South Pacific Regional Environment Programme

Western Samoa:

Land-based pollution sources and their effects on the marine environment

A Report by Pavel Klinckhamers

Apia, Western Samoa
October 1992

Western Samoa:

Land based pollution sources and their effects on the marine environment

A Report by Pavel Klinckhamers

South Pacific Regional Environment Programme
Apia, Western Samoa
Professor H.C. van Hall Instituut
Groningen, The Netherlands

Preface

This report documents the results of a survey on the land based pollution sources and their effects on the marine environment of Western Samoa. This survey was carried out from June to October 1992 in order to locate the major waste sources in Western Samoa, to locate the coastal areas which were probably affected by the effluents of such waste sources, and to assess the actual state of the coastal environments which are probably affected.

This survey has been carried out as a probationary term of the Environmental Science course at the Professor H.C. van Hall Instituut in Groningen, The Netherlands. This survey has been made possible by the South Pacific Regional Environment Programme (SPREP) in Western Samoa, which provided office utilities, access to information and personnel working in the fields of coastal management, marine pollution and environmental contamination. Introductions were also made to numerous Western Samoan government departments.

Pavel Klinckhamers
October 1992

Contents

1. Introduction

Over the last twenty years the South Pacific region has seen numerous changes in its physical environment due to human-related activities such as increased industrialisation and rapid urbanisation. While increased industrialisation has led to the production of large volumes of waste products/water requiring subsequent disposal (usually into surrounding marine environments), the rapid urbanisation has resulted in increased discharge of large volumes of human wastes and domestic rubbish usually into surrounding aquatic environments due to inadequate waste disposal facilities. One likely consequence of such activities is the degradation or destabilisation of the surrounding ecosystems to the point where it has become impossible to maintain the limited natural resources on which most of the island communities depend (S. Naidu et al., 1991).

In this report the land based pollution sources in Western Samoa were identified and examined. In Western Samoa, there has already been some waste inventorisation, albeit incomplete, but these did not include information about the effect on surrounding coastal waters. They also did not locate the source of the pollution. All these data are, however, necessary when, in the future, these polluters have to be handled or regulated.

I looked at the land based pollution because land based pollution sources are the biggest contributor to the marine pollution. At the United Nations Conference on Environment and Development (UNCED, 3-14 June 1992) it was stated: "Degradation of the marine environment can result from a wide range of sources. Land based sources contribute seventy percent of marine pollution. Many of the polluting substances originating from land based sources are of particular concern to the marine environment since they exhibit at the same time toxicity, persistence and bio-accumulation in the foodchain."

In the first part of this report the pollution sources in Western Samoa are discussed. This part especially concentrates on discussion and location of pollution coming from industrial activities and tourist facilities.

In the second part the effects on the marine environment are discussed. This part is split up into a section about the environmental effects, the ecological characteristics of the interesting spots, and a description of the environmental impacts caused by the polluting sites.

2. Country Background

2.1. Geography and population

Western Samoa is a tropical island state with a terrestrial surface of approximately 2930 square kilometers on two large and several small islands. Four of the islands are inhabited: Savai'i (approximately 1820 km^2), 'Upolu (approximately 1100 km^2), Apolima (approximately 2 km^2) and Manono (approximately 5 km^2). Over seventy percent of the population of approximately 160,000 is living on 'Upolu with 33,000 people (20 percent) living in the capital Apia. The other thirty percent of the population is living on Savai'i. Apolima and

Manono are very scarcely populated. Several additional very small, uninhabited islands lie within or on the reef systems of 'Upolu and Savai'i. Western Samoa's Exclusive Economic Zone (EEZ) is approximately 131,000 km^2. Contiguous countries are Tokelau at the north, American Samoa at the east, the Kingdom of Tonga at the south and Wallis and Futuna at the west. Some distances to better known places are 4200 km to Hawai'i which lies northeast of Western Samoa, 4350 km from Sydney, Australia (in the west) and 2900 km from New Zealand (in the southwest).

All of the islands are volcanic in origin. The island of Savai'i is still considered volcanically active, with its most recent eruption producing a lava flow between 1905 to 1911. 'Upolu is older and, as a result of weathering and erosion, is generally more rugged. Maximum elevations range from 1858 m on Savai'i, 1100 m on 'Upolu, 200 m on Nu'utele, 165 m on Apolima and 60 m on Manono, to near sea-level on the smallest islands (S.H. Pearsall and W.A. Whistler, 1991).

