A REVIEW OF FLOODING IN APIA, SAMOA, APRIL 2001

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ABSTRACT

Intense rain (200 mm in four hours) over short, steep watersheds generated rapidly-rising floods across little more than a 10 km strip of the northern coast of Upolu on the night of Easter Sunday (15 April) 2001. The daily rainfall was not especially rare, and historical inquiry points to a long history of flooding at Apia. Based on this, the frequency of the 2001 event is tenuously estimated as 3-4% chance of happening in a year.

Despite modest depths of flooding (rarely more than a metre over ground level), much property was damaged, leaving a repair bill in excess of WST$11 million, of which damaged commercial premises and infrastructure like roads and water pipes were the largest contributors. It is estimated that about 5000 residents were directly affected, and perhaps 28 000 people experienced disruptions to water supply.

Development of reclaimed swamps has exacerbated Apia's flooding problem. Strategies to promote sustainable development of floodplains need to be fostered. Flood-proofing measures such as floor-raising can reduce potential damage. Flood warning systems have limited value where the flow regime is so flashy, though weather radar may extend lead times. Flooding may be alleviated in part by development of a stormwater management plan and maintenance of clear drains. However, during heavy rain, flooding is a natural phenomenon at Apia. An information brochure contains several ideas to enhance community resilience to future flooding.

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Thanks to the three insurers who provided loss data. I am very grateful to Paul Fritz and Matini Tanielu (Apia Management Solutions) for open and insightful discussions of the flooding problem, and for introducing me to some of Apia's flood-affected areas.

Paul Taylor provided instructive comments on the draft.

1. INTRODUCTION

Samoa is subject to five cyclones per decade on average (SOPAC, 2000, p.7). Flooding from heavy rain is a well-recognized paired hazard with cyclones, and caused some damage to Samoa in Cyclones Gina (1989), Ofa (1990) and Val (1991). However, the flooding of northern central Upolu on the night of Easter Sunday (15 April) 2001 arose from a microsystem associated with an intensifying trough (Meteorological Division, 2001). Damages to the Apia urban area – a city with a population of 34 126 at the 1991 Census (Department of Statistics, 1991) – were severe.

This report summarizes a two-week project commissioned by SOPAC, which has as its aims: to review and evaluate the causes and effects of the April 2001 flood; and to develop recommendations to enhance the levels of resistance to future events. The various tasks to be undertaken are attached at Appendix 1.1.

Reports on the Apia flood were sparse, and one was available only in Samoan. Interviews were conducted with 21 flood-affected entities, comprising 4 businesses, 3 combined businesses/ households, 11 households and 3 schools (see Appendix 1.2 for the survey form). Some rainfall and hydrological data were provided by Apia Observatory, and some damage data were provided by three local insurance underwriters. Consultations were held with the Ministry of Foreign Affairs, National Disaster Management Office, Public Works Department, Samoa Water Authority, Department of Education, Department of Lands, Surveys and Environment, Apia Management Solutions and the Samoa Red Cross. Newspapers at the Nelson Memorial Public Library (Apia) and at the State Library of NSW (Sydney) were checked to construct a flood history.

The first section of this report evaluates the nature, causative factors and frequency of the April 2001 flood event. Flood damages are reviewed in the following section, including financial losses and the number of people affected. The report concludes with an investigation of the lessons to be learned.

2. FLOOD EVENT

2.1 Nature of flooding

The Easter 2001 flood had all the attributes generally used to describe a flash flood: confined areal extent; high velocity flow; rapid speed-of-onset; short duration; and a mix of overbank and overland flow (Yeo *et al.*, 1999). Only four or five river systems across a width of about 10 km were severely affected, from Fuluasou River in the west to Laulii Stream in the east (Figure 2.1). Velocities were sufficient in places to sweep a Dyna Truck and other vehicles off the road (*Samoa Observer*, 20 April 2001), though elsewhere the flow was reported to be relatively sedate (Site 11).

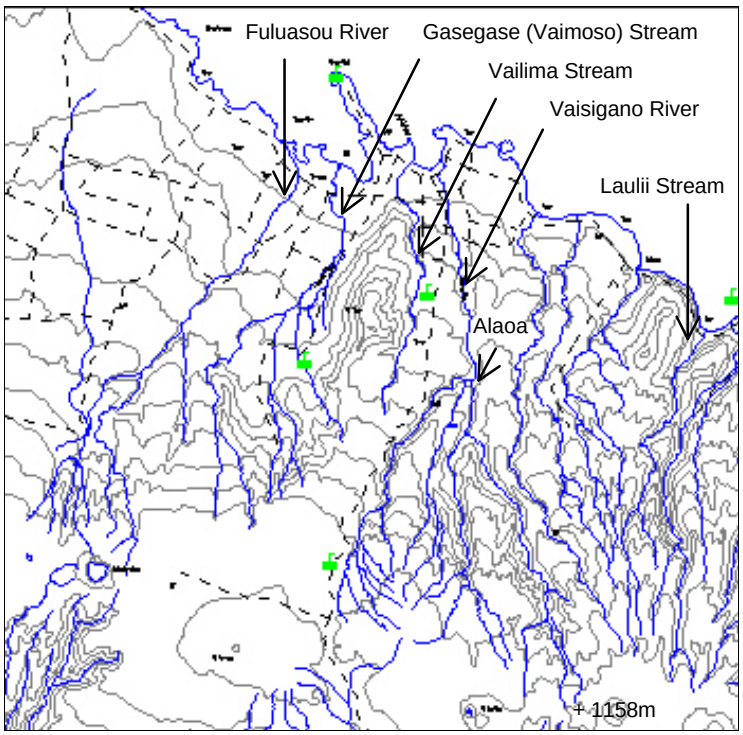

Figure 2.1: Flooded rivers, northern central Upolu

The rapid rise of the rivers is demonstrated by the flood hydrograph for the Vaisigano River (East Branch) at Alaoa East station (Figure 2.2). The lag between rainfall (at Apia) and river response was negligible. The flood rose at about 9.30 pm and was reported to have receded from most affected properties by 3 am.

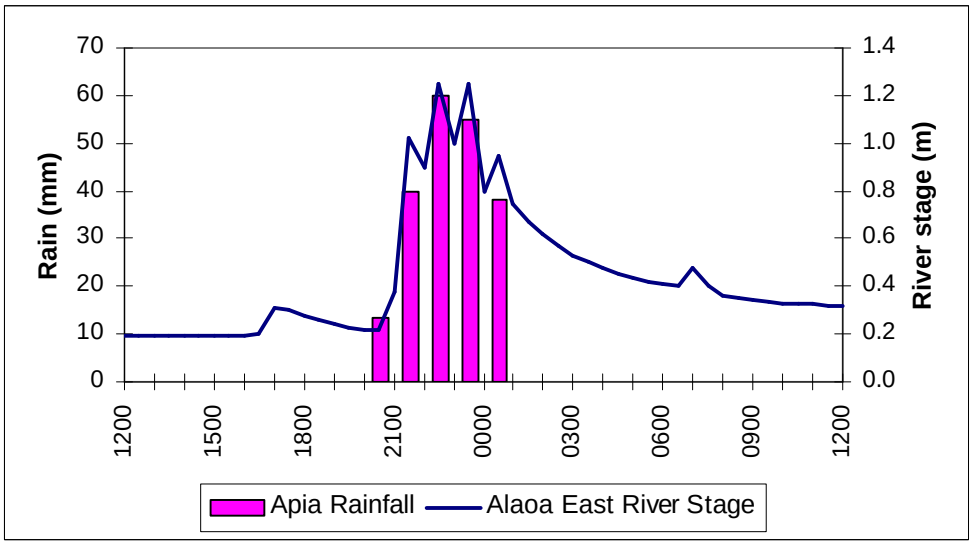

Figure 2.2: Hourly rainfall at Apia Observatory and flood hydrograph at Alaoa East (Vaisigano River East), 15-16 April 2001

Note: Catchment area 16.5 km^2 at Alaoa East. Source: Data from Apia Observatory

Parts of Apia were inundated from overflowing channels, parts from overland runoff, and parts from both sources (a feature in common with the Wollongong [NSW] flood of August 1998 – Yeo, 1999). Figure 2.3 depicts the areal extent of water escaping from the Fuluasou, Gasegase (Vaimoso), Vailima and Vaisigano channels. The source of the inundation in the area between Gasegase Stream and Vailima Stream is uncertain but it is thought to result from the ponding of rainfall and the overflowing of drains. Indeed, inundation from the ponding of rainfall can occur almost anywhere – it was also recorded at Site 3. Such flooding tended to be relatively 'clean', whereas thick deposits of mud were reported for some areas close to rivers ('four inches' [10cm] thick or more).

The depths of inundation exceeded a metre at some sites near the flooded watercourses (Figure 2.3), especially in the lower Vaisigano River (Sites 7, 8, 20). Such was the volume of floodwater along the Vaisigano that what appeared to be an old channel was re-activated through Faatoia (near Sites 4 and 16). Nevertheless, depths vary with topography – some areas were flooded to a depth of only 0.3 m (e.g. Site 12). Moreover, given typical minimum floor levels of about 0.3 m, even over-ground flood depths of a metre translate into only moderate over-floor flood depths, certainly relative to the Ba and Nadi (Fiji) floods of January 1999 (Yeo, 2000) and to the Macuata (Fiji) flood of April 2000 (Yeo, 2001, p.14).

