drainages in the Vaisigano watershed converge to serve Apia). A hydro power station is also located near the water storage and filtration area on the river (Figure 27).

Following a cyclone some 10 years ago fast growing species were planted in the steep headwater area of Vaisigano to prevent severe erosion. On the midslopes crops were planted along with trees to provide food and control erosion. Lower in the watershed where the villages were located people were encouraged to plant ornamental trees and shrubs. This agroforestry approach has helped balance environmental and social needs. Farmers have been encouraged to plant food crops for the short term and mid-term as well as Poumuli trees for the long-term. taro, banana, coconut and Poumuli are some of the typical crops being grown on the many tenured plots. Approximately 80% of the land on the island is family owned or tenured land.



Figure 26. Vaisigano Water Intakes

Maturo Paniani indicated that there is also a need to research and document the effects of agroforestry on soil erosion, soil fertility, and water yield. It may be intuitive that agroforestry is a very viable and appropriate alternative to planting only agricultural crops but we must demonstrate the benefits beyond the physical observations. There is also a need to model runoff under different land use practices.



Figure 27. Water Storage tanks for Viasigano Watershed

The class discussed road construction and stabilization problems in the afternoon. Figure 28 shows the road accessing the water treatment facility and a slope where gabions were used to stabilize a small slide area. The effects of improper road drainage were demonstrated by pointing out a headcut and erosion above a small stream (Figure 29).



Figure 28. Road to water storage tanks in Vaisagano Watershed



Figure 29. Class demonstration of erosion caused by improper drainage



Figure 30. Field demonstration of water sample collection and testing.

At the water storage and hydropower site, Ms. Kuinimeri A. Finau demonstrated how water samples are taken (Figure 30) and provided an overview of the water quality parameters analyzed by the Samoan Water Authority. The class later met with one of the local farmers that practices agroforestry in the Vaisigano watershed in cooperation with the Forestry Department. The farmer was very pleased that agroforestry does provide for his food and helps prevent erosion. On the second day the class visited the headwater area of the Falefa watershed where we discussed landslide processes and erosion control on steep slopes. Figure 31 shows characteristics of old landslide remnant where trees have been planted. .



Figure 31. Old landslide remnant and tree planting.

Maturo Paniani pointed out where trees had been planted horizontally below taro crops on very steep slopes. The trees were planted to control erosion and stabilize the slopes below where the crops were planted. Figure 32 provides an overview of the Falefa watershed. Grazing does occur in the middle of the watershed but this area does not drain into a stream that is used as a drinking water source.



Figure 32. Headwater view of Falefa watershed

APPENDIX B

People Contacted During the Mission

Rarotonga (Cook Islands)

Mathilda Maria-Tairea	Legal Counsel/Project Manager
Sabati Solomone	Director of Planning, Ministry of Agriculture
Ngatokorua Mataio	Secretary, Ministry of Agriculture

Mangaia (Cook Islands)

Taata Tangatakino	Mayor
Paul Ora Harry	Island Council and Construction Supervisor
Unlucky Tungata	Agricultural Officer
Marion Harry	Finance Manager (Mangaia Island Administration)
Allan Tuara	NGO-REAP Project Coordinator
Jan Christianson	Ara Moana Bungalows (owner)

Mangaia Island Council

Piri Amataiti
Vavia Tangetataia
Peea Agauora
Upokomaki Atariki
Nooroa Ruua
Paul Orauamai
Matareu Harry
Tangmelia Oralangi

Kingdom of Tonga

Simone Helu	General Manager, Tonga Water Board
David Alatini	Deputy Chief Draftsman
Seli Tafua	Assistant Senior Draftsman
Tevita Faka'osi	Project Manager Eua Forest Plantation
Taniela Hoponoo	Officer-In-Charge Division of Forestry
Quddus Fielea	Water Engineer
Tevita Taukei Vea'ila	Environmental Project Officer
Tevita Fatai	Assistant Hydrogeologist

Island of 'Eua (Tonga)

Maloni Havea	Forestry Technical Officer
Sitiveni Hamani	Officer-In-Charge, Department of Forestry

Samoa

Malaki Iakopo	Director, Department of AFF&M
Faumuina Sailimalo Pati Liu	Assistant Director, Environment and Conservation
Iosefatu Eti	Scientific Officer (MAFFM)
Faatoia Malele	Assistant Director Met. (MAFFM)
Walter Vermeulen	Executive Director, Matuaileoo Environment Trust, Inc
Sami Lemula	Assistant Director, Division of Forestry
Tu'uau Letaulau	Community Forestry Officer

Maturo Paniani
Kuinimeri A. Finau
Nimarota Leti

FSM

Valentine Santiago
Robert H. Jackson

Fiji

Evelyn Reigber

Kanawi Pouri

Senior Forestry Officer
Team Leader, Samoa Water Authority
Training & Translator Ofcr. Matuaileoo Env. Trust, Inc.

