SANITATION AND WASTEWATER MANAGEMENT IN TONGA

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Acronyms and Abbreviations

BOD	Biochemical Oxygen Demand
CPD	Central Planning Department
DOE	Department of Environment
GOT	Government of Tonga
IWP	International Waters Programme
MLSNRE	Ministry of Lands, Survey, Natural Resources and Environment
MOH	Ministry of Health
MOW	Ministry of Works
NGO	Non-Governmental Organization
SOPAC	Pacific Islands Applied Geoscience Commission
TEMPP	Tonga Environmental Management Planning Project
TWB	Tonga Water Board
UNEP	United Nations Environment Programme
USP	University of the South Pacific

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Introduction

A training course on "Improving Sanitation and Wastewater Management for Tonga" is scheduled for 25 – 29 August 2008 in Tonga. Its implementation is a collaborative effort by the Tonga Community Development Trust, Pacific Islands Applied Geoscience Commission (SOPAC) and United Nations Environment Programme (UNEP) Coordination Office for the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) and the United Nations Educational, Scientific and Cultural Organisation – Institute for Water Education (UNESCO-IHE). The donors EU Water Facility, UNDP and GEF are sincerely acknowledged.

This report acts as a background paper on the current status of wastewater and sanitation in Tonga. It was based on an independent review of available literature and stakeholder consultations conducted from 4 – 8 August (refer to annex 1 for agencies/representatives consulted).

Tonga does not have a central reticulated wastewater system and thus relies on household-based management. This presents a number of problems when individual households are left to deal with wastewater (from bathrooms, kitchens and toilets).

The identified issues relating to this were groundwater and marine water pollution, human health complications, improper human excreta disposal, and animal waste mismanagement. The constraints in dealing with these issues were insufficient knowledge on the benefits of improving household sanitation facilities, lack of funding and capacity-building opportunities, negative behaviours and attitudes, institutional barriers, and lack of village regulations enforcement. These constraints were also the basis for improvement opportunities which are also discussed here.

Areas of focus included awareness and community participation, institutional arrangements, capacity-building, technology and operation, and financial and economic issues. All these tied back to the identified constraints in dealing with wastewater management and sanitation improvement.

This background paper closes with a short conclusion and offers recommendations that may improve current wastewater management and sanitation practices here in Tonga.

Agencies with Mandates on Sanitation and Wastewater

This section summarizes relevant stakeholders that address sanitation and wastewater issues. It contains a comprehensive list of government and non-government agencies with work mandates and activities that confront these important issues (Table 1).

Table 1 Profile of institutions with mandates and roles that directly or indirectly address wastewater management and improve sanitation

Agency	Mandate	Relation to sanitation and wastewater issues
Ministry of Lands, Survey, Natural Resources & Environment (MLSNRE)	> Environmental research and monitoring > Environmental policies/legislations enforcement > Education and awareness campaigns	> Quarterly monitoring of Tonga's groundwater systems > Environmental assessments upon request > Administration of Environment Impact Assessment Regulations 2004 > Economic impacts of wastewater on natural resources
Ministry of Health (MOH)	> Public health policies > Rural water supplies > Septic management (outer islands) > Water quality	> Water contamination and degradation > Human health and hygiene
Ministry of Works (MOW)	> Building codes > Road/drainage construction > Collect and dispose sewage > Nuku'alofa Infrastructure Development (with Asian Development Bank) > Freshwater resources management	> Public construction (including causeways, roads, government buildings and drainage systems) > Operates septic tank pump trucks for Ministry of Health > Dispose sewage sludge under supervision of Ministry of Health > Drainage system and stormwater management > Flooding in low-lying areas
Ministry of Tourism	> Eco-tourism unit > Commercial businesses	> Proper wastewater drainage/treatment in resorts
Ministry of Finance	> Manage government funds	> Allocate budget to Ministries with sanitation schemes
Ministry of Marine & Ports	> Ports policies and development	> Control wastewater discharge from ships/boats > Control sewage open-water dumping
Ministry of Labour, Commerce & Industries	> Business policies > Business licenses > International trade	> Competent authority for setting minimum standards for personal hygiene and sanitation and wastewater discharge (industrial)
Ministry of Agriculture, Food, Forestry & Fisheries (MAFFF)	> Agricultural policies and development > Domesticated animals	> Impacts of agricultural runoff > Animal husbandry (management of animal waste)
Ministry of Police	> Domesticated animals	> Free roaming animals (pigs, dogs, etc) and other nuisances
Tonga Water Board	> Municipal water supply > Fresh water resources management	> Quarterly monitoring of urban water supplies (groundwater)