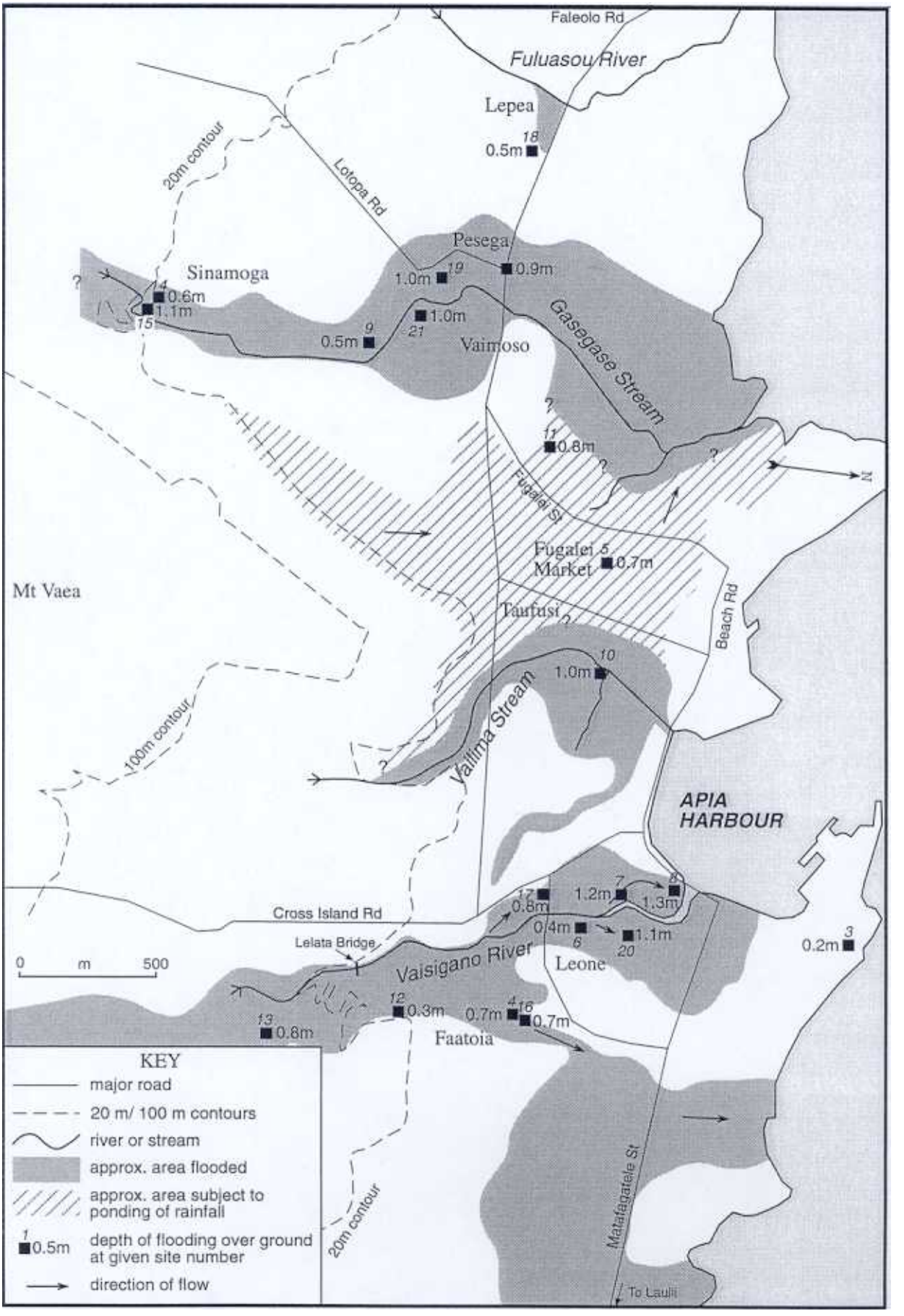

Figure 2.3: Extent and depths of flooding, Apia, 15-16 April 2001

Note: Interview sites 1 (Laulii) and 2 (Moamoa) are off the map. Source: Extent of flooding estimated by Apia Management Solutions

2.2 Causative factors

The cartoon reproduced in Figure 2.4 illustrates a typical attempt to make sense of a recently experienced disaster. Sea-level rise, heavy rain, shallow drainage and high tides are all cited as potential causes of the flooding, though the final comment suggests some exasperation! This section investigates the influence of the watershed, the rain and the tide.

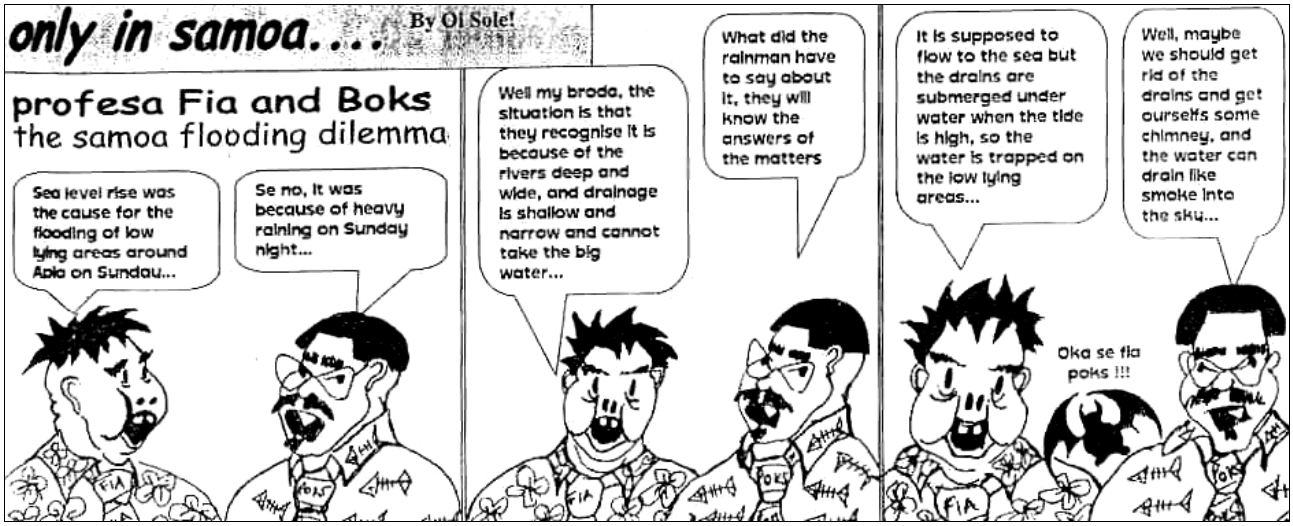

Figure 2.4: Perceived causes of the flooding problem
Source: *Samoa Observer*, Thurs 19 Apr 2001 p.7

Catchment

The short and steep nature of the catchments of northern central Upolu render them conducive to rapid-rising floods following heavy rain. The character of these river valleys is exemplified by the Vaisigano watershed, which has an area of 33 km^2 (Baisyet, 1990), rising at an elevation of 1158 m on top of Upolu's lava dome and falling to sea level over a distance of only about 12 km, which yields an average slope of about 1 in 10. The topography is illustrated in Figure 2.5, and the high proportion of steep slopes is indicated in Table 2.1. The drainage pattern for the Vaisigano River is distinctively pear-shaped, as three tributaries meet at Alaoa (Figure 2.1), resulting in a propensity for particularly flashy hydrographs.

(a) Upper valley

(b) Lower valley

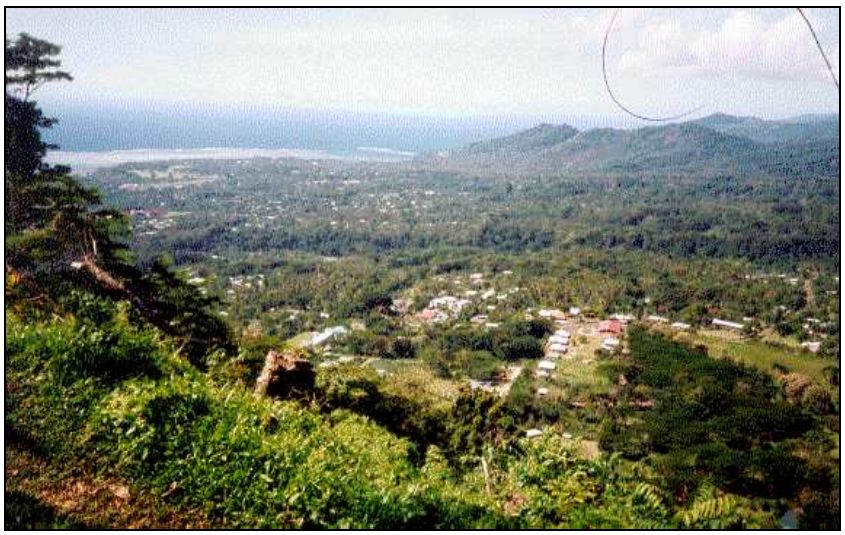

Figure 2.5: Views of the Vaisigano River Valley from Robert Louis Stevenson tomb site, Mt Vaea

Table 2.1: Slopes in the Vaisigano watershed (Source: Baisyet, 1990, p.10)

Slope class	Area (ha)	Proportion
0-15%	735	22%
15-30%	549	15%
30-100%	519	17%
>100%	1497	46%
	3300	100%

In the past, degradation of the Vaisigano watershed has been cited as a cause of frequent flooding (Baisyet, 1989, pp.2, 3, 8). Calls to halt the indiscriminate cutting of trees and to prevent the cultivation of slopes have been raised after several floods (*Samoa Times*, 31 Jan – 7 Feb 1975, p.2; *Samoa Observer*, Thurs 19 Apr 2001, p.7). Current watershed management practices have not been investigated for this study. Baisyet (1990, p.12) calculated that 68 % of the Vaisigano watershed was forested, a feature confirmed (albeit superficially) by a viewing from Mt. Vaea of this catchment that is utilized for water supply. However, the rainfall from December 2000 to February 2001 was 33 % below average at Apia and 56 % below average at Afiamalu, which may have contributed to a less-densely vegetated catchment surface, promoting runoff and transportation of soil when the heavy rains came in April.