CASO

Environmental Educator

Team Leader, SPC/GTZ Pacific German Regional
Forestry Project
Adviser, Forest & Trees Programme, SPC

APPENDIX C
Workshop Participants and Speakers
Watershed Management Participants and Contact List
Instructors: Jack Holcomb and James Ward

Name	Position	Contact Information
Mr. Iosefatu Eti	Scientific Officer (MAFFM)	Apia, Samoa Tel: (685) 20 855/22 561 Fax: (685) 20 857
Mr. Faatoia Malele	Assistant Director Met. (MAFFM)	Apia, Samoa Tel: (685) 20 855/22 561 Fax: (685) 20 857 Fmalele@meteorology.gov.ws
Mr. Tevita Faka'osi	Project Manager Eua Forest Plantation	Ministry of Agriculture & Forestry P.O. Box 14, Nuku'alofa Tonga Tel: (676) 29 500 Fax: (676) 24 271
Mr. Taniela Hoponoa	Officer-In-Charge Division of Forestry	Ministry of Agriculture & Forestry P.O. Box 14, Nuku'alofa Tonga Tel: (676) 29 500 Fax: (676) 24 271
Mr. Quddus Fielea	Water Engineer	Tonga (676) 23 299 (676) 23 518 quddus@tongatapu.net.to
Mr. Tevita Taukei Vea'ila	Environmental Project Officer	Tonga Tel: (676) 21 494 Fax: (676) 24 898 tedt@kaiagnet.to
Mr. Tevita Fatai	Assistant Hydrogeologist	Tonga Tel: (676) 23 611 Fax: (676) 23 212 fataitm@tongatapu.net.to
Ms. Mathilda Miria-Tairea	Legal Counsel/Project Manager	Ministry of Works P.O. Box 102 Rarotonga
Ata Herman	Secretary	mat@mow.gov.ck
Daryl Rairi	Acting Director of Works	Tel: (682) 20 034 Fax: (682) 21134

Mr. Allan Tuara	NGO-REAP Project Coordinator	P.O. Box 16 Mangaia (Cook Islands) Tel: (682) 34 007 Fax: (682) 34 281
Mr. Walter Vermeulen (Speaker)	Executive Director	Matuaileoo Environment Trust Inc. P.O. Box 1878 Apia, Samoa Tel/Fax (685) 21 896 meti@samoa.ws
Mr. Sabati Solomone	Director of Planning	Ministry of Agriculture P.O. Box 96 Rarotonga, Cook Islands Tel: (682) 28 720 28 711 Fax: (682) 21 881 cimoa@oyster.net.ck
Mr. Ngatokorua Mataio	Secretary	Ministry of Agriculture P.O. Box 96 Rarotonga, Cook Islands Tel: (682) 28 720 28 711 Fax: (682) 21 881 cimoa@oyster.net.ck
Mr. Malaki Iakopo	Director Department of AFF&M	Ministry of Agriculture, Fisheries, Forestry & Meteorology P.O. Box 1874 Apia, Samoa Tel: (685) 22 561 Fax: (685) 22 565/ 22 171
Mr. Sami Lemalu	Assistant Director Division of Forestry	Ministry of Agriculture, Fisheries, Forestry & Meteorology P.O. Box 1874 Apia, Samoa Tel: (685) 22 561 Fax: (685) 22 565/ 22 171
Mr. Tu'uau Letaulau	Community Forestry Officer	Ministry of Agriculture, Fisheries, Forestry & Meteorology P.O. Box 1874 Apia, Samoa Tel: (685) 22 561 Fax: (685) 22 565/ 22 171
Mr. Maturo Paniani	Senior Forestry Officer	Ministry of Agriculture, Fisheries, Forestry & Meteorology P.O. Box 1874 Apia, Samoa Tel: (685) 22 561 Fax: (685) 22 565/ 22 171 maturo_p@yahoo.com

Ms. Kuinimeri A. Finau (Field Trip Demonstration)	Team Leader Samoa Water Authority	Samoa Water Authority Tel: (685) 20 409 Fax: (685) 21 298 tonimerioo@yahoo.com
Mr. Valentine Santiago	CASO	FSM Tel: (691) 320 5409 Fax: (691) 320 5063 csp@mail.fm
Mr. Robert H. Jackson	Environmental Educator	FSM Tel: (691) 370 2076 Fax: (691) 370 2867 rhjackson@hotmail.com
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APPENDIX D

ITINERARY FOR WATERSHED MANAGEMENT MISSION FOR SMALL ISLAND COUNTRIES IN THE SOUTH PACIFIC (2002)

July 25	Depart from Atlanta, Ga. USA
July 27	Arrive in Nadi, Fiji
July 29-August 03	Attend Pacific Region Consultation Meeting on “Water in Small Island Countries” in Sigatoka, Fiji
August 05-09	Briefing for Mission and Preparation for Workshop
August 10-15	Mission to Cook Islands via New Zealand
August 17-22	Mission to Tonga
August 22-25	Mission to Western Samoa
August 26-29	Workshop in Apia, Western Samoa
Sept. 01	Depart from Apia, Western Samoa via Tonga
Sept. 02	Arrive in Suva, Fiji
Sept. 03-06	Report Preparation
Sept. 07	Depart from Nadi, Fiji
Sept. 08	Arrive in Atlanta, Georgia, USA