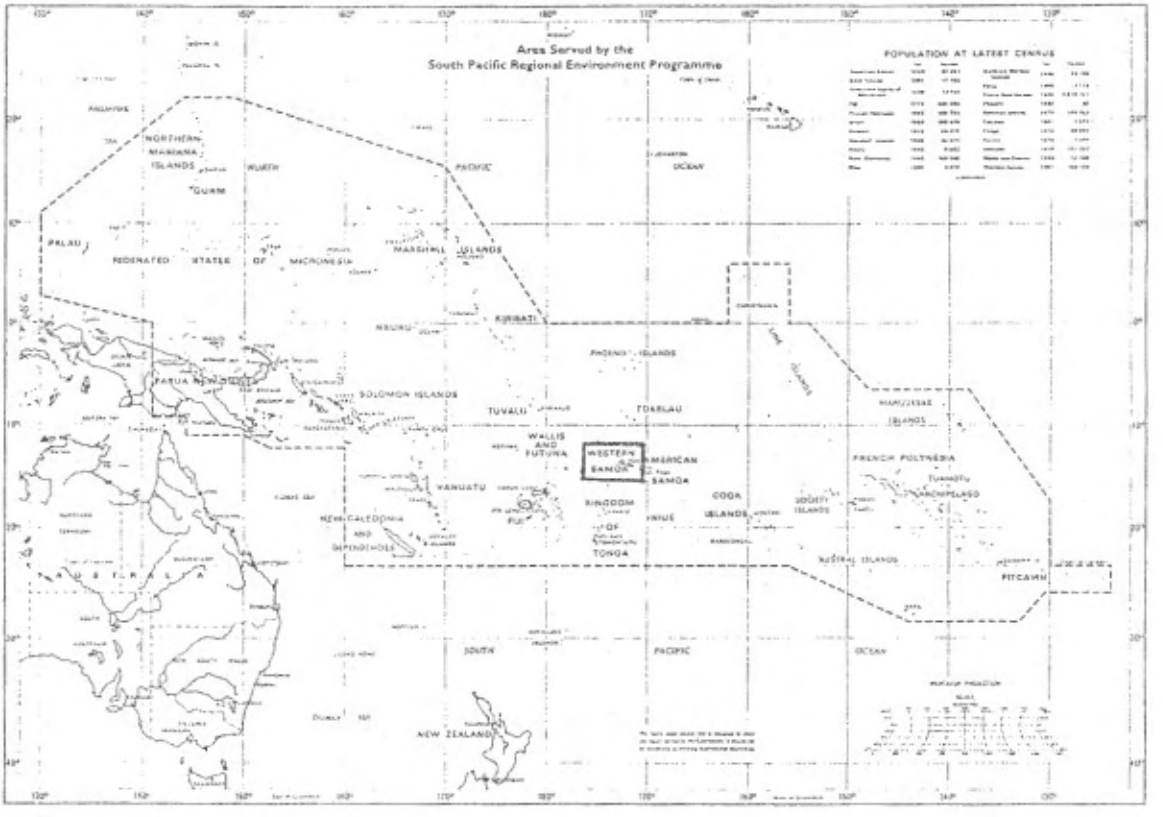


Figure 2.1. The location of Western Samoa in the South Pacific

2.2. Climate

The climate is generally tropical and mild, having wet and dry seasons. The southern and western sides of the main islands tend to receive more rainfall than the eastern and northern sides due to prevailing southwesterly trade winds and orographic effects. In Apia, on the northern coast of 'Upolu, rainfall averages 2870 mm/year with the heaviest rainfall in January (424 mm) and the lightest in July (96 mm). On the windward south and southeastern shores annual rainfall averages between 5000 and 7000 mm. At higher elevations, rainfall averages 5000 mm at 1000 m elevation and 7000 mm above 1200 m on Savai'i. There are no abrupt rainfall transitions; wet and dry seasons grade into each other. Droughts are common.

The main annual temperature in Apia is 26 degrees centigrade. (S.H. Pearsall and W.A. Whistler, 1991).

Major hurricanes were rare in Western Samoa in the period prior to 1990, with only two hurricanes striking the islands in 1939 and 1966. In February 1990, however, Ofa, the worst cyclone in 169 years hit the islands and caused serious damage to crops and vegetation. In December 1991, only 21 months later, cyclone Val struck the still recovering islands, causing even more damage.

2.3. Ecology

In Western Samoa, environmental gradients are quite steep, with cloud forests occupying the upper elevations on Savai'i, montane and mid - elevation rain forests on the larger islands, and coastal and littoral forests on most islands. The coastal ecosystems include rock and sand strand communities, isolated mangrove forests, and extensive fringing reefs. Most of the coastal forests have been replaced by gardens, plantations, villages and, in Apia, urban development (S.H. Pearsall and W.A. Whistler).

Whistler (1992) estimates that Western Samoa supports 775 native vascular plant species of which approximately 30 % of the angiosperms are endemic. There are about 280 genera of native angiosperms. In addition there are about 250 introduced plant species. Whistler lists 47 threatened plant species.

There are 21 butterfly species in Western Samoa (including one species of swallowtail butterfly endemic to the Samoas and threatened). There are 9 endemic charopid snail species and 8 endemic partulid snail species. Approximately 15 (mostly marine) invertebrates are considered threatened in Western Samoa.

Western Samoa supports 11 species of reptiles including 7 species of lizards and 1 snake. None of Western Samoa's terrestrial reptiles is considered threatened, but all marine turtles that visit the islands are considered threatened or endangered on a global basis.

Of 43 resident bird species in Western Samoa, eight are endemic. Most resident land birds have one or more subspecies endemic to Western Samoa. Nine bird species are considered to be threatened.

The Samoan archipelago supports one sheath-tailed bat and two flying foxes or fruit bats. All three are considered threatened. Six species of cetaceans (whales and porpoises) that visit Samoa's waters are considered threatened (S.H. Pearsall and W.A. Whistler, 1991).

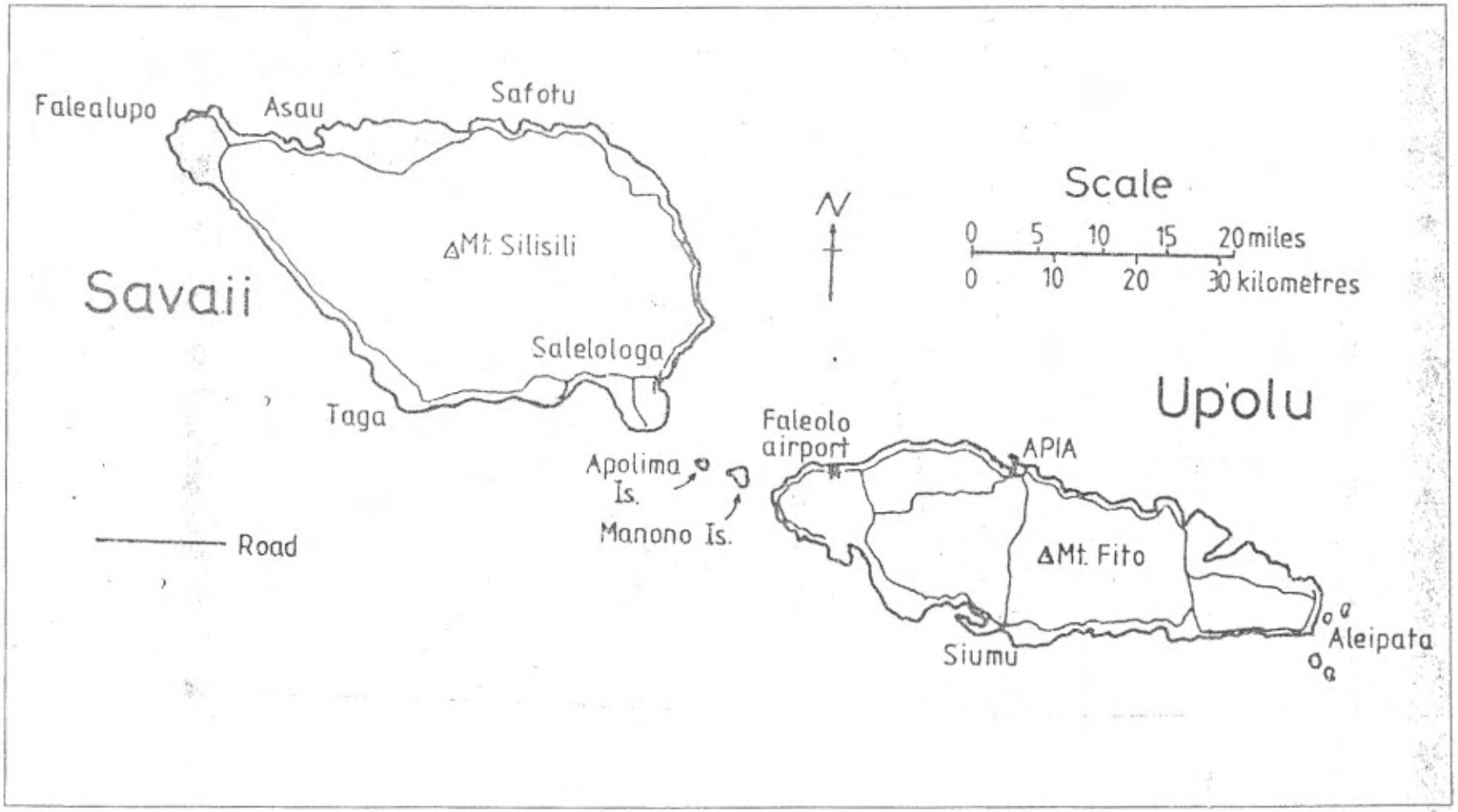


Figure 2.2. Western Samoa

PART ONE: POLLUTION SOURCES

The pollution sources which have been examined in this survey are industrial sources, tourist facilities, laboratories and some other pollution sources. These will probably comprise most of the land based pollution sources in Western Samoa.