Rainfall

The dry spell from December 2000 to February 2001 is indicated in Figure 2.6. Daily rainfall for April 2001 has not been received at the time of writing, but soil moisture levels are said to be high even before the storm of 15 April (Faatoia Malele, Apia Observatory, pers. comm., 12 July 2001). The distribution of rain in the 24 hours to 9 am 16 April is illustrated in Figure 2.7. Interpretation of such diagrams must be tempered by the knowledge that rain in Samoa is highly variable through space – compare, for instance, Moamoa (12 mm) to Nafanua (221 mm), which are only 3 km apart and of similar elevation. Nevertheless, the restricted influence of the microsystem is clearly apparent, with negligible falls in north-west Upolu, modest falls in the south and east (with the exception of Ma'asina) and heavy falls in northern central Upolu, including a record 685mm at Lauli'i. Consistent falls in the order of 200 mm from Apia to Afiamalu suggest that topography did not exert a significant influence on the distribution of rain for this event. This amount of rain could generate flooding even if spread across 24 hours. Hourly rainfall for Apia (Figure 2.2) shows that the rain was concentrated in a period of only four hours, including 60 mm from 10 to 11 pm. This intense rain is the primary cause of the flash flood.

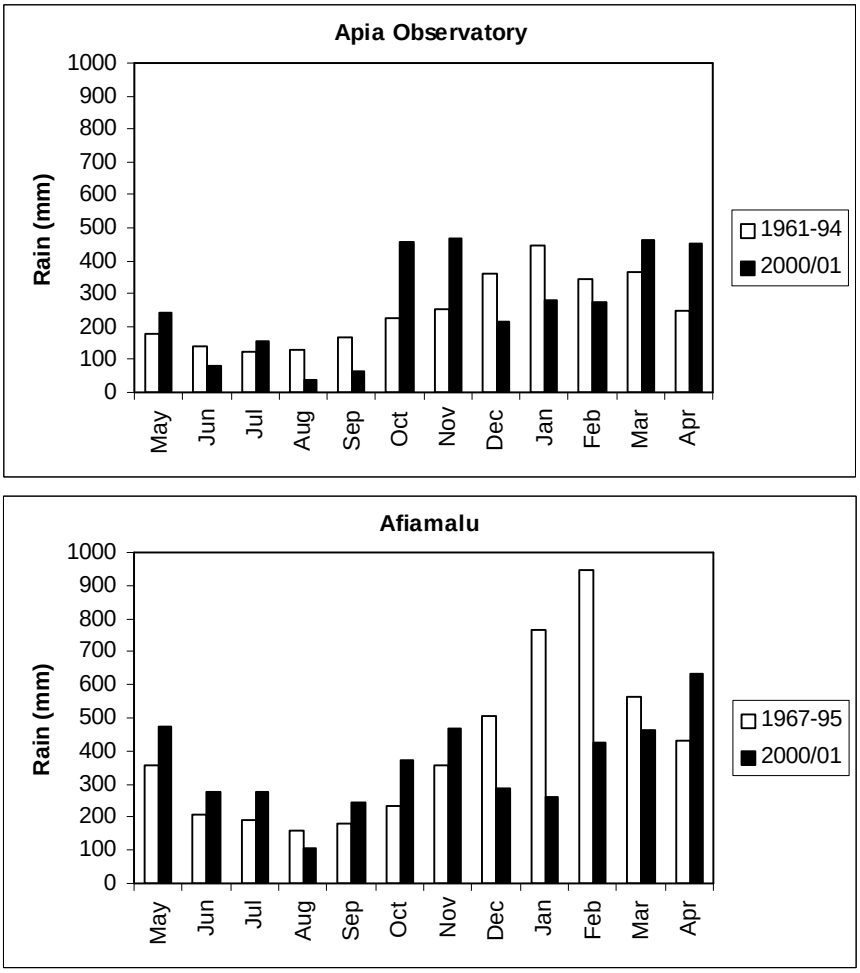

Figure 2.6: Monthly rainfall totals, Apia Observatory and Afiamalu, averages and 2000/01
Source: Average data from Chan (1996); 2000/01 data from Samoa Meteorology Division, Apia

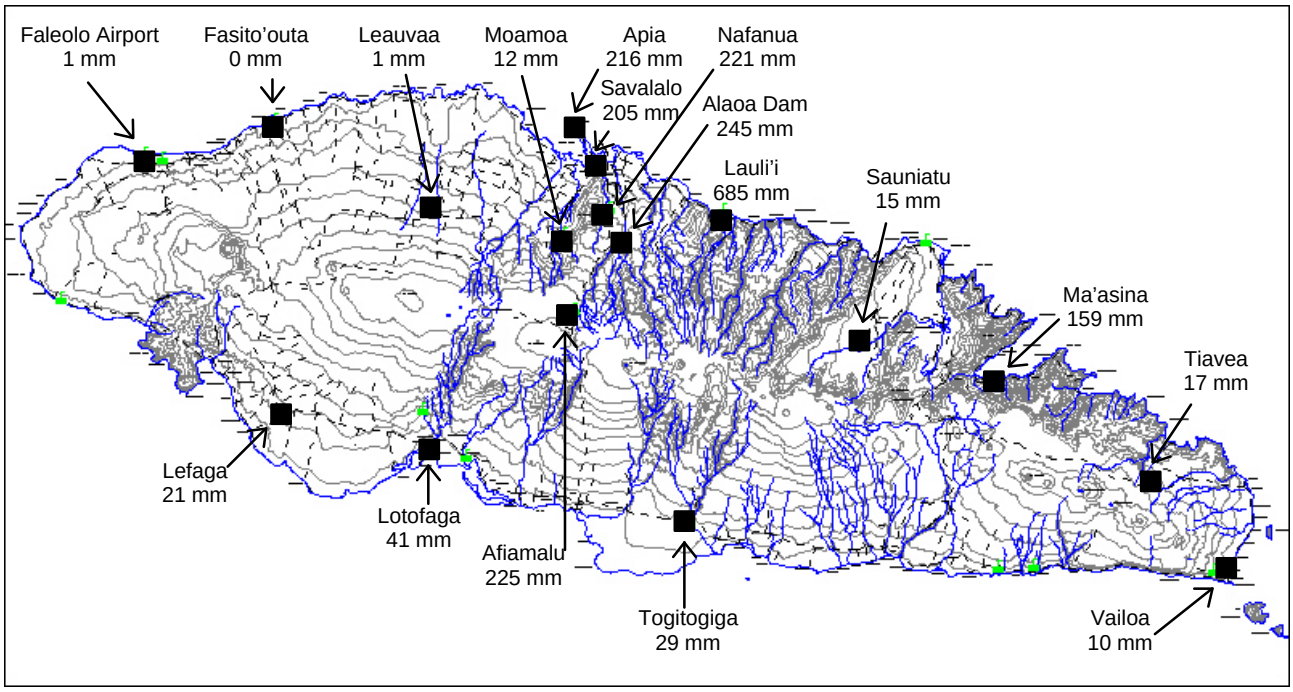

Figure 2.7: Daily rainfall, Upolu, 15 April 2001 (measured at 9 am 16 April)
Source: Data from Samoa Meteorology Division

Tides

The maximum tidal range at Apia Wharf in April 2001 was 1.27 m (on the 6th-7th). Data from the National Tidal Facility (Flinders University) indicate that a low tide of 0.41 m was forecast for 8 pm on April 15, followed by a high tide of 0.90 m at 2 am on April 16. This was disputed by Apia Observatory, which stated that the measured tide reached 1 m at midnight, a peak of 1.09 m at 1 am, and was still above 1 m at 2 am (Meteorological Division, 2001; *Samoa Observer*, Thurs 19 Apr 2001, p.7). If this is correct then it seems feasible that the rising tide may have raised the base level for the flooding that inundated properties from 11 pm[1] Nevertheless, the flooding is regarded as primarily rain-driven for two reasons. First, some respondents reported flooding at 10 pm, at least two hours before high tide (but corresponding to the heavy rain). Second, some surveyed properties were situated a substantial distance upstream where tidal influence would be reduced.