Waste Authority Board	> Coordination of Tapuhia Landfill operations > Management of solid waste and sewage in Tongatapu	> Proper management of human waste
Waste Management Ltd	> Collection and disposal of solid waste and sewage in Tongatapu	> Proper management of human waste
Rotamould (Pacific) Ltd	> Production of septic and water collection systems	> Proper management of human waste
Nukuhetulu Village	> Composting toilet project (pilot with International Waters Programme)	> Proper management of human waste
Ahau Village	> Piggery project	> Proper management of pig waste
Tonga Red Cross Society	> Health promotion (Tongatapu)	> Promote healthy living > Provide first aid treatment
Tonga Community Development Trust	> Water supply and health > Training and institutional development	> Improvement of rural water supply through assistance to families and communities in many outer islands > Ongoing strengthening and training
Aloua Ma'a Tonga	> Improve standard of living at grassroots level	> Organize land filling and home improve projects in swampy settlements surrounding Nuku'alofa > Conduct training sessions on health and the environment > Implement and oversee construction of fence pens for domestically raised pigs > Implement coastal clean-ups and lagoon rehabilitations
Langafonua 'A Fafine Tonga	> Promote and enhance development of Tongan women through coordination of women's NGO activities > Provide technical assistance with member affliates	> Member of TEMPP Project Implementation Committee to raise awareness on the Fanga'uta Lagoon Management Plan > Promotion of waste issues in the village of Havelu
Tonga Association of Non-Governmental Organizations	> Provide technical assistance to member NGOs	> Umbrella organization for all NGOs operating in Tonga assisting with member NGOs' activities
Tonga National Youth Congress	> National coordinating body for youth based NGOs	> Undertake environmental and community development work

(Source: IWP Tonga (2003) which also includes recent updates)

Methods of Wastewater and Sewage Disposal in Tonga

There are no central/public sewerage systems in Tonga. The majority of the population are served by on-site facilities. The commonly used disposal methods are briefly discussed below.

Septic Tanks

This is a common means of disposal in residential areas with piped water. Information recorded for Tonga's Water Safety Plan (draft) as well as enquiries during this study indicated that septic tanks are rarely properly designed, usually consisting of single compartment tanks, the sizes of which are not adjusted for the number of persons using the facility.

Sludge extracted from septic tanks is disposed of in a stabilization pond at the Tapuhia Landfill. However, it has been observed that the size underestimates the volume of sewage taken in daily.

Improved Ventilation Pit Latrines and Water Seal Latrines

These are promoted by the health inspectors in areas where water supplies do not allow septic tanks to be constructed. This covers the western districts of Tonga and some parts of Ha'apai (Scott *et al*, 1999).

Flush Pits and Traditional Pit Latrines

These are still used in many areas especially in the eastern and western districts.

Open Soaked Pits

Households all over Tonga still direct domestic wastewater (particularly greywater) into open soaked pits.

Wastewater and Sanitation Issues in Tonga

Groundwater and Marine Water Pollution

Groundwater pollution by sanitation systems is a universal problem and is particularly severe for communities on low-lying islands such as Tonga. These systems include latrines, septic tanks and common effluent schemes (Dillon, 1997). Of most concern here are the Ha'apai Group and the Western District of Tongatapu.

All households have access to groundwater, either through the local water supply, the village water supply or their own wells. Piped treated water is available to all households in the Nuku'alofa area through the Tonga Water Board. However, village water supplies are generally untreated, or treated only when the water contains a high coliform count. Fortunately most households do not use groundwater for drinking.