Industries are known for discharging large amounts of wastes of various compositions (depending on the industry type) into the nearby environment. The industries are divided into food and beverage industry, oil storage, mechanical shops, photo processing and printing, saw mills manufacturing, industrial chemical manufacturing, power plants and other industries.

The emphasis in this report is on the environmental effects from pollution coming from industrial sites. This, however, does not mean that the industrial sites are responsible for the major part of the marine pollution. Very polluting factors in Western Samoa are, for example, urbanisation and over population (sewage and domestic waste problems), overfishing, illegal fishing practises (fish poisoning, dynamiting and reef gleaning) and siltation from agriculture and deforestation.

The tourist facilities are of interest because they are frequently located close to the sea. They are often quite small, but because the sewage can easily reach the ocean it is interesting to have a look at these tourist facilities in this report.

Laboratories discharge toxic materials in a relatively small amount in Western Samoa but because many of these chemicals are unknown to the receiving environment, it is important to see how they are discarded.

Other pollution sources are domestic solid waste, the two food market areas on 'Upolu and Savai'i, domestic sewage, siltation from eroded soils and mining, pesticides and fertilizers. Domestic solid waste and domestic sewage are increasing because the population is increasing and centralising, and the increasing import of western products is also causing an increasing domestic waste flow. Siltation, pesticides and fertilizers are pollution sources which are difficult to locate because of their wide spread use. The data about siltation, pesticides and fertilizers is all taken from other reports, but they generally result from extensive agricultural expansion and a seriously high level of deforestation.

In this first part only the pollution sources are discussed. The effects on the marine environment are not specifically discussed in this part but in the second part which deals with the marine environment and in which the different types of pollution like eutrophication, siltation and oil-pollution are specifically examined. The only effects that are mentioned in this first part, relate to whether or not there is an expected impact on the marine environment.

3. Industry

According to a list of the Trade, Industries and Commerce Department of Western Samoa there are 118 registered enterprises in Western Samoa as at January 1992. Of these 118 enterprises many are in the food and beverage industry. But not all of the enterprises are really industries: there is, for example, also a quite large proportion involved in the tourist industry

(see chapter 4) and another portion of the enterprises include offices. The bigger industries are mainly breweries, oil storage, wire harnassing and a concrete factory.

Most of the bigger industries have already been examined in previous surveys (paragraph 3.2.). This survey examines mainly the smaller industries (paragraph 3.1.). When the results of this survey and the previous ones are combined, it will give quite a complete view of the industries in Western Samoa and their waste flows. It should, however, be mentioned that the industries in Western Samoa are subject to change. For example, companies from abroad are now establishing in Samoa (e.g. Yazaki) because of the low cost of labour. The Western Samoan government is encouraging these companies because they can bring foreign currency to Samoa which is needed for the development of the country. It is therefore possible that the data in this report will need updating in the not too distant future.

3.1. List of industrial sites which were visited during this survey

Food and beverage industry

i1. Island Styles	Vaoala
i2. Talofa Wines	Vaoala
i3. CCK Trading	Vaigaga
i4. R.V. Meredith	Levili
i5. Natural Food	Savalalo
i6. Selprize	Vaitele
i7. Smack	Vaitele

Oil storage

i19. Mobil	Sogi
i20. British Petroleum (B.P.)	Sogi

Mechanical shops

i21. H.J. Keil and company	Taufusi
i22. Air Cool and General Refrigeration	Leififi
i23. Mr Leiu	Savalalo
i24. Mac Donalds Motors	Savalalo
i25. Burns Philp	Savalalo
i26. Palm Island Motors	Matautu
i27. Rees Refrigeration Services	Lotopa

Photo processing and printing

i29. Apia Studio	Beach road
i30. Photo Mart	Vaisigano
i31. Pacific Printers and Publishers	Saleufi

Saw mills

i32. Samoa Forest Corporation	Asau

Manufacturing

i34. Samoa Iron and Steel / aluminium division	Puipa'a
i35. Samoa Iron and Steel Fabrication	Fugalei
i36. Samoa Upholstery	Saleufi
i37. Yazaki	Matautu (hea
i38. Pacific Aluminium	Vaitele
i39. Apia Concrete Products	Vaitele

Industrial chemical manufacture

i40. Samoa Paints	Savalalo

Other industries

i44. Pepa Industries	Savalalo
i45. Mac Kenzie's Wholesale	Saleufi

3.2. Industrial sites which were visited during previous surv

(By Nancy Convard (1992) and Paula Warren and Warren Sisirich (1992)

Food and beverage industry

i8. Piggery of G. Ross	Tiavi Road
i9. Vailima Breweries	Vaitele
i10. Manuia Breweries	Vaimea
i11. Apia Bottling	Taufusi
i12. Apia Bottling - fruit juices	Taufusi
i13. Icecream Factory	Taufusi
i14. Samoa Coconut Products	Vaitele
i15. Samoa Tropical Products	Taufusi
i16. Hellaby	Vaitele
i17. Alexander Coolstore	Vaitele
i18. WSTEC Meat Slaughter House	Vailele

Mechanical shops

i28. Public Works Mechanical Shop	Vaitele

Saw mills

i33. New Samoa Industries	Vaitele

Industrial chemical manufacture

i41. South Pacific Industries	Vaitele

Power plants

i42. EPC - 'Upolu	Tanugamanono
i43. EPC - Savai'i	Salelologa

Other industries

i46. Rothmans	Vaitele
i47. Samoa Industrial Gases	Vaitele

3.3. Waste that is produced at the sites

3.3.1. Food and beverage industry

i1. ISLAND STYLES

Island Styles is a manufacturer of garments, soaps (about 20,000 cakes of soap per year) and they make printed textiles. For the production of the soap they use coconut oil and for the garments and textile printing they use paint and textiles. According to their information there is no important waste flow in the process. Probably there will be some wasted paint from the cleaning of the empty paint bottles and the printing machinery and some leftovers from the garment production which can be used as cleaning cloth. There are apparently no problems affecting the marine environment expected because the factory is not close to the ocean and there is no major waste flow.

i2. TALOFA WINES

Talofa Wines is situated in the same building as Island Styles and is a manufacturer of wines. The raw materials that are used in the process are mainly fruit pulp, fruit juice and ginger. There is a production rate of 1500 gallons of wine annually. There is some organic waste which is dumped in the garden, and from the cleaning of the (recyclable) bottles there is a flow of waste water containing caustic soda which goes into the seepage. There are no problems expected for the marine environment because the factory is not close to the ocean and there is no major waste flow.

i3. CCK TRADING

The products that are produced are cocoa (60 tonnes/year), coffee (40 tonnes/year) and kava (100 tonnes/year). Because of cyclone Val there is no kava powder production at the moment and the coffee and cocoa is now being imported. The only waste which is produced are plastic bags which are burned outside the factory and kava dust which lies around the mill. The location is quite near the ocean but because there is no major waste flow the impact on the marine environment is low.However, it must be mentioned that the burning of some plastics can produce toxic or carcinogenic fumes harmful to employees and neighbours.