2.3 Frequency

That flood frequencies are well understood is fallacious (Pielke, 1999). Estimates may be particularly imprecise for steep rivers (Lustig and Irish, 2000). This is true even where data are widely available. In Samoa, very few historical hydrological data are available, partly because the storm surge associated with Cyclone *Ofa* destroyed a large number of records at Apia Observatory, and partly because floods tend to destroy recorders (e.g. of the flooded rivers, only the gauge at Alaoa East survived the 2001 flood). In the absence of a continuous hydrological record, flood frequency must be estimated using rainfall as a surrogate and using written and oral evidence to construct a record.

The annual rainfall series for Apia and Afiamalu (Appendix 2.1) indicate that the measured rains of 15 April 2001 were not particularly rare when compared to other daily maxima: at Apia the fall was the 8th highest in 29 years of record and at Afiamalu the fall was the 7th highest in 20 years of record. A table of maxima derived from secondary sources shows that high daily falls also occurred at Apia in 1923, 1935 and 1939 (Appendix 2.2). The frequency of a fall of 200 mm *within four hours* is not known, but would be rarer. Some respondents indicated that before previous floods it would rain for a day. This would be expected in flooding associated with tropical cyclones, as rain bands gradually affect Upolu. The flood of April 2001 was reportedly different in character.

Table 2.2 presents a list of historic floods known to have affected Apia, derived primarily from a search of newspapers. Certainly the list is incomplete. Its extension would be a highly profitable exercise, perhaps using the daily rainfall (Appendix 2.2) or even monthly rainfall as a starting point.

For example, flooding would be expected in January 1988 (after 500 mm of rain in a day), but this has not been investigated. Nevertheless, even the current list demonstrates that Apia is no stranger to flooding. In 1975 an 87-year old man who had come to Samoa when aged five recalled flooding of the Vaisigano River that probably occurred in the German colonial era (pre-1914). The determination of flood magnitudes from the descriptions in Table 2.2 is difficult. Based on the stated depths of flooding at Pesega and Aggie Grey's Hotel (Site 8 on Figure 2.3), the 1975 flood may have been about 0.3 m below the 2001 flood levels. This does not represent a very significant difference. Further evidence for the seriousness of the 1975 flood is the apparent destruction of houses at Leone. The damages to houses and infrastructure, and loss of life, suggest that of the other events in Table 2.2, the 1939 flood was particularly severe. It is hazardous to estimate a frequency for the 2001 flood using such incomplete and general data, but the occurrence of what seem to be floods of similar extent and damage in 1939, 1975 and 2001 suggests an average recurrence interval of about 25-30 years. This does not mean that such an event will occur every 25-30 years, but (if accepted) that an event of such magnitude has about a 3-4 % chance of occurring in any year. Lesser but still serious floods like those of February 1982, January 1991 and January 2000 would occur more frequently.

Two important points are apparent from the surveys of people inundated by the 2001 flood. First, all those with at least 10 years experience at the same site had experienced flooding previously. Second, apart from a house at Lauli'i (Site 1) where the *Ofa* and *Val* floods were higher, and a house at Fa'atoia (Site 12) where an undated flood (probably late 1980s) was 0.6 m higher, most respondents stated that the 2001 flood was the highest in their experience, which for one was said to be about 40 years. For example, Alfred Schwalger's house at Fa'atoia was flooded for the first time in 24 years (*Samoa Observer*, Sat 21 Apr 2001, p.7). (There, however, it is likely that the flood height was influenced by the factory his neighbour had built across a flood channel). Nevertheless, although it is recognized that especially in Pacific cultures, significant events are often well-preserved in oral tradition, all humans have fallible memories (this was certainly true for Ba, Fiji – Yeo, 1998). The available oral evidence provides no compelling reason to modify the estimated frequency for the 2001 flood as (tenuously!) having a 3-4 % chance of happening in a year in Apia district.

[1] 11 pm is the *median* time at which respondents reported water entering their house or business.

Table 2.2: Historic floods, Samoa

Date	Extent / magnitude of flooding	Effects of flooding	Sources
1893–1914?	Vaisigano River	Washed everything away at sawmill	*Samoa Times*, 18–24 Apr 1975 p.1
1923 Mar		Much damage to roadways and two or more bridges carried away by floodwaters	*Samoa Times*, Fri 16 Mar 1923 p.4
1931 Jan	Apia		UNCTD 1983, Annex 15
1935 Jan 16–18	All low-lying land inundated; 'immense' body of water came down Vaisigano River	Floors of fales under water, damage not serious, several small bridges washed away and roadways damaged	*Samoa Herald*, Fri 18 Jan 1935 p.2
1939 Jan 16	Widespread; Vaisigano River; Fuluasou River (water rushed through Lepea village); Vaimoso River (there was a lake at Pesega)	Water supply cut; huge trees, Samoan houses, dead cattle and pigs swept down river; 8 piles of Vaisigano Bridge carried away; £50 000 damage to repair roads and bridges alone; one boy drowned at Vaimoso; one 20-year old man drowned at Sauniatu [Falefa River]; damaged pipeline at Tuaefu; Morris Hedstrom store damaged at Tafua, Savaii	*Western Samoa Mail*, Sat 21 Jan 1939 pp.1, 4 & Sat 28 Jan 1939 pp.1,5
1974 [Nov?]	Northern coast [of Upolu], including Vaisigano River	[1] Roads and bridges damaged; [2] severe damage to Aggie Grey's Hotel; [3] Solosolo Bridge destroyed	[1] Baisyet 1989, p.8 [2] *Samoa Times*, 31 Jan – 6 Feb 1975 p.1 [3] *Samoa Times*, 7–13 Feb 1975 p.1
1975 Jan 30	Apia: Vaisigano and Vaimoso Rivers burst their banks; flooding at Sinamoga and Lelata; water 2 ft deep on road at Pesega; water 3 ft deep at Aggie Grey's Hotel; water 3 ft deep on area in front of houses at Vaimoso village	Scores of homeless persons in Apia and village areas; severe damage to Aggie Grey's Hotel; houses 'disappeared' at Leone; Leone bridge gone; Vaisigano Bridge damaged; muddy water went through houses damaging furniture at Vaimoso and Lepea	*Samoa Times*, 31 Jan – 6 Feb 1975 pp.1,13

Date	Extent / magnitude of flooding	Effects of flooding	Sources
1982 Feb 4–8	Apia, especially Taufusi–Fugalei, also Lepea and Pesega	[1] Health hazard in swampy area behind Apia seafront when cesspits overflowed; some pigs and cattle lost; overall a minor disaster; [2] estimated damage US$300 000; [3] enormous road damages; private industries at Taufusi damaged; houses at Taufusi, Saleufi, Vaimoso and Apia village evacuated when flooded; pipelines damaged; Sinamoga Bridge partially knocked out; Sinamoga chicken farmhouse with >1000 chicks washed away; car swept off road	[1] UNDRO 1982, pp.2,5 [2] Baisyet 1989, p.8 [3] *Samoa Observer*, Thurs 11 Feb 1982 pp.1,15
1989 Jan 7 ('Gina')	Widespread, including Vaisigano River	[1] Estimated damage US$5 million (from floods and landslides); [2] several families from central Apia evacuated when houses flooded; loss of belongings, half Apia without clean water; major water intake at Vaisigano destroyed and water mains at Tiapapata washed away; roads damaged; bridge washed away at Salani [south Upolu]; Vaimoso and Lepea bridges damaged; motor bike swept off bridge; estimated $10 million damage in eastern Savaii, especially to roads	[1] Kishore 1989, p.3 [2] *Samoa Observer*, Thurs 12 Jan 1989 pp.1, 13, 16 & Wed 18 Jan 1989 pp.1,15
1990 Feb 2–4 ('Ofa')	Extensive flooding caused by heavy rain		Prasad 1990, p.10
1991 Jan 18	Many rivers overflowed	Traffic slowed in many parts of Apia town area; schools closed due to lack of water	*Samoa Observer*, Wed 20 Jan 1991 pp.1-2
1991 Dec 6–10 ('Val')	Large areas in Upolu and Savai'i hit with heavy flooding	[1] Some houses flooded; [2] roads and dams damaged; 15 major bridges damaged; construction of hydro-power project delayed for up to a year due to damage associated with flooding and siltation; water supply disrupted	[1] *Samoa Observer*, Fri 13 Dec 1991 pp.1,19 [2] Fairbairn 1997, pp.52,54,55
2000 Jan 21	3 ft in front of Fugalei Market	[1] Damage from driving/riding into holes; health hazard as pit toilets flooded; [2] water inlets blocked	[1] *Sunday Samoan*, Sun 23 Jan 2000 pp.1,7 [2] *Samoa Observer*, Wed 26 Jan 2000 p.3

3. FLOOD DAMAGES

3.1 Financial losses

Infrastructure

Damages to roads, bridges and water-supply pipelines, and the subsequent interruptions, have been recorded after most floods in Table 2.2. Damages to infrastructure after the 2001 flood were estimated to cost $3.3 million.[2] This includes an estimated loss of $1.1 million to Public Works Department (PWD), principally to roads (not bridges); a loss of $2.0 million to Samoa Water Authority (SWA),[3] with almost half the damage sustained at Alaoa Treatment Plant and with much damage to transmission pipes (e.g. Figure 3.1); and a loss of $0.2 million to Electric Power Corporation (EPC), which manages hydro stations (*Sunday Samoan*, Sun 27 May 2001, p.3). The PWD's losses do not include insured damages to construction work at the Lelata Bridge site (which crosses the Vaisigano River – see Figure 2.3) and at the Tuaefu Bridge site (which crosses the Fuluasou River). Holes drilled at Lelata Bridge for a new foundation were filled by rocks and debris, and the completion dates for the bridges were put back by months, at an estimated cost of 'hundreds of thousands of tala' (*Samoa Observer*, Sat 21 Apr 2001, p.5). The Hydrology Section at Apia Observatory sustained a loss of about $31 500 when three recorders and their sheds were washed away (Iosefatu Eti, Hydrology Section, pers. comm., 11 Jul 2001).