Groundwater is believed to be contaminated with faecal coliform and *Escherichia coli* bacteria from human and animal waste although documents are not made public by the Ministry of Health unless they present alarming results.

In a study by Lal & Takau (2006) they found most piped water supplies to contain *E. coli* and coliform counts greater than World Health Organization (WHO) standards (<1 per 100mL water). Villages susceptible to regular flooding (Fo'ui, Ha'ateiho, Hoi, Kanokupolu and Nakolo) had higher bacterial counts (Table 2).

Table 2 Village bacterial counts (per 100mL)

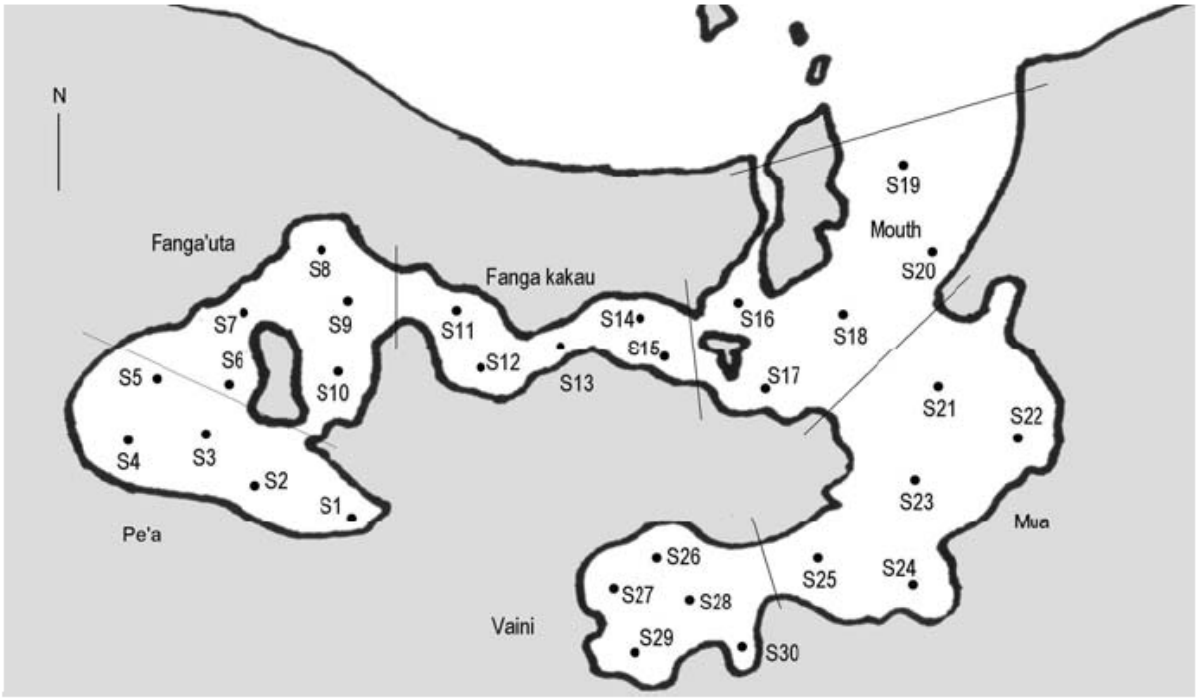
Village	Rainwater tank	Village, urban water supply	Piped groundwater
Fasi	0	0	0
Fo'ui	0	2	15
Ha'ateiho	0	0	27
Hala'ovave	0	n/a	0
Hoi	0	0	14
Kanokupolu	0	4	8
Nakolo	0	0	11
Nukuhetulu	0	2	1

(Source: Lal & Takau, 2006)

This is of crucial concern because although groundwater may not be the main source of drinking water, it is used by all households for general household purposes.

The monitoring of the Fanga'uta Lagoon (TEMPP, 2000) also found areas (Pea – S2, S5; Fanga'uta – S7, S8, S9; Fangakakau – S11-S15; Mouth – S16-26; Mu'a – S21, S24, S25; and Vaini – S26, S27) with excessive levels of nutrients (Figure 1). The results indicated sources of pollution originated from untreated human and animal waste from surrounding villages and an increase in urban development. These nutrients were believed to have been carried through runoff from heavy rain or through the porous soil onto the ground water lenses.