4. R.V. MEREDITH

This company produces coconut cream, biscuits and bread and the raw materials it ıses are coconuts (7000 nuts per day) and flour (4000 kg per month). By-products are ıutshells and Pegu (coconut leftovers) which are reused in the process. The only liquid waste hat appears is from the cleaning of the factory and this goes into the drain. There is no marine ɔollution expected.

5. NATURAL FOODS

The products that are produced by Natural Food are snack foods, ice lollies and :aro chips. The snack foods are produced by frying wheat pellets which are obtained from New Zealand. The daily production is 14,000 bags of 15 gram whereby 200 kg wheat pellets are ısed. The only solid waste in the process are plastics (about 2 kg daily) from unusable plastic bags and ice lollies wrappers. The plastics are dumped in the mangroves at Vaitoloa. The waste water contains cleaning chemicals and is probably polluted with frying oil. This waste water is dumped untreated in the swamp behind the factory. Because this swamp is connected with the ocean and the waste water contains chemicals and oil there will probably be marine pollution. This pollution however will not be severe because the amount of oil and chemicals is low.

i6.SELPRIZE

Selprize is a producer of plastic bags , taro chips and breadfruit chips. They were not cooperative in giving information about quantities, raw materials and waste flows. They do not produce the plastic themselves but they import it from overseas as raw material and they only make bags from it and print a logo on them. There will probably be a waste flow which contains plastics, ink (from printing), oil and organic waste from chip production and wastewater from cleaning the factory. Marine pollution is possible, the factory is about 500 meters from the ocean. There are no figures about the waste flow.

i7. SMACK

Smack is a chicken farm with about 4000 chickens. The daily production is about 24,000 eggs which are sold to stores and at the market. The main waste which is produced at this site is chicken manure which accumulates on the ground because the chickens live on the ground (not in cages). The premises are cleaned with water. The waste water is probably highly contaminated with nutrients because of the chicken manure and chicken feed. The waste water goes via the drain into Vaiusu Bay. The contribution to marine pollution from the chicken farm is probably noticeable but not too high because most nutrients will seep into the drainage ground.

i8. PIGGERY OF G. ROSS

The pigs are fed on coconuts, imported foods and meat wastes from the slaughtering operation on the site. Liquid effluents from washing down pigs, pens and slaughtering room are flushed down a drain which reaches a river. The researcher thought that it is likely that many of the nutrients in the waste will be lost to leaching before reaching the river and he could not find any evidence of problems arising. Solid wastes are dumped in a hole

on the property. According to this information there will be no problems to the marine environment.

i9. VAILIMA BREWERIES

The waste water flow from Vailima Breweries amounts to 9500 m^3 per month and it contains up to 0.2 % caustic soda, acidic materials (pH 4), 0.5 % of sugar and 2500 kg of yeast per day (this is about 76.25 tonnes per month).The final waste water is high in nutrients, pH neutral and produces a strong yeast smell. Because the sedimentation tank where the waste water is collected is often full, it is often discharged directly into Vaiusu Bay. Solid materials from the brewing tank are sold as animal feed or dumped at the landfill in Vaitoloa. Broken bottles (breakage rate 0.1%) and broken plastic crates are also dumped at the landfill. There are different figures about the brewery: Nancy Convard is talking about a waste water flow of about 55,000 cubic meters per year which is half the amount of the figures from Paula Warren and Warren Sisarich.

People who are living near the factory on the shore line are complaining about the smell of the factory and the decrease of fish. Before the factory was established at Vaiusu Bay, there was plenty of fish in the Bay. At present the amount of fish has declined dramatically and there are only small fish left. The impact on the marine environment is probably very high.

i10. MANUIA BREWERIES

There is no detailed information available but the waste stream is suspected to be similar to the waste stream of Vailima Breweries. They reported around 1 tonne of solid waste from each brew, with one to two brews done per day. The impact on the marine environment is high because the waste water will be released into the mangroves at Vaiusu Bay.

i11. APIA BOTTLING

The waste water which is produced is from washing bottles and machinery so it would probably be polluted with cleaning chemicals and some leftovers from the bottles (mainly sugars). These are discharged into a ditch which flows into the sea. Broken glass is used as landfill for the factories. The importance to the marine environment will be high.

i12. APIA BOTTLING - FRUIT JUICES

Cleaning water is discharged to a sump hole where the solids can settle out. Solids are thereafter removed and used as a fertilizer. Fruit residues are used as cattle and pig food or dumped at the landfill at Vaitoloa (about one truck of waste per day). The impact on the marine environment is probably not very high.

i13. ICE CREAM FACTORY

The waste water from the ice cream factory contains milk and sugar and is discharged into a soak hole next to the factory. An acidic material is added to break down the solids which accumulate. The hole is periodically pumped out , but there is no information about the fate of the removed material. Because there is no information whether the material is dumped into the sea it is impossible to give an idea of the importance to the marine environment.

i14. SAMOA COCONUT PRODUCTS

The only wastes which are produced in the process are solid wastes (sand, dust, metal) obtained after the screening process, bad coconut cake, worn out sacks and rubbish from around the premises which are all dumped at Vaitoloa three times a week. Liquid waste is used for cleaning the premises and goes into the nearby storm water drain. The factory is near the ocean so probably there will be some liquid waste run into Vaiusu Bay. Contamination, however, will probably be low.

i15. SAMOA TROPICAL PRODUCTS

Chemicals that are used for the production of the coconut cream are Tween 60 (to prevent the cream from disintegrating into a water and coconut milk layer) and Divolux (for cleaning machines and floors). The effluent goes into a separate tank which is emptied two times a week. Solid wastes (packaging materials) are dumped at Vaitoloa at a rate of one truckload per week. Because there is no certainty about the destination of the effluent it is difficult to say whether there is an impact on the marine environment.

i16. HELLABY

The liquid waste from canning the imported meat contains washing water with fats and some meat residues and goes into a DAFF tank and after that into two consecutive ponds where the waste water soaks into the ground. The fat is removed and burned together with plastic liners, cardboard and cans. The impact on the marine environment is probably not very high.

i17. ALEXANDER COOLSTORE

Organic wastes (meat scraps, bones and fat) are converted into dripping and dog food or dumped into a pit. The liquid effluent contains blood, scraps, fat and washing water with cleaning compounds going into a sump pit which is tidally influenced via the groundwater Plastic and cardboard wastes are burned. It is likely that the nutrients will reach the lagoon via the groundwater. There is an impact on the marine environment expected.

i18. WSTEC MEAT SLAUGHTER HOUSE

Waste water from the abattoir flows directly to the ocean without any treatment. The waste water flow amounts to 700 litres for each production of 520 head of cattle. The impact on the marine environment is probably high.