Figure 3.1: Damaged pipeline near Fuluasou River
Source: Samoa Water Authority

[2] All damage figures are given in Western Samoan Tala (WST) unless otherwise stated. On 25 July 2001, 1 WST = 0.28 USD or 0.55 AUD.
[3] This includes $0.7 million damage on top of the original damage bill of $1.3 million (Latu Kupa, SWA, pers. comm., 4 Jul 2001).

Commercial

The 2001 flood caused substantial damages to the commercial sector. Insurance data were supplied by the three major local underwriters, and the combined data are presented in Table 3.1. This shows that with a total insured loss of $6.6 million, damages to the commercial sector were at least twice that of damages to infrastructure. Indeed, the true cost is probably higher, because some businesses may have been insured offshore, and because some businesses were under-insured or not insured against flood. Three of the seven surveyed businesses were only partly insured, and two small businesses were not insured at all (Table 3.2). Table 3.2 points to a diversity of commercial damage, from carpets and shop stock to baking and manufacturing equipment, and from a minimum of $2000 to a maximum of $900 000. Very few companies had taken out insurance for interruption of business (Table 3.1). In addition to the $50 000 spent on renovation, Le Culinaire's Bistro must have lost considerable trade in being closed for four weeks (*Samoa Observer*, Sat 12 May 2001, p.4).

*Table 3.1: Insured losses, 2001 flood (*Source: Raw data provided by three local insurance underwriters)

Sector	Number of claims	Loss	Average loss per claim
Commercial	80	$6,584,500	$82,306
Business Interruption	2	$150,000	$75,000
Domestic	36	$942,200	$26,172
Motor Vehicle	17	$133,300	$7,841
Total	135	$7,810,000	$57,852

Table 3.2: Commercial flood damages, 2001 flood (Source: Interviews)

Description of flood damage	Loss	Insurance
▪ Shop stock, e.g. diapers	$2 500	No
▪ Fridges damaged and goods such as rice destroyed in 50 tenant shops ($2500 each); cleaning-up ($40 000)	$165 000	Part
▪ Carpets, shop stock, timber	$60 000	Yes
▪ Bakery equipment and stocks, generator, interior wall space	$140 000	Part
▪ 65 ground-floor rooms flooded: carpets, fridges, ovens, fans, mattresses, etc.	$900 000	Yes
▪ Carpets, fridges	$2000	No
▪ Muddied manufacturing equipment	$500 000	Part

Residential

The insurance loss data indicates that significant damages were sustained to houses in the Apia area (Table 3.1). The average domestic insured loss of $26 000 sounds high, but probably reflects

an over-representation of well-to-do households. That only 36 claims are listed indicates a significant degree of non-insurance. Stated losses for the surveyed households (which probably did not capture the worst affected houses) range from zero to $3000.[4] With the exception of the occasional *uma-kuka*,[5] little structural damage was reported. Contents like carpets, mats, clothes, plates, couches and even mattresses were damaged. Interestingly, the Samoa Red Cross did not view the losses to be sufficient to warrant external assistance (Ben Mulitalo, Samoa Red Cross, pers. comm. 12 Jul 2001). In addition to the damages to household contents, at least 17 motor vehicles were flooded (Table 3.1).

Education

Limited data have been collected to demonstrate the effect of the flood on schools in the Apia area. At least six schools were subject to some degree of inundation: Falevalu Public School, Vaimea Public School, Congregational Senior College (Vaisigano), Manumalo Baptist School (Leone), St Mary's College (Vaimoso) and St Mary's Primary (Savalalo) (Gulumalemana Peters, Department of Education, pers. comm., 12 Jul 2001). Two of those schools reported damages of about $5000, mainly for repainting and to replace books. One principal reported a damage bill of $300 000 (which sounds exaggerated) for cleaning, for electrical and plumbing repairs, and for the replacement of computers and a photocopier.

Agriculture

The Central Bank of Samoa attributed a decline in the volume of several crops supplied to Fugalei Market in April 2001 to the wet weather conditions, especially to the flash flood: *ta'amu* fell by 3 % from March, taro by 9 %, pumpkin by 16 % and tomatoes by 76 % (CBS, 2001). It is not clear, however, why the supply of other produce to the market should increase, such as taro palagi (61 %), chinese cabbage (107 %) and cucumber (108 %). There are several more reasons why caution should be used before attributing these downturns to the flood: first, the flood occurred on April 15, in the middle of the period of survey; second, the limited extent of the heavy rain (Figure 2.2) meant that many agricultural areas of Upolu were unaffected; and third, the influence of seasonal trends requires explanation. The overall impact of the flood on agricultural produce was minor.

[4] A reported loss of $100 000 appeared to be inflated and has been excluded.
[5] An *uma-kuka* is an easily constructed (and deconstructed) kitchen.

There were some reports of lost animals, especially chickens and pigs. One pig reportedly was washed down the Vaisigano River but made its way home to Leone the next day.

3.2 Number of people affected

The number of residents affected by the 2001 flood is here estimated by counting the number of buildings in the flooded zone, and multiplying that number by the average number of people per building. In this there are a number of assumptions that inevitably limit confidence in the final figure. The first source of error is that the actual areal extent of flooding is not precisely demarcated. Second, the aerial photograph used to count buildings is of a scale (1:8000) at which buildings can only just be distinguished from adjacent buildings. Third, some flooded areas lie beyond the boundaries of the photo, such as at Lauli'i and Moamoa. Fourth, judgements as to the nature of activity in a building, whether commercial (excluded from the count) or residential (included), are subjective. Perhaps the most significant assumption is using an average of 4.4 people per building, an average determined for the whole of Samoa at the 1991 Census.[6]

Given all this, 1342 buildings are situated in the flooded zone on the photograph. Accepting an average of 4.4 people per building yields a population of 5905 (an average of 6.4 people per building would give a figure of 8589). However, not all buildings within the flooded zone would experience over-floor inundation, because several have raised floors. For the surveyed sites, about 60 % of buildings are situated 0.3 m or less above the ground. Therefore, 805 houses (60 % of 1342) can be taken to represent a lower limit of houses actually inundated by floodwater, which then yields a population of 3543 (or 5153 using the higher population). In view of likely under-counting, it seems reasonable to assume a well-rounded figure of 5000 for the number of residents directly affected by the flood.

The six flooded schools (see Education in Section 3.1) have a total enrolment of about 3000. Students there missed classes for from a few days to two weeks.

The number of people affected by disruption to water supplies was large. Given that 81 % of Samoa is supplied by Samoa Water Authority (Latu Kupa, SWA, pers. comm., 11 Jul 2001), and given that most supplies to Apia were disrupted, then perhaps about 28 000 people in the capital were affected in this way. Water shortages delayed the cleaning process. In addition, some schools which were not flooded had to be closed for a time due to lack of water, especially for

[6] In 1991, 22 195 households occupied 36 136 buildings, with an average of 4.4 persons per building or 7.3 persons per household (Department of Statistics, 1991, p.47). While certainly not statistically valid, the interviews for this study yielded an average of 6.4 persons per building or 9.4 people per household. Is it possible that more people occupy fewer buildings in the densely populated and growing Apia urban area?

sanitation purposes. This affected 4000 students at the Malifa compound alone (G. Peters, pers. comm.).

No casualties were reported from the 2001 flood.

4. LESSONS AND RECOMMENDATIONS

4.1 Modifying floods

The usual calls for structural solutions to the flooding problem were raised after the 2001 flood. The editor of the *Samoa Observer* (Thurs 19 Apr 2001, p.7) suggested construction of a deep and wide canal around central Apia, and for the widening and deepening of the Vaisigano and Vaimoso Rivers. Two respondents along the lower Vaisigano River argued that the river channel had been narrowed artificially as part of a riverbank protection programme and that it should be restored to its original width. One official argued the need for a flood mitigation dam. These strategies have limitations: they would be expensive, face the difficulty of land acquisition and often give rise to a false sense of security, but do not remove flood risk. The benefits of river enlargement would be limited due to the tidal influence: 'channel modifications are unlikely to have any significant effect … where flooding effects are dominated by tide levels' (ESCAP, 1991, pp.28-29).

Some small-scale river straightening may be warranted, however. It is interesting to observe that in more than one area the floodwater first escaped from channels on very tight river bends, and that flood depths opposite those bends tended to be greater than in adjacent areas. The Gasegase Stream at Sinamoga is one such place (Figure 4.1). Rocks from the revetment wall were removed by the flood and deposited in the road, and depths near the shop behind were about 1.1 m (see Site 15 on Figure 2.3). River straightening can have unforeseen geomorphic consequences, however, for when a channel is straightened the slope is steepened, and stream power increased, ultimately leading to unwanted channel instability elsewhere.