Figure 1 The six sections and 30 sampling sites in Fanga'uta Lagoon



(Source: TEMPP, 2000)

Other impacts on coastal resources caused by increased nutrient inputs from poor wastewater management have been documented in Tonga. These include coral and seagrass degradation, and mangrove die backs (Kaly 1998; Prescott, 2001; TEMPP 2001).

In addition to groundwater and marine water pollution from the unsustainable management of wastewater and poor sanitation practices, human health is threatened.

Human Health Complications

A vicious cycle exists of human health impacts forms when wastewater and sanitation levels are poor. Disease-causing pathogens present in human excreta enter the environment (air, water, soil), infect people through exposure, and then are shed back to the environment through human faeces and/or urine.

Three broad categories of water-related conditions have been identified to be the causes by poor sanitation practices. These are dengue fever, gastrointestinal diseases, and skin infections. Of these, only dengue and gastrointestinal cases are officially reported by the Ministry of Health (2003) (Table 3).

Table 3 Reported cases of selected water-related diseases, 1999-2003

Disease	District	Year				
	Tongatapu	2003	2002	2001	2000	1999
Bacillary dysentery	4	9	8	0	5	10
Gastroenteritis	117	175	637	216	750	958
Amoebic dysentery	4	4	0	0	0	0
Dysentery unclassified	9	9	9	0	178	0
Diarrhoea (infants)	852	1,035	1,396	1,425	1,893	1,588
Diarrhoea (adults)	850	1,285	1,273	1,459	1,596	1,286
Dengue fever	192	194	0	0	0	0

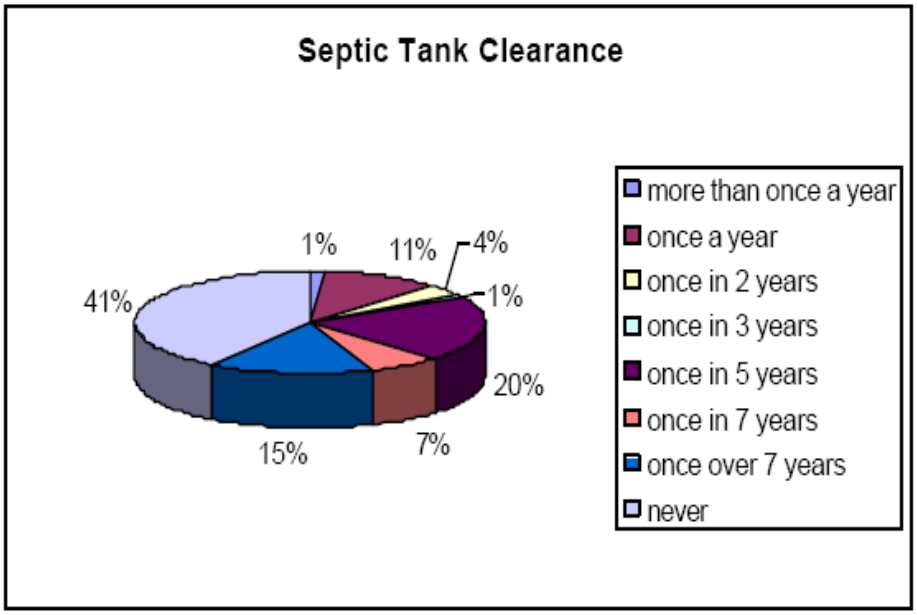
(Source: Ministry of Health, 2003)

Improper Human Excreta Disposal

A comprehensive economic cost analysis by Lal & Takau (2006) found over three quarters of surveyed households used septic tanks for human waste disposal. Of this, 10% used flush pits and 7% used traditional pit toilets. All with the potential to contaminate the immediate environment if the facilities' design, operation and maintenance is poor.