3.3.2. Oil storage

i19. MOBIL

At Mobil in Sogi the LPG, lubrication oil, gasoline and diesel arrives from oversea and is distributed throughout Western Samoa. A new shipment of oil products with a quantity of 2880 tonnes arrives every five weeks. The oil products are pumped into the land based tank by means of a submarine pipeline which normally contains seawater. This seawater (which is

contaminated with oil) is pumped out of the pipeline before the oil products are pumped into the tanks. The water goes through a separator which separates the oil from the seawater. The waste-oil is pumped into oil drums and stored at the site where people can pick them up for using the waste-oil for preservation of wood. During this survey (on 23 July 1992) there were about 50 to 70 drums, each 200 litres (thus 10 to 14 tonnes) stored on the site. The cleaned ocean water, which probably still contains an amount of oil, is pumped directly into Vaiusu Bay into the mangroves in a quantity of 50 tonnes of oceanwater per five weeks. The impact on the marine environment is high because there is a periodic and large waste water flow into the ocean.

i20. BRITISH PETROLEUM

The process at British Petroleum is the same as at Mobil. The storage capacity, however, is smaller: only 2000 tonnes can be stored at the site. The oil products are aviation fuel (kerosine) and lubrication oil. Every five weeks, a new shipment of about 800 tons of oil products arrives. The waste-oil from the B.P. submarine pipeline amounts to 176 gallons every five weeks which is burned at Vaitoloa. The waste water (probably contaminated with oil) amounts to 20 tonnes every five weeks and is also released into Vaiusu Bay into the mangroves. The impact on the marine environment is high because there is a periodic and large waste water flow into the ocean.

3.3.3. Mechanical shops

i21. H.J. KEIL AND COMPANY

This company sells spare parts for cars as well as tyres (about 100 new tyres in a month) and also repairs tyres. The solid waste contains old tyres and rubber parts which are taken by the customers. Waste water is produced in the cleaning of the workshop and is probably polluted with rubber and oil. This water goes into the drain. There is probably little marine pollution. The waste water will be transported by the Fugalei stream to Vaiusu Bay but this will not be of significant importance.

i22. AIR COOL AND GENERAL REFRIGERATION

This refrigeration service repairs and imports air conditioners, deep freezers and refrigerators. In a month there are about five refrigerators and seven air conditioners repaired. The only solid waste which is produced are old spare parts like compressors. Broken parts, old refrigerators and old air conditioners are stored at the workshop for spare parts. Freon gas is collected into a gas tank and sent to Australia (following advice from a consultant earlier this year). Waste water is coming from high pressure cleaning of air conditioners and is probably polluted with dust and grease. This water goes into the drain. Importance to the marine environment is probably low because the site is not near the ocean and there is no major waste flow.

i23. MR LEIU

Mr Leiu is a truck repair garage and the main activities are welding and metal plating. The solid wastes are metal pieces and old machinery and they are all stored at the garage for spare parts. Oil is used for corrosion prevention and is partly spilled with the

washing water into the nearby drains. The workshop is near the ocean, and it is reasonable that some of the oil will reach the ocean. This will not be much though, so only very minimal marine pollution is expected.

i24. MacDONALDs MOTORS

Besides the selling of household machinery and food, Mac Donalds Motors also repairs refrigerators, air conditioners, lawn mowers, etc. The waste which is produced by repairing these items is broken spare parts like relays and compressors and they are dumped at Vaitoloa. The Freon (about 250 grams per week) goes directly into the air and is not caught in a gas tank. Waste water from cleaning the workshop and testing the repaired machinery contains soap and detergent and goes into the drain. There is no marine pollution expected. Although releasing Freon into the air is not a marine environment problem there is undoubtedly a severe impact on the ozone layer.

i25. BURNS PHILP

Burns Philp is a company which sells cars and repairs them (mainly Toyota). At the workshop, the average amount of repaired cars is about 10 cars per day. Waste that is produced are spare parts like oil filters, oil and washing water. The solid waste is dumped at Vaitoloa, the oil is given to the customers for the preservation of wood and the washing water (probably polluted with oil) goes into the drain. The workshop is quite near the sea. There is some marine pollution expected because the drain water probably reaches the ocean.

i26. PALM ISLAND MOTORS

Palm Island Motors sells spare parts and cars (only about 4 to 5 cars per year). They hardly do any service work. The only wastes that they produce are packaging material: boxes are stored and wood crates are burned. No impact on the marine environment is expected.

i27. REES REFRIGERATION SERVICES

Rees repairs walk-in freezer rooms, car- and home air conditioners, home freezers and refrigerators in an amount of 30 air conditioners per week. The waste contains non repairable air conditioners, waste parts like compressors and Freon which is collected into gas tanks and shipped to Australia (following advice from a consultant). The waste parts are stored on the premises. Waste water comes from the cleaning of the air conditioners and is probably a bit polluted with dust and grease. Because of the location and the amount of waste, there are no problems expected relating to the marine environment.

i28. PUBLIC WORKS MECHANICAL SHOP

There is 300 litres of oil wasted at the mechanical shop daily. The oil is used to paint tools, timber and for greasing machines to prevent corrosion. The machines that are beyond repair are stored for spare parts or are given to locals (after useable spare parts are taken out). The wastes which are dumped at Vaitoloa contain spare parts beyond repair, packaging rubbish, old tyres and useless batteries. There is no major impact on the marine environment expected, only at Vaitoloa where the dumped batteries can cause problems.

3.3.4. Photo processing and printing

i29. APIA STUDIO

Apia studio is a film processing company and it processes about six films per day. The materials that they use for the film processing are photopaper and photochemicals (7 bottles of 1 litre per week). The solid waste is a box full of empty plastic bottles, paper, film paper and empty rolls of film per week. This is burned. The liquid wastes are the photochemicals diluted with water in an amount of 4 litres per day. These chemicals are buried in a hole at the back of the store. The owner knows that the photo chemicals are dangerous but does not know where to put them. The chemicals are buried not far from the shore. The amount, however is too small and the distance to percolate through the ground is too far to have any serious impact on the ocean environment.

i30. PHOTOMART

Photomart develops and prints films in an amount of 1 to 15 rolls per day. The products that are used in the process are photopaper, bleach and C41 developer. The wastes are all dumped at the dumpsite in Vaitoloa and contains empty rolls of film, photopaper, developer (4 litres in two weeks, not diluted) and bleach (4 litres in two weeks, not diluted). Because the photochemicals are dumped at the mangroves in Vaitoloa they can directly affect the marine environment and can cause problems.

i31. PACIFIC PRINTERS AND PUBLISHERS

This company does all kinds of printing: from newspapers to magazines and business cards. They also produce rubber stamps. The amount of newspaper they produce is 7000 per week (16 pages each). The raw materials they use are paper, metal plates, films, chemicals, wires, inks (5 kg per week) and rubber. All raw materials are obtained from overseas (New Zealand, Fiji, United States of America). Waste products are paper (about 10(sheets per week) and rubber (from producing the rubber stamps). This waste is dumped at th dump in Vaitoloa. Waste water is polluted with 4 litres of chemicals and probably also some (and ink per week. This water goes into the drain. There is quite a lot of waste water flow which contains chemicals, but, because of the location, it is not expected that many of these chemicals will reach the marine environment.