Figure 4.1: Gasegase (Vaimoso) Stream, Sinamoga, showing directions of flow

The PWD, SWA and EPC prepared a joint report arguing that the only way to stop future damage to property and public amenities was for extensive improvement to the drainage system (*Sunday Samoan*, Sun 27 May, p.3). A similar conclusion was reached after the 1975 flood (*Samoa Times*, 31 Jan – 7 Feb 1975, p.2)! The current status of Apia's drainage system has not been investigated for this project, but it seems that despite the work of a German-funded project in 1989 (Isikuki Punivalu, PWD, pers. comm., 4 Jul 2001), there remains a need for an integrated stormwater management plan (Paul Fritz, Apia Management Solutions, pers. comm., 12 Jul 2001). It is, however, important to remember that all drainage systems are built to a design event (e.g. the 10% flood), and will be overcharged in rare events, such as during rainfalls of 200 mm in four hours! Nevertheless, there is evidence to suggest that even existing drains could be better maintained by regular removal of rubbish (or prevention of its dumping there in the first place), which would have additional ecological benefits (Paul Fritz, pers. comm.).

Sustainable watershed management practices are important for retarding flood peaks. Practices in the Vaisigano watershed may have improved since Baisyet's work in 1990 (see Section 2.2).

4.2 Modifying human behaviour

The danger of emphasizing strategies to modify floods is a tendency to think that nature is controllable, forgetting the natural propensity for flooding that exists in the Apia area. Indeed, a focus on engineering solutions can divert attention from the ultimate (even if unpalatable) causes of the problem. It is helpful to conceive of flood damages as the product of a physical phenomenon and a susceptible population. At least as much consideration should be devoted to means of increasing community resilience as to means of alleviating the depth of water.

Floodplain occupancy

Much of Apia is situated only one metre above sea level (Isikuki Punivalu, pers. comm.). Flooding is not unexpected in such areas – a comment after the 1939 flood is telling: 'We noticed many houses which had all the appearance of being built in the middle of a lake' (*Western Samoa Mail*, Sat 21 Jan 1939, p.4). Reclamation and subsequent development of low-lying land has exacerbated the problem. Place names of now developed areas provide some indication of their history – Taufusi, for example, means 'swamp' (*Samoa Times*, 31 Jan – Feb 7 1975, p.2). Sites 5 and 11 on Figure 2.3 were originally swamps. It is natural that after heavy rain these areas revert to drainage sinks. Site 16 contains a factory that was apparently constructed on land reclaimed from an old river channel (Figure 4.2). Re-activation of this channel following heavy rain should not surprise.

Figure 4.2: Factory situated on reclaimed land, blocking flood channel, Fa'atoia

Settlement of flood-liable land, and reclamation from swamps and old channels, has been fuelled by a shortage of land as people migrate to Apia for work and education. Apia recorded a net gain of 1218 people in the five years to 1991 (Department of Statistics, 1991, p.22), and is now estimated to have a population as high as 42 000 (Nia Belcher, Department of Lands, Surveys and Environment [DLSE], pers. comm., 12 Jul 2001). These immigrants may have little choice over where to live, such as a family from Savai'i that rents freehold land (Site 9).

This urban growth has not been regulated by a town-planning scheme. This reflects the high proportion of *customary* land in Samoa (>80%),[7] over which the Government has very little control. There is evidence, however, to suggest that even the development of *freehold* land has been largely uncontrolled. There are few, if any, regulations in place to direct development, despite demands for the prohibition of building close to riverbanks or across old riverbeds (e.g. *Samoa Observer*, Thurs 19 Apr 2001, p.7 and Sat 21 Apr 2001, p.7). One provision of potential benefit is the Government Reserve within 5 m of rivers, but this is new and would be difficult to enforce (Nia Belcher, pers. comm.). The Government has not had a department to supervise urban planning – only recently has a Land Management Division been established within DLSE. And only in August 2001 is a draft urban plan scheduled for release by Virtual Consulting (Nia Belcher, pers. comm.).

In any case, a highly regulatory approach is unlikely to succeed in Samoa. A more effective means for promoting sustainable management of floodplains is through a cooperative approach. One model of a cooperative approach is the recently launched Coastal Infrastructure Management Strategy (CIMS), which has as its vision, 'Coastal Infrastructure and Communities Resilient to Natural Hazards'. CIMS aims to promote partnerships between Government and local communities for integrated coastal management. *Pulenu'u* and the *Fono a Matai* (community leaders) are regarded as key figures for advocating coastal management. A philosophy of 'working with nature' and adoption of a precautionary principle are central tenets (BICL, 2001). There is much in the CIMS model to commend, and even imitate. Indeed, improved floodplain management could be achieved by extending the scope of CIMS to incorporate not only the coastal-flood hazard zone (mainly referring to flooding from the sea, which has already been mapped) but the riverine flood-hazard zone as well (Paul Fritz, pers. comm.).

Flood-proofing

In view of the current difficulties in controlling development of floodplains, and the constraints to undoing what has already been done, measures to safeguard property through flood-proofing

[7] For the Apia Urban Area, the proportion of customary land is probably less and the proportion of freehold land probably more. One hint of this is the number of buildings under different tenure (Department of Statistics, 1991, p.47).

techniques take on special importance. Dr Bourke (*Samoa Observer*, Wed 26 Jan 2000, p.3) advocated the use of barriers to stop trees and other debris clogging water inlets. Where possible, transmission pipes (such as those in Figure 3.1) should be relocated beyond the active river channel, which is a naturally dynamic entity. The most obvious flood-proofing technique for buildings is to raise floor levels, which may require external financial assistance (*Samoa Observer*, 11 Feb 1982, p.2). The advantages of floor-raising (such as the fale in Figure 4.3) are reduced frequency, depth and duration of flooding. Even if there is no scope to raise floors, valuable equipment or goods can be stored at a higher level. The recent relocation of the electrical switchboard to the first floor, and construction of an off-site storage shed on high ground, are examples of this at Aggie Grey's Hotel. The flood-prone schools should relocate administration offices (with their valuable equipment) to first floors where available. The substitution of water-resistant materials for susceptible materials (e.g. chipboard furniture) is another form of flood-proofing. Insurers can promote these measures by specifying conditions in contracts with flood-liable businesses, for example by insuring nothing within 0.30 m of the floor (at one time a common approach in Ba, Fiji). In response to the April flood, an insurer has required one business to construct platforms above the factory floor for the storage of equipment.

Figure 4.3: Raised fale, Fa'atoia

Flood warning systems

There was no formal flood warning before the April 2001 event. The forecast for the night of 15 April was for 'heavy showers with possible thunderstorms', based on an intensifying trough and on a GASP precipitation model which predicted a rainfall of more than 70 mm within a 120-km resolution in the five hours to midnight (Meteorological Division, 2001). While severe thunderstorms eventuated – with an amazing display of thunder and lightning – the actual rain was 200 mm. Samoa does not have the benefit of weather radar, nor radar for Faleolo International Airport (F. Malele, pers. comm.), which could have facilitated the rapid release of warnings as the event was unfolding.

There are, however, serious doubts as to whether more-precise predictions would have made a great deal of difference. The obvious constraint governing flood warnings in the Apia area is the naturally short time between rainfall and river response (Figure 2.2). Though up to two hours' warning may be provided by weather radar (*Samoa Observer*, Thurs 19 Apr 2001, p.7), inevitably a significant uncertainty would be attached to such warnings. The public tends to lose confidence in forecasts if 'false alarms' are frequent. Indeed, in the same way as in Fiji the number of 'false alarms' rose after the 'missed' flood of January 1999 (Yeo, 2000, p.13), the Samoa Meteorological Division is said to have issued flood warnings rather too freely in the weeks after the Easter flood.

To constraints on forecasting must be added the challenge of provoking behavioral change. A flood warning *system* consists of much more than a forecast (Yeo, 2000, p.19ff). The process of *communicating* a forecast, in a way that prompts people to take appropriate actions, is critical. Even if the best imaginable forecast had been released on 15 April, engendering an efficient response would have been difficult on an Easter Sunday night, among a community relatively unfamiliar with such floods. Often people await confirmation of the threat from their own experience. In April 2001 this informal warning was all that was available, and being alerted to the threat only when flooding was imminent, few had success in saving property. It was fortunate that flood depths were not sufficient to pose a great threat to life – all respondents remained at their houses. In the long-term, flood sirens may allow for a slightly faster response.

Education

It is appropriate when considering the development of a Public Awareness Information Brochure (Task 11, Appendix 1.1) to identify and evaluate any existing brochures. In Samoa, the mandate for disaster education rests with the Samoa Red Cross, which in 1998 produced a flood brochure (reproduced in Appendix 4.1, with English summary in Appendix 4.2). This describes the 1989

flood, lists some flood-affected areas, and contains comprehensive recommendations to increase community resilience to floods. Most recommendations relate to *short-term* preparedness and recovery, although the need to avoid building houses in flood-liable areas is emphasized. There is much in this brochure to commend and to carry-over to revised editions. Of course, it should now be updated by reference to the experience of the 2001 flood. The 1998/99 Samoa telephone directory also contains recommendations for responding to floods (Appendix 4.2). The advantage of conveying information in this form is its dispersal to many households, but whether people actually read it is questionable, and the five recommendations are too general to be of much value.