In the same study, over 63% of surveyed households had not desludged their septic tanks in the past five years (Figure 2). Due to poor maintenance and design, septic tank leaks are common, causing local contamination of groundwater also ending up at the Fanga'uta Lagoon as already discussed. Groundwater and lagoon contamination may not only be caused by human waste.

Figure 2 Desludging rates of households in Tongatapu



(Source: Lal & Takau, 2006)

According to Waste Management Ltd, the invention of Tapuhia Landfill of which operations are coordinated by the Waste Authority Board, underestimates the volume of human waste produced (no data available on volume). Because of this, major delays are caused regarding sewage pumping and disposal allowing for potential environmental contamination.

The Department of Environment have also documented similar results for poor sanitation practices in the outer islands (DOE, 2006; 2004a; 2004b). In addition to human sewage, animal waste mismanagement is an emerging concern.

Animal Waste Mismanagement

Animal waste is also a significant source of pollution in Tonga. Given the cultural importance of pigs in Tongan culture, almost every household keeps a certain number of pigs. According to Table 4 a typical household in Tongatapu may own three to 14 pigs which are allowed to roam freely.

Table 4 Animals kept per Tongatapu household

Village	Households	Pigs	Dogs	Chickens	Pigs per household	Dogs per household
Fasi	80	222	125	404	3	2
Fo'ui	20	133	78	76	7	4
Ha'ateiho	90	309	160	755	3	2
Hala'ovave	43	287	78	324	7	2
Hoi	20	111	43	120	6	2
Kanokupolu	20	286	50	175	14	3
Nakolo	20	157	38	54	8	2
Nukuhetulu	20	160	37	143	8	2
TOTAL/AVERAGE	**313**	**1665**	**609**	**2051**	**5**	**2**

(Source: Lal & Takau, 2006)

Although village regulations requiring the confinement of pigs are in place, they are rarely enforced. Similarly, dogs – of which there is an average of two per household also pose health hazards. It should be noted that households do clean up after their domesticated pets, but the collected animal waste is generally swept into a rubbish heap or dumped in nearby bush clad. During rains, organic matter and bacteria may leach into the groundwater table and be transported elsewhere.

This lack of animal waste management, if any, contributes to the movement of waste and sediments to the immediate environment.

Wastewater and Sanitation Constraints in Tonga

Priorities and Perceived Investment Costs

The demand for sanitation is not recognized to its full extent. Households often consider the cost of investment too high and laborious (GOT, 2002). Few unserved households are fully aware of the invisible costs of inadequate sanitation, including poor health, lower productivity, inconvenience and environmental degradation. Since these households are usually the marginalized, existing demand for sanitation is often ignored. Although women may express desire for sanitation facilities, they may have only limited influence on household decision-making, and even if demand for latrines is high, if affordable options do not exist households will be unwilling to invest.

Nationwide consultations by the Central Planning Department found that families are facing financial hardship and are unable to meet their various obligations to families, church and community (CPD, 2006). This presents constraints for families because they are forced to budget limited funds towards their daily living (e.g. food, running water).

Funding

Although government and the private sector assist with sanitation initiatives such as sewage collection and disposal, funds are often limited to cover all of Tonga including the marginalized households discussed above. The financial and economic issue arising from this are the communities/individual's capacity to pay for sanitation including investment and operation and maintenance costs because there is a great dependence on external agencies to assist Tonga in such initiatives. This mainly applies to grassroots groups – target groups of donor agencies are more than willing to help with environmental projects but are unable to secure financial assistance.

Traditional/Cultural Norms Impeding Education and Awareness

Sanitation and hygiene are intensely personal and difficult to discuss. With Tonga being an island country preserving traditional values, sanitation is not always a comfortable topic of discussion. The social norms and cultural taboos governing relationships get in the way of honest discussion and complicate efforts to bring sensitive issues forward. This may explain the *ad hoc* nature of participation in village *fonos* (meetings). This may also explain why sanitation and hygiene education programs, messages and materials are often adapted from outside sources – of which contains little to no relevance to local conditions.