3.3.5. Saw mills

i32. SAMOA FOREST CORPORATION MILL

The only major waste which is produced at this timber mill is sawdust and large pieces of wood which cannot be used for building material. The large wood parts are sold as firewood to private persons. The wood parts and some of the sawdust is also used to heat th(boiler which is used to produce steam for the steam treatment. The non burnable waste is dumped on land near the mill. There was not any preservation liquid (CCA, PCP) left at the mill. However, the Department of Lands, Surveys and Environment noticed quite the opposit one month before this survey. The employees told me that the treatment with CCA and PCP

was stopped after all liquid was used in the process so it is not dumped anywhere. The impact on the marine environment is probably low.

i33. NEW SAMOA INDUSTRIES

All the waste from the sawmill is re-used: the off-cuts are sold as firewood or as building material for cooking fales (Samoan cooking house). Sawdust is sold as bedding for chicken farms or as fuel for the umu (Samoan cooking fire), and waste oil is used for lubrication and rust proofing. There is no impact on the marine environment expected.

3.3.6. Manufacturing

i34. SAMOA IRON AND STEEL - ALUMINIUM DIVISION

The products that are produced are aluminium windows and doors and the raw materials that are used for such fabrication are aluminium strippings and glass which are obtained from New Zealand. Broken glass and aluminium leftovers are crushed and shipped back to New Zealand for recycling. Empty wooden boxes and cardboard packages are dumped in the mangroves at Vaitoloa. Despite the location near the ocean there is no important marine pollution because there is no liquid waste flow to the ocean and all the solid waste is recycled or dumped at the dumpsite.

i35. SAMOA IRON AND STEEL FABRICATION

The products that are produced are roofing iron, nails, barbed wire, chainlink and aluminium for doors and windows. The quantity which is stored is about 400 - 500 tonnes. The raw materials that are used are wire, steel and aluminium. There is no liquid waste and the only solid wastes are sawdust and leftovers which are sold to private persons. The impact on the marine environment is negligible.

i36. SAMOA UPHOLSTERY

The products that are produced by this company are foam mattresses, pillows,carseats and the re-upholstering and manufacture of furniture in a quantity of about 50 pieces per week. The solid waste contains wood parts, foam parts and empty packaging material in an amount of 10 percent of the total. This waste is dumped at Vaitoloa, burned or given away with the customers. The waste water comes from the cleaning of the factory and goes into the nearby storm drain. There is no impact on the marine environment expected.

i37. YAZAKI

Yazaki is located at several places in and around Apia and this company produces about 15,000 wiring looms for cars per week. The raw materials they use for the production of the wiring looms are 80 ton of wire per month (obtained from New Zealand) and 20 containers of plastic (obtained from Japan). There is not much waste in the process: scrap wire is sent back to New Zealand for recycling and cardboard boxes are dumped at Vaitoloa. Waste water contains cleaning chemicals and comes from the cleaning of the premises. The waste water goes into the drain in front of the factory. Because the factory at Leauva'a is very near to the shore the waste water and sewage is probably polluting the marine environment. Pollution of

the marine environment varies from factory to factory and is, in most cases, not severe. Only at the factory at Leauva'a is marine pollution expected. But because all factories will be concentrated at one big factory at Vaitele, this problem will be over before the end of 1992.

i38. APIA CONCRETE PRODUCTS

Apia Concrete Products at Vaitele produces about 2500 concrete blocks per day, 50,000 m^3 crushed metal per year, sand and 10,000 m^3 ready-mixed concrete per year. The raw materials that they use are locally obtained lava rock and black sand (from beaches) and imported cement. The produced wastes are sand and rocks and they are stored near the shoreline. There is no waste water produced in the process. The impact on the marine environment is probably high because firstly, the gaining of the black sand from the beaches is causing severe siltation problems and secondly, the storage of the waste sand near the shoreline can cause siltation problems into Vaiusu Bay.

i39. PACIFIC ALUMINIUM

Pacific Aluminium produces aluminium joints like windows and doors from aluminium extrusions which are obtained from New Zealand. The aluminium waste is dumped at the back of the factory and the broken glass and empty boxes are dumped at Tafaigata. There is a small waste water flow from the cleaning of the factory. The impact on the marine environment is likely to be low.

3.3.7. Industrial chemical manufacture

i40. SAMOA PAINTS

Samoa Paints produce house paints in a quantity of 15,000 litres per month. The raw materials are emulsion, pigments and resins and they are obtained from New Zealand and Australia. The only thing that Samoa Paints has to do is to put the raw materials together in the correct proportions. The only waste that is produced are the empty paint barrels which are sold, and polluted cleaning chemicals at a quantity of 16 litres per week which are burned. The impact on the marine environment is negligible.

i41. SOUTH PACIFIC INDUSTRIES

The products that are produced are soap and plastic bottles. The only thing that the factory has to do is to mix the imported dry soap ingredients together and mould them into bars of soap. As for the bottles, the factory has to melt the imported polystyrene and polyethylene granules and mould them into bottles. That is why there is not much waste in this process. The only wastes are solid wastes from around the premises and package material which are dumped at Vaitoloa about two times per week. Wash water is poured out onto the lawn. There is no impact on the marine environment expected.

3.3.8. Power plants

i42. EPC PLANT - 'UPOLU

The EPC plant on 'Upolu is currently arranging to collect the waste oil from the generators. Contaminated water (mostly contaminated with oil) is discharged into the Vaisigano river.Copper wire is exported for recycling. Another source reveals the fact that hundreds of litres of diesel flow into the river and that all waste oil from the generators is flushed into the Vaisigano River. A major impact on the marine environment is expected because the Vaisigano River runs into the sea which will receive the contaminated water.

i43. EPC PLANT SAVAI'I

A total of 200 litres of waste oil from the generators is dumped on the site monthly. The plant did not appear to produce contaminated water discharges. Copper wire is also exported for recycling. There will be an impact on the marine environment.

3.3.9. Other industries

i44. PEPA INDUSTRIES

Pepa Industries makes, from big bags of toilet tissue which are obtained from abroad, small rolls of toilet paper in an amount of about 6500 rolls per day. Because they do not really produce the paper but only make smaller rolls from a bigger quantity, there is not much waste. There is a daily waste of about 3 kg of toilet tissue. This is burned or used for cleaning the factory. Waste water is coming from cleaning the machinery from dust and is probably not really polluted. The waste water goes into the mangrove swamp behind the factory together with all the household kitchen scraps, tins and bottles from its employees. There is a waste water flow which goes directly into the ocean (swamp) but the water is probably quite clean. Because all the solid wastes are dumped in the swamp the impact on the marine environment, however, will be noticeable.

i45. MacKENZIEs WHOLESALE

Mac Kenzie's does not produce products but sells only large amounts of canned and frozen foods purchased from overseas for the local retailers. There is only some waste from packaged material what is also dumped in the Vaitoloa mangroves. No impact on the marine environment is recorded.

i46. ROTHMANS

The work that has to be done at Rothmans is only the assembling of the cigarettes and packaging material. There is not much waste: mainly solid packaging material and rubbish from around the premises in an amount of about 60 cubic feet/week and it is disposed of at Vaitoloa. There is no impact on the marine environment expected.

i47. SAMOA INDUSTRIAL GASES

There is no information available because the manager of the SIG refused to co-operate.