It is also appropriate to consider the value of brochures, in comparison to alternative methods of raising awareness and, ultimately, enhancing resilience to flood hazards. Brochures are just one means of communicating information, and can be rather impersonal and hence easily ignored. So, there is scope to include flood hazards in school curricula (G. Peters, pers. comm.). A participatory, 'bottom-up' approach to hazard education via the Red Cross, Ministry of Internal Affairs and village *pulenu'u* is recommended in the Samoan context.

The development of a draft brochure here is limited by the short time spent in Samoa, in which it was clearly impossible to learn much of Samoan culture, let alone language and idioms. Despite several inquiries, no suitable photographs depicting flood damage have been obtained to date (a loss assessor from GAB Robins [NZ] is seeking permission from insured clients to supply these). What follows needs to be checked (before translation) for clarity, relevance, acceptability, persuasiveness and appropriateness (Garcia, 1997). Further, what is presented here really represents the (proposed) *content* for a brochure rather than the *packaging*. It is, very much, a draft! It is not, however, a draft without foundation, for several people have been questioned to illuminate perceptions of flooding (Q19-Q21 in Appendix 1.2). The aim of this brochure (Figure 4.4) is to promote flood preparedness (excluding storm surge) among adults in Apia.

5. CONCLUSION

Financial losses from the Apia flood of Easter 2001 exceeded WST$11 million, with a $3.3 million damage bill to infrastructure and a $7.8 million insurance pay-out, especially for commercial damages. This figure represents an underestimate of damages, because many houses were not insured and few businesses were insured for business interruption. A coarse estimate suggests that about 5000 residents were directly affected by over-floor inundation, and in the order of 28 000 people may have been affected by water shortages.

Floods may be alleviated to a degree by localised straightening of congested river bends, by the development of an integrated stormwater management plan, and by the maintenance of clear drains. However, flooding like that of April 2001 would still be expected to occur, given the intense rain (200 mm in four hours) over short, steep watersheds. High tides can also promote flooding, though the influence of the tide in 2001 is a matter of debate – possibly overrated.

Given the difficulties of developing an effective flood warning system where rivers are so ‘flashy’, more attention should be given to long-term mitigation through flood-proofing measures. The best long-term solution is for a more sustainable development of floodplains. High resolution (0.5 m) floodplain maps are prerequisite for informed planning decisions. In Samoa, regulations are unlikely to gain the acceptance of land-owners, highlighting the need for cooperative approaches to land use management, such as through the Coastal Infrastructure Management Strategy.

Insufficient data are available to estimate the frequency of the 2001 flood with much confidence. The *daily* rainfall was not particularly rare. An incomplete flood history constructed from newspapers points to severe flooding in 1975 and 1939. On that (tenuous) basis it is estimated that the 2001 event has a chance of about 3-4 % to occur in a year. Actual flood depths were not too serious, but the sometimes heavy losses suggest that preparedness could be improved. Certainly, the message people need to hear is captured in the draft flood preparedness guide: ‘Apia has had floods before and will have floods again’.

FLOOD PREPAREDNESS GUIDE, APIA, SAMOA

The night of Easter Sunday 2001 will long be remembered as a time when flash floods descended from the hills above Apia, causing severe damages to many houses, businesses, roads and pipelines. Some of the worst affected areas were along the Vaisigano River (Faatoia, Leone, Vaisigano), Vailima Stream (Taufusi), Vaimoso Stream (Sinamoga, Pesega, Vaimoso) and Fuluasou River (Lepea).

These floods rose very quickly as the result of heavy rain (200 mm in four hours) falling on the short and steep watersheds that flow through Apia. A rising tide may also have contributed to the flooding.

Flooding in Apia is not new. Cyclone Gina caused flooding at Vaisigano, Vaimoso and Lepea in 1989. Old newspapers record other floods in 2000, 1991 (with Cyclone Val), 1990 (with Cyclone Ofa), 1982, 1975, and 1974. Houses were washed away and two people drowned during a flood in 1939. Low-lying areas reclaimed from swamps (e.g. Fugalei) are especially flood-prone. But sometimes floods can cut completely new river channels.

Rock walls do not prevent flooding. But you can alleviate flooding in four ways.
(1) Do not strip slopes of trees.
(2) Do not cut down trees along riverbanks.
(3) Do not dump rubbish in drains or rivers – this can block the flow of water.
(4) Do not build over an old river channel – this can actually shift the flood to your neighbour's place.

However, sometimes the rain is so heavy that a flood will come whatever you do.
Apia has had floods before and will have floods again!
For that reason, you need to **be prepared**.

You can reduce your risk in several ways.
(1) Try to build on high land.
(2) Try to raise buildings above ground level.
(3) Construct raised platforms for valuable assets.
(4) Store valuable assets at a high level.
(5) Choose water-resistant floor-coverings (not carpets) and furniture (not chipboard).
(6) Consider purchasing insurance against flood.

Sometimes there will be some warning of a flood – every cyclone has the potential to produce a flood. But floods can also occur without a cyclone (e.g. April 2001). Since it is difficult to forecast flooding at Apia, you need to **be alert** to heavy rain as well as listen to the radio. Be ready to disconnect electricity and to evacuate to high ground. Remember that depths of flooding can be deceptive, so avoid swimming or driving through floodwater.

'A prudent man sees danger and takes refuge…' (Proverbs 22:3, NIV)

Figure 4.4: Draft flood awareness brochure

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APPENDIX 1.1

Project tasks (SOPAC)

1. Conduct an in-country review and evaluation of the extent of damage caused by recent flash flooding in Apia, Samoa
2. Hold meeting with appropriate representatives of Government agencies such as the Meteorological Office, Public Works Department and Water Authority
3. Ascertain extents and heights of flooding at different locations within Apia urban area
4. Identify which buildings were inundated to which levels
5. How many people were affected and to what extent
6. Gather meteorological details and tide information
7. Causative factors
8. Hydrology of streams
9. Probability information on flood return periods and heights
10. Prepare an evaluation report including lessons learnt
11. Draft a Public Awareness Information Brochure

APPENDIX 1.2

APIA FLOOD DAMAGE SURVEY, 15-16 APRIL 2001
Disaster Management Unit, SOPAC

Survey Number:

BACKGROUND

1) Today's date: __ / __ / __ Your name: _____

2) House/shop address: _____ [Grid Ref: _____]

3) What is [was] the primary wall material in your house/shop? _____

4) How high is [was] the main floor level of your house/shop above ground level? ____ m, or ____ ft

5) Do you own or lease the affected property? Own ð Lease ð

6) How long have you been living at this address? Since ____, or ____ years

7) a) Have you experienced other floods (before April 2001) at this address? No ð Yes ð
b) If yes, in what years? _____
c) How did they compare to the recent flood? _____

FLOOD DETAILS

8) At about what time of day or night did the recent flood enter your house/shop?

9) At about what rate did the water rise? _____

10) What was the maximum height of floodwater over the main floor? ____ m, or ____ ft

11) About when did the water fall below the floor of your house/shop? _____

WARNING AND EVACUATION

12) a) Did you have any forewarning of the flood? No ð Yes ð
b) If yes, how? Radio ð Contacted by family/friends ð Saw heavy rain ð Saw river rise ð

13) a) Did you lift or shift any property? No ð Yes ð
b) If yes, were your actions effective in saving property? No ð Yes ð Partly ð

14) a) Did you or your family evacuate the house? No ð Yes ð
b) If yes, where did you go? _____

FLOOD DAMAGES

15) Please indicate whether the following items were damaged, detail any damage, and estimate the cost:

Item	Damage?		Details of any damage	Cost ($)
Building structure	No ð	Yes ð		
Contents	No ð	Yes ð		
Animals	No ð	Yes ð		
Crops	No ð	Yes ð		
Other	No ð	Yes ð		

16) What is the total direct damage bill from the flood? $ _____

17) How many days did it take to clean the house / restore trade or production? _____ days

18) Were you insured against flood? No ð Yes ð Partly ð

COMMENTS

19) Do you have any comments about the causes and solutions to the flooding problem?
_____

20) Is there anything the Government can do better to manage the problem?
_____

21) What lessons have you learned from the event?
_____

CONTACT DETAILS

22) May we contact you about this survey? No ð Yes ð
Phone: _____ Postal address: _____

Please return to:
Dr S. Yeo, SOPAC Secretariat
Private Mail Bag, GPO, Suva, Fiji

APPENDIX 2.1

Annual Series of Daily Rainfall Maxima, Apia and Afiamalu

Source: Samoa Meteorology Division, Apia

	Apia		Afiamalu	
	Date	Rain (mm)	Date	Rain (mm)
1973	29-Jan	165		
1974	18-Dec	115		
1975	26-Jan	173		
1976	9-Dec	148		
1977	27-Jan	150		
1978	27-Jan	237		
1979	24-Mar	127		
1980	21-Sep	177	8-Feb	153
1981	1-Mar	144	31-Dec	188
1982	4-Feb	224	8-Feb	238
1983	26-Dec	170	23-Dec	232
1984	21-Dec	80	28-Dec	172
1985	1-Mar	191	1-Mar	138
1986	1-Mar	191[#]		
1987	30-Jan	163		
1988	14-Jan	**486**	14-Jan	**500**
1989	6-Jan	195	6-Jan	460
1990	20-Mar	106	20-Mar	189
1991	19-Feb	232	17-Feb	231
1992	8-Apr	170	19-Dec	149
1993	30-Jan	286	18-Feb	136
1994	28-Nov	120	16-Aug	115
1995	24-Jan	145	24-Jan	161
1996	19-Jan	97	6-Jan	192
1997	8-Jan	233	12-Jun	269
1998	14-Jan	486[#]	21-Dec	177
1999	12-Jan	130	12-Jan	169
2000	6-Mar	134	27-Feb	178
2001[##]	16-Apr	216	16-Apr	225