This limits wastewater and sanitation issues being brought to attention. Insufficient knowledge of these issues often lead to ignorance. An ignorance that undermines pro-active institutions/communities/group activities in the sanitation sector.

Insufficient Capacity-Building Opportunities for Communities

There is generally an insufficient number of on-site capacity-building opportunities for communities. The majority of environmental trainings and workshops are attended by a representative from the village/district of which is always the town/district officer. The main reason for this is to cut down on costs. The common assumption is that the officer or 'local leader' will pass on the knowledge to the community via village *fonos.* This study can only assume that this is not always the case.

Technology vs. Behaviour Change

Interventions focus on building toilets and not changing behaviours. IWP Tonga (2006) identified this as one of the root causes of village water pollution. Sanitation projects often focus on toilet construction rather than sustained behaviour change e.g. Nukuhetulu Pilot Project (IWP Tonga, 2005) and the Composting Toilet Trial and Groundwater Pollution Study in Ha'apai (Crennan, 1999; Crennan, 2001). Behaviour change towards sanitation improvement ensures that activities that address the issue are sustained and worth the investment.

Political and Institutional Barriers

Political and institutional barriers remain high. Sanitation has not been a priority in Tonga's policies and governmental budgets. Lack of clear responsibility for sanitation activities created by 'institutional fragmentation' and the absence of national level sanitation policies are compounded by capacity gaps at the local government level.

The mandates and roles of relevant agencies regarding wastewater management and sanitation also overlap (Table 1). Due to the institutional barriers, there is also insufficient coordination between stakeholders, information and lessons learned are not shared, often resulting in project duplications and unnecessary expenses.

Policy/Regulation Enforcement

National policies and village regulations are hardly enforced because sanitation and the management of wastewater policies/regulations are not fully addressed. This may be due to the above mentioned constraints (cultural norms, institutional barriers, little knowledge of roles and direction to appropriate authorities).

Opportunities for Improvement

Awareness and Community Participation

When people start living close together in villages or urban areas the need for sanitation increases if health problems are to be avoided. There will be a need for stimulation of demand for sanitation from individual householders.

Education is fundamental to the sustainability of programmes. This should start with mothers then extend to the school curriculum and continue into the community. Graphical displays and videos may be the most effective vehicles for learning. Wherever possible, the written or spoken local language should be used.

The means of communication of the essential information to villagers concerning sitting, design, maintenance and monitoring of domestic sanitation and water supply systems, and public health, will need to be determined at a local level.

Public health, general health and hygiene education are major factors in changing people's attitudes towards effective wastewater management and improved sanitation. It is not simply a question of transmitting educational messages, but a more complicated effort at modifying human behaviour especially when it comes to 'breaking the ice' with Tonga's culture and traditions.

Institutional Arrangements

Coordination mechanisms between relevant agencies should be strengthened. This includes the establishment of a Wastewater Management and Sanitation Committee whereby members are encouraged to meet on a regular basis. They may be able to share experiences and document lessons learned from previous, current and upcoming sanitary-related cross-sectoral initiatives.

When political and institutional barriers are overcome, government, the private sector and non-governmental organizations can actively cooperate to ensure that they are integrated into national development policies and plans. They may also have the collaborative power to enforce existing policies and regulations (especially in rural areas).

Capacity Building

New training programs, manuals to support the improvement of sanitation and the realization of wastewater issues, and community facilitators should be established. This includes an initial nationwide consultation with relevant stakeholders, schools, town/village officers and churches. This may ensure that they are well-informed of this current issue and that they can formulate solutions to alleviate them.

Local experts should be explored, trained and utilized – especially in a small island country whereby people are comfortable learning from fellow Tongans. Once people have had the opportunity to see a sanitary system first-hand and experience its benefits, they are more likely to invest their own time and resources and are also able to adapt to improve upon it to suit their needs.

Technology and Operation

If sanitation is to be introduced the right technology should be chosen to suit local situation and needs. This includes low cost sanitary waste disposal options with creative adaptations to existing designs (Depledge, 1997).

Although septic tanks are widely used in Tonga and is promoted as the most appropriate technology (especially in areas with high water tables and frequent flooding), they are often poorly constructed and maintained.