3.4. Location

Most industries are located in Apia and its environs. A survey along the entire coastline of 'Upolu showed that there were no industries on 'Upolu outside the Apia region. There is an industrial zone in Apia at Vaitele where some of the bigger industries are situated like the Vailima Brewery, the concrete factory and more recently (August 1992) Yazaki. Many of the smaller factories are located in Apia, especially in Savalalo, Saleufi and Taufusi. Some other industrial sites which are important to marine pollution are located at Sogi (Mobil and British Petroleum) and Vailele (WSTEC Slaughterhouse).

The receiving water for the effluent from the Vailima Brewery and other industries which are located at Vaitele is Vaiusu Bay and the Falefa area. The oil distributors at Sogi are also discharging their waste water into Vaiusu Bay.

A big part of the waste water which is discharged by the smaller industries in Apia will reach the sea by means of the Mulivai Stream and the Fugalei Stream or is dumped directly into the mangrove swamp at Savalalo which is an integral part of Vaiusu Bay.

The location of the industrial sites is mapped in figures 6.1, 6.2 and 6.3 in chapter six and figure 7.1 in chapter seven.

3.5. Conclusions

Most of the industries in Western Samoa do not produce much waste. This is for the main part explained by the fact that these industries are secondary industries. Half-made products are shipped from overseas (mainly from New Zealand, Australia and Japan) after which they are transformed into a definitive product in Samoa with relatively little pollution. A good example is the toilet paper industry which produces, instead of the real production of toilet paper, only little rolls of toilet paper out of big imported bales of toilet tissue. This is much less polluting, while the primary production of paper is very polluting. Another example is the aluminium and steel industries which only produce aluminium frames for doors and windows out of imported aluminium strippings and which produce roofing iron out of steel sheets. In this process there is only a demand of energy, the real pollution from the production of steel and aluminium stays in the countries from where the products are obtained. As a final example, we can consider Yazaki where all raw materials are obtained from abroad. Yazaki uses only the labour in Samoa for the assembling of the products, after which the completed products are shipped back overseas.

Another remarkable fact is that much of the waste is re-used for other purposes. There are not many places where the waste oil is wasted (except the EPC plant at Tanugamanono which spills all their waste oil into the Vaisigano River). There are many customers who want to have the oil to use it for the preservation of wood, to use it as a lubricant, to use it to prevent corrosion on metals and for marking sports grounds. It has to be said that these ways of re-using the oil are not the most environmentally sound ones. It would be better for the environment if the waste oil could be collected and recycled. In Western Samoa there is an oil recycling plant which is run by Tony Hill.

Other wastes which are re-used are waste wood and sawdust as a fuel and boxes, buckets and bottles for the packing of all kinds of material.

The final remarkable fact is that many workshops store all of their discarded machines and spare parts in or near their workshop. This will result in congestion of the same old materials (mainly iron) on several spots of the island rather than in the mangrove dump in Vaiusu Bay.

4. Tourist facilities

In Western Samoa, according to information provided by the Western Samoa Visitor's Bureau, there are 22 registered tourist facilities (January 1992). 17 of these 22 are on 'Upolu island and only 5 are on the bigger island of Savai'i. The smaller islands, Manono and Apolima, do not have tourist accommodation. The 17 tourist facilities on 'Upolu island include the 2 major hotels, Aggie Greys Hotel and Tusitala Hotel, both of which are situated within 20 metres of the ocean in Apia.

Because this report is mainly dealing with marine pollution, the most interesting sites are those which are situated close to the shoreline because they cause the most pollution problems to the marine environment. Marine pollution which is expected from such hotels are mainly sanitary waste water which, by lack of an efficient drainage system, can easily run into the ocean. Especially when the septic tanks are located on the beach, the overflow can very easily cause marine pollution. Another marine related problem is souvenir collecting by tourists which results in breaking coral and taking living shells out of the marine environment. This problem is, however, not expected to be of major importance.

4.1. The tourist facilities

'Upolu island

t1. Aggie Greys Hotel	Vaisigano
t2. Ah Kam's Motel	Saleufi
t3. Betty Moors	Matautu
t4. Coconut Beach Club / Hotel	Maninoa
t5. Harbour Light Hotel	Matautu
t6. Le Godinet Beach Front Hotel	Tiafau
t7. Motel Insel Fehmarn	Motootua
t8. Olivia Yandall's Accommodation	Vaiala
t9. Samoan Village Resort Cape Fatuosofia	Falepuna
t10. Satapuala Beach Resort	Satapuala
t11. Seaside Inn	Matautu-tai
t12. Tusitala Hotel	Sogi
t13. Temple View Lodge	Pesega
t14. Vaiala Beach Cottages	Vaiala
t15. Vaiula Beach Houses	Tafatafa
t16. Valentine Parker's Accommodation	Fugalei
t17. Vavau Beach Resort	Vavau

Savai'i Island

t18. Safua Hotel	Lalomalava
t19. Salafai Inn	Salelologa
t20. Siufaga Beach Fale	Faga
t21. Taffy's Paradise Beach Inn	Salelologa
t22. Vaisala Hotel	Vaisala

4.2. Discussion

t1. AGGIE GREYS HOTEL

This is the biggest hotel in Western Samoa with 154 rooms. It has been surve by Nancy Convard in which she did not expect any problems concerning the potential of v water which reaches the near-shore waters (Aggie Greys is on the shore). The hotel utiliz septic tank and soakage field system.

t2. AH KAM'S MOTEL

This motel has 10 rooms and is not situated near the shore. Because of the situation and the size of the motel there are no problems expected concerning the marine environment.

t3. BETTY MOORS

This budget accommodation has 12 rooms and is not situated near the shore, therefore it is not expected that there will be much marine pollution.

t4. COCONUTS BEACH CLUB / HOTEL

Located near the beach, this 8 room hotel uses three septic tanks and will prob have some effluent going into the ocean. The impacts on the marine environment, however will probably be not very big.

t5. HARBOUR LIGHT HOTEL

This hotel is located near the harbour in Apia and has 32 rooms. Therefore, it is likely that there will be some marine pollution coming from sewerage.

t6. LE GODINET BEACH FRONT HOTEL

Le Godinet has 10 rooms and is situated near the waterfront between the Mobil and BP oil storage sites. Probably there will be some effluent running into the ocean but I th that it is not relevant with respect to the effluent coming from the Mobil and BP sites.