[#] probable errors (compare 1986 to 1985 and 1998 to 1988)
[##] to June

APPENDIX 2.2

Historic Rainfall Maxima, Samoa

Date	Station	Rainfall	Duration	Sources
1923 Mar 9	Apia Observatory	264 mm	1 day	*Samoa Times*, 9 Mar 1923 p.7 & 16 Mar 1923 p.7
1923 Mar 5–10	Apia Observatory	675 mm	6 days	*Samoa Times*, 9 Mar 1923 p.7 & 16 Mar 1923 p.7
1935 Jan 17	Apia Observatory	337 mm + (overflowed)	1 day (to 9 am)	*Samoa Herald*, 18 Jan 1935 p.2
1935 Jan 17	Vaipoto	397 mm	1 day	*Samoa Herald*, 1 Feb 1935 p.5
1939 Jan 16	Apia Observatory	405 mm	1 day	*Western Samoa Mail*, 21 Jan 1939 p.4
1939 Jan 15–16	Apia Observatory	714 mm	2 days	*Western Samoa Mail*, 21 Jan 1939 p.4
1939 Jan	Vailima	1118 mm	3 days	*Western Samoa Mail*, 21 Jan 1939 p.4
1939 Jan 17	Tapatapao	660 mm	1 day (to 9 a.m.)	*Western Samoa Mail*, 28 Jan 1939 p.5
1939 Jan 16-17	Tapatapao	1311 mm	2 days (to 9 am)	*Western Samoa Mail*, 28 Jan 1939 p.5
1966 Jan (hurricane)	Apia Observatory	141 mm	1 day	*Samoa Times*, 12 Feb 1982 p.1
1968 Feb (hurricane)	Apia Observatory	76 mm	1 day	*Samoa Times*, 12 Feb 1982 p.1
1972 (‘Elenore’)		476 mm	6 days	UNCTD 1983, Annex 15
1975 Jan	‘some places’	700 mm +	1 day	*Samoa Times*, Jan 31–Feb 7 1975, p.1
1982 Feb 5	Apia Observatory	251 mm	1 day	*Samoa Times*, 12 Feb 1982 p.1
1982 Feb 4–9	Apia Observatory	841 mm	6 days	*Samoa Times*, 12 Feb 1982 p.1
1982 Feb	Afiamalu	1014 mm	5 days	UNDRO 1982, p.2
2000 Jan 21	Apia Observatory	132 mm	1 day (to 9 am)	*Sunday Samoan*, 23 Jan 2000 p.1

APPENDIX 4.1

Red Cross Brochure

FAUTUAGA. I Taimi ua amata Lologa.

- **Ia manatua o le Saogalemu o lou aiga o le mea e sili ona taua lea.** Aua le toe faatali ae vave ona agai atu loa I ni laufanua maualuluga pe a iai ni fautuaga mai le leitio pe iai foi ni faailoga e mautinoa ai ua amata ona faatupulaia ni Lologa.
- Afai ua latalata mai le po, ua tatau loa ona agai atu I laufanua saogalemu.
- Aua le taumafai e laasia se vaitafe, ae maise I se taavale.
- Faatonu le fanau e aua le taeele I vaitafe poo autu.
- Nonofo pea i laufanua maualuluga se ia tea Lologa.

FAUTUAGA. Ina ua tuanai Lologa.

- Ina ua tuanai Lologa ia faapuna uma vai inu faapea le faavela uma o mea taumafa.
- Ae lei toe faaolaina le eletise o lou fale, e tatau ona siaki lelei uaea faapea pusa-aisa ma ogaumu uila.

Ia manatua, ae le i fauina sou fale, ia mautinoa o le fanua o le a fauina ai i luga, e le ono aafia i ui Lologa.

Faafetai i le Ofisa o le Vaai- Tau mo le fesoasoani i le tusia o lenei pepa.

Koluse Mumu a Samoa,
Pusa Meli 1616,
Apia.
Telefoni 23686.

Fepuari 1998.

LOLOGA.

KOLUSE MUMU A SAMOA.

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O **Lologa** e mafua ona o le tetele o timuga. O nofoaga e aafia soo i Lologa o vaega ia e latalata i vaitafe e iai Lalomauga, Falevao, se vaega o Magiagi, Pulaia, Samalaeulu ma isi; faapea lautanua maualalao e tuai ona tafe ese atu le vai pe a timu e pei o se vaega o Mateutu uta, Togafusfua, Saleufi, Taufusi ma Fugalei i Apia.

I le 1989 ina ua aafia Samoa i le Afa o Gina, sa iloga ona faaleagaina maota o nisi o aiga i le Faasaleleaga i le anata atu i Saasaai se ia oo atu i Puapua i Lologa. O le molimau a nisi o nei alalafaga, o se tulaga fou lea sa le masani ai i latou.

O nisi foi o taimi ua maitauina le vave ona siisii le maualuga o le tafe a le Vaisigano i Apia e ui ina e le tetele ni timu. E le taumate o loo faapea foi i vaitafe i nisi vaega o le atunuu.

E iai le talitonuga e oo tasi o mafuaaga o tulaga e pei ona taua i luga, ona o le malosi lea o le taina i lalo o laau i autafa o mauga faapea i lautanua i tafatafa o vaitafe.

O le aoga o nei laau, latou te apoina le suavai mai le timu i o latou lapiaau ae maise o latou a'a ma faapea ona faamatuu malie atu ai e nei laau le alu atu o le suavai i vaitafe. O le mafuaaga foi lea na maitauina ai i aso ua mavae, se le i malosi le taina o le vao i Samoa, le maua pea o le suavai i nisi o vaitafe e pei o le Vaisigano e ui lava ina leai ni timuga i se taimi umi. O le tasi aoga o laau o le tafia lea o le elesie i o latou a'a ma le mafai ai ona solo pe a timu ma avatu ai e vaitafe i le sami.

Talosaga.

- Faatitia le taina o le vao i tafatafa o vaitafe e pei ona fautuaina ai e le Ofisa o le Siosiomaga faapea le Ofisa o le Vai a le tatou Malo

- Aua le lafoina otaota i alavai o loo ua uma ona fausia i nofoaga e pei o Togafusfua, Taufusi, Saleufi ma Fugalei.

FAUTUAGA. A o lumanai timuga.

- Ae le i oo i le vaitau o timuga, Oketopa ia Mati, vaai pe ono aafia lou fale i ni Lologa; ae poo fea foi se lautanua maualuga tou te o atu iai ma lou aiga pe a tulai mai ni Lologa.

- Faamalamalama i le fonau le tulaga o pei ona taua i luga ma faamatala iai le mea e tatau ona fai pe afai e tulai mai ni Lologa ae na o i latou o loo i le fale.

FAUTUAGA. I taimi ua ono faatupulaia ni Lologa.

- A mamafa ma faifai pea timuga o failoga ia e ono iai ni Lologa ma ua tatau loa ona sauniuni mo le o ese vave atu ma agai atu i lautanua maualuluga.

- Faalogologo i le faitio mo ni lapataiga.

- Vaai meafale na nisi mea aoga tuu i luga o ni vaega maualuluga o le fale.

- A iai ni vailaau [vailaau fagavao na nisi ituaiga.] tuu i luga o se mea maualuga ia aua nei oo iai le vai.

- Tape le eletise o lou fale.

- Ia lava ni lavalava mamago e tuu i ni tagapepa mo le soifua-maloloina o le aiga.

- Ua tatau ona ave le fanau, tama ma tina matutua, faapea i latou e le atoatoa le malosi i ni laufanua saogalemu.

APPENDIX 4.2

Summaries of Existing Flood-awareness Materials

The Samoa Red Cross Society produced a flood brochure in 1998 (reproduced in Appendix 4.1). In this, a number of flood-prone areas are listed, the 1989 flood is described, and the influence of deforestation is emphasized. Several recommendations are made for each phase of the emergency continuum. *At the start of the wet season*, readers are advised to plan to evacuate to high ground and to teach children of the danger. *Prior to a flood*, people should watch for heavy rain, listen to the radio, lift valuable possessions and weed-killers, disconnect electricity, and take dry clothes, children, the elderly and handicapped to high ground. *During flooding*, readers are encouraged to evacuate early rather than late, to avoid crossing a river even in a vehicle, and to tell children not to swim in the river. People should boil water and cook all food, and check appliances and wires *after a flood*. Highlighted in large, bold type at the end of the Red Cross brochure is the instruction, ‘Before you build your house, ensure the land is not low-lying or flood-prone’ (translated by Sharon Potoi, Ministry of Foreign Affairs).

The 1998/99 Samoan telephone directory contains five recommendations for responding to floods under its ‘Civil Defence’ section (p.15): to act on warnings from radios, to turn off electricity and water at the mains, to move all valuable goods out of the reach of water, to remove weed killers out of the reach of water, and to avoid swimming in flood waters.