Financial and Economic Issues

The training of local suppliers and individuals can help to promote sanitation and generate income for Tongans. People trained in constructing latrines have the incentive to generate demand for their services. Once trained, local labourers seek to become 'recommended' suppliers and technicians as demonstrated in Indonesia (Shatifan, 2008).

Conclusions and Recommendations

The sanitation sector lacks a lot of attention in Tonga as described in this document. The majority of Tonga found this a 'new' issue although a lot of concerns and constraints in dealing with them have been documented and reported. Therefore outlined below are recommendations for wastewater management and improved sanitation in Tonga as concluded from the constraints and improvement areas above.

- Establishment of a National Wastewater Management and Sanitation Committee
- Mainstream wastewater management and sanitation into government development plans and policies
- Enforce existing regulations on improved sanitation especially at the local level
- Provide local on-site trainings and workshops on sanitation in non-technical English and Tongan to include the whole community. This should extend to train-the-trainers workshops should finances be insufficient.
- Assess household septic tanks and latrines for sewage leakage
- Extend the sewage settling pond at Tapuhia Landfill to accommodate the increasing volume of sewage transported over
- Improve awareness campaigns and programmes that cater to a wide audience and target first and foremost behaviour change
- Engage communities and women's groups in sanitation initiatives and decision-making meetings
- Train locals on project proposal development with the assistance of government
- Provide economical alternatives to current sanitation facilities (a summary of available technologies reproduced from Depledge (1997) is provided in Annex 3)

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Annexes

Annex 1: Key Stakeholders Consulted

1. Ministry of Lands, Survey, Natural Resources and Environment (Geology Division)
   Mr. Kelepi Mafi (Senior Geologist, Head of Division)

2. Ministry of Lands, Survey, Natural Resources and Environment (Environment Planning Division)
   Ms. Lupe Matoto (Senior Environment Information Officer)

3. Ministry of Lands, Survey, Natural Resources and Environment (Urban Planning Project)
   Mr. Tukua Tonga (Director)
   Hon. Kalaniuvalu (Project Officer)

4. Ministry of Health (Public Health Sector)
   Dr. Malakai ‘Ake (Chief Medical Officer)
   Mr. Taunisila (Health Inspector Grade 1)

5. Ministry of Works (Roads and Building Divisions)
   Mr. Manase Lavulavu (Acting Deputy Director for Building Division)
   Mr. Tevita Lavemai (Works Officer)

6. Ministry of Tourism
   Mr. Edgar Cocker (Director)

7. Department of Fisheries
   Mr. Pau Likiliki (Senior Fisheries Officer)
   Mr. Vili Mo’ale (Legal Officer)

8. Ministry of Marine and Ports
   Mr. Vuni Latu (Marine Nautical Officer)
   Ms. Paea Mailau (Marine Officer)

9. Ministry of Finance
   Ms. Avalon Sika-Kautoke (Tonga Education Support Programme Accountant)

10. Ministry of Labour, Commerce and Industries
    Mr. ‘Alipate Tavo (Senior Licensing Officer and Acting Secretary for Commerce Division)

11. Ministry of Agriculture, Forestry, Food and Fisheries
    Dr. Viliami Manu

12. Tonga Water Board
    Mr. Vaha’akolo Palelei (Planning Engineer)
    Mr. Timote Fakakovikaetau (Principal Water Chemist)

Mr. Lindsay Lavemai (Principal Distribution Officer)

13. Waste Management Ltd
    Ms. Karen Lee Miller (General Manager)

14. Rotamould (Pacific) Ltd
    Mr. John Raass (Acting General Manager)

15. Tonga Red Cross Society (Health Promotion Section)
    Ms. Silongo Fasi'i'eiki (Health Promotion Officer)

Annex 2: Participants for Improving Sanitation and Wastewater Manager Training Course 25 – 29 August 2008

Ministry of Lands, Survey, Natural Resources and Environment (Geology Section)

1. Rennie Vaimo'unga (Senior Geological Assistant)
2. 'Apai Moala (Geological Assistant)

Tonga Water Board

1. Vaha'akolo Palelei (Planning Engineer)
2. Lindsay Lavemai (Principal Distribution Officer)

Tonga Red Cross Society

1. Silongo Fasi'i'eiki (Health Promotion Officer)

Ministry of Marine and Ports

1. Vuni Latu (Marine Nautical Officer)

[Note: participants confirmed as attending training 25-26 August 2008]

NAME	ORGANIZATION
Sinama Fa'anunu	Ministry of Finance
Elaine Havealeta	Ministry of Tourism
Azania Fusimalohi	Ministry of Land Survey, Natural Resources, Environment
Tupe Samani	Ministry of Land Survey, Natural Resources, Environment
Lu'isa Latu	Popua Town
Siesi Pale	Lapaha Council
Roger Miller	Waste Management Ltd
Tevita Haukinima	Free Wesleyan Churches of Tonga
Semisi Halaholo	Government Representative – Eua
Kepu 'Ioane	Secretary - Ha'apai Governor Officer
Tevita Hu'akau	Ministry of Labour, Commerce and Industries
'Anitelu Toe'api	Civil Society Forum of Tonga

Robert Cocker	Tonga Association of Non Government Organization
Manumu'a Moala	Ministry of Work
Te'efoto Mausia	Ministry of Health – Tongatapu
Linisi Lavemai	Tonga Water Board
Sioape Tu'iono	Vaini District
Saia Tu'ikolongahau	Ministry of Agriculture, Forestry and Fisheries
Huufi Filiai	Ministry of Agriculture, Forestry and Fisheries
'Ofiu 'Isama'u	Ministry of Health – Vava'u
Uatesoni Tuangalu	Ministry of Health - Tongatapu
Sio Tuiono	Kolomotu'a Village
Rajnesh Reddy	Rotomould (Pacific) Ltd

Annex 3: Available technologies for sanitation improvement

CHOICE	RELATIVE COST	TECHNOLOGY	RISKS	RESOURCE RECLAMATION	PATHOGEN CONTAINMENT	PATHOGEN REMOVAL	CONSTRAINTS	ADVANTAGES
beach/bush	zero	zero	direct F/O transmission	no/yes	no	?	low population good tidal flush (beach) designated defecation site (bush)	easy
night soil	low	very low	F/O transmission at spills social odium vectors/vermin at disposal site	yes	yes	no	requires designated safe disposal good access to houses	easy, private
pit latrines	low-moderate	low	vector breeding	yes/maybe	yes	yes	requires land	private
general	low-moderate	low	pollution potential	yes/maybe	yes	yes	deep soil/water table	low O and M contains pathogens
wet pit	low-moderate	low	groundwater pollution	yes/maybe	yes	yes	requires permeable soils	slow to fill
dry pit	low-moderate	low		yes/maybe	yes	yes		
ventilated	low-moderate	low		yes/maybe	yes	yes	requires exposed site for sunlight and wind	odourless traps vectors
septic tanks general-tank	moderate-high	medium	vector breeding poor construction	yes/maybe	yes	yes	requires water supply requires desludging facility	proven technology
absorption	moderate	low	groundwater pollution	yes/maybe	yes	yes	requires depth of soil/water table	simple
ET	moderate	low	plants may not tolerate	yes/maybe	yes	yes	requires land area	simple
wetlands	moderate-high	medium	overflow, vector breeding	yes/maybe	yes	yes	requires land area	minimal discharge
filters/aeration	high	high	breakdown problems	yes/maybe	yes	yes	expensive	high quality effluent
mix'n match water-borne small sewers	high	medium	pipe-damage pollution households may not connect	maybe	yes	yes	requires pipeline routes requires safe disposal areas	removes wastes
municipal sewers	very high	high	breakdowns	maybe	yes	yes	requires pipeline routes and pumps requires treatment/disposal areas high O and M costs	clean, modern
composting toilet	moderate	medium	very few	yes	yes	yes	requires dry organics requires high set structure	very clean

(Source: Depledge, 1997)