t7. MOTEL INSEL FEHMARN

This motel is relatively large with 54 rooms. It is, however, not located near the ocean so that there is not an impact on the marine environment expected.

t8. OLIVIA YANDALL'S ACCOMMODATION

This quite small accommodation with 27 units is situated at 400 meter from the mangroves near the shore. There is no impact on the marine environment expected.

t9. SAMOAN VILLAGE RESORT, CAPE FATUOSOFIA

This bungalow park is located near the sea. Some units are still under constructic and there is no more information available at the time of writing.

t10. SATAPUALA BEACH RESORT

This resort is not very big but is located directly on the beach. There will probabl be some untreated effluent running into the sea.

t11. SEASIDE INN

The Seaside Inn is also located near Apia Harbour and contains 13 rooms. There will probably be some effluent running into the nearby ocean but with respect to its size, it probably will not be much.

t12. TUSITALA HOTEL

The Tusitala Hotel is Western Samoa's second biggest hotel and is located in Api at Sogi next to the ocean. The hotel has 96 rooms and was surveyed by Nancy Convard. According to her, the Tusitala Hotel uses an oxidation ditch for the treatment of the sewerag but because of mechanical difficulties there is poor or no treatment of the waste water. There is, therefore, an impact on the marine environment expected.

t13. TEMPLE VIEW LODGE

This hotel is not situated near the sea, so there is no impact on the marine environment expected.

t14. VAIALA BEACH COTTAGES

The seven cottages are situated on the beach so there will probably be some sewerage effluent running into the ocean. Because there are only 7 units, the impact on the marine environment will be low.

t15. VAIULA BEACH HOUSES

The houses are situated on the beach of Tafatafa, There are two houses each wit four rooms. There will probably be some effluent running into the ocean, but because of the expected amount, this will not cause problems to the marine environment.

16. VALENTINE PARKER'S ACCOMMODATION

There are only twelve rooms and the place is not situated near the ocean. Therefore there is no marine pollution expected.

17. VAVAU BEACH RESORT

These rental fale (Samoan house) units are built on the beach so it is likely that some sewerage will run into the ocean. The quantity will not be large, however, so the impact on the marine environment will probably be quite low.

18. SAFUA HOTEL

This hotel has only 9 units and is within 100 metres of the beach. There is no impact on the marine environment expected.

19. SALAFAI INN

Salafai Inn has only 11 rooms and is not near the ocean. Therefore, there is no impact on the marine environment expected.

20. SIUFAGA BEACH FALE

These 8 fales are on the beach so there will probably be some sewerage run-off into the ocean. Because there are only 8 units, the contribution to marine pollution will probably be rather low.

21. TAFFY'S PARADISE BEACH INN

This Inn is located just near the waterfront and contains 7 rooms. There will be some sewerage effluent running into the ocean but the quantity is low. The impact on the marine environment will also be quite low.

22. VAISALA HOTEL

This hotel is right on the beach and contains 18 self-contained units. It has been surveyed to get more information about its waste and sewage-system.

Its refuse contains, for the major part, domestic waste. Waste is separated into burnable and non-burnable waste. The burnable waste is burned almost daily near the hotel and the non-burnable waste (glass, cans) is buried in a hole near the hotel. When the hole is full it is covered with sand and a new hole is dug. The Health Department checks the disposal of the waste every month.

Almost every apartment at the hotel has its own septic tank. Some of them are situated on or near the beach without any appropriate drainage system so the overflow can easily run into the ocean. At the time of survey however, there was no sign of overflow running into the ocean, because the occupation rate at the hotel was very low. There will probably be an impact on the marine environment.

4.3. Location

The hotels are distributed over the two main islands of 'Upolu and Savai'i. Most of them (55 percent or 12 including the two major hotels) are, however , situated in Apia and surrounding neighbourhood. If there is any discharge into the ocean, then it will be at the same places as the discharge from the industrial sites, namely Vaiusu Bay and Apia Harbour. The 10 other accommodations which are not located in or near Apia are situated at several mostly remote places and are, therefore, of little concern. However, as most of them are located on the beach, there will probably be some effluent running into the ocean.

The location of the tourist facilities is mapped in figure 6.1, 6.2 and 6.3 in chapter six.

4.4. Conclusions

There is not much pollution expected from the tourist facilities in Western Samoa. According to Nancy Convard the Tusitala Hotel may cause problems because its effluent goes directly into the ocean. The sewerage from the hotels situated in Apia and its environs which goes into the ocean will cause pollution problems at the same locations as the major industries, namely Vaiusu Bay and Apia Harbour. Hotels outside the Apia region are mostly smaller hotels and are located near the beach. If there is any impact on the marine environment it will cause only local problems because the waste flow is, in most cases, very small.

5. Laboratories

There were two laboratories investigated during this survey, namely the laboratory at the University of the South Pacific (USP) at Alafua and the National Hospital laboratory at Motootua. There should be a third laboratory at the observatory at Mulinu'u point, but, after inquiry, it seemed that it was no longer used.

5.1. Waste that is produced at these sites

11. USP LABORATORY

At the laboratory of the USP there are several chemicals used,depending on the tests which are done (these change with time). All the used chemicals, useless chemicals and other waste is dumped at the University into a ravine which means that these chemicals can eventually reach the Le'ele stream which enters the mangroves of Vaiusu Bay at Pesega. At that time, the chemicals will be diluted into a very low concentration so it will not cause big problems to the marine environment. The fact that the chemicals are just dumped at the site is, however, a very big problem and it would be a good idea if an efficient collection system could be developed.

Some of the used chemicals which are dumped are ethanol, methanol, KCl, NaOH, H_2SO_4, NH_4OAc, $K_2Cr_2O_7$, $CuSO_4$, H_3PO_4, HNO_3, $HClO_4$, H_2O_2 and mineral oil.

All chemicals are discharged into the drain after use. Also the blood samples are going into the same drain after sterilisation (which makes them more soluble in water). The drain is at the side of the hospital and the effluent will finally reach the Mulivai Stream. Solid wastes such as glass are put into bags and are given to the hospital disposal. They could not give me quantities or qualities of the chemicals used.

According to the survey of Nancy Convard, the Hospital uses an Imhoff tank and trickling filter to treat the sewage but the treatment is very minimal. The discharge enters the Mulivai Stream and reaches thereafter, due to little self-purification, the near shore area. The medical solid waste includes needles, syringes, drugs and contaminated dressings (P. Warren and W. Sisarich, 1992). There is no high temperature incinerator available at the hospital and the waste is, therefore, burnt in low temperature incinerators, holes in the ground, on the open ground or are dumped into the stream at the back of the hospital (a stream which is used for bathing at some times of the year).

5.2. Conclusions

Laboratory and other waste from the Hospital will reach Apia Harbour by means of the Mulivai Stream. Waste from the USP laboratory will probably not reach the ocean in a concentrated form.

It is important that a collecting system is developed to collect the chemical wastes from these laboratories. The best way to deal with this problem would be possibly to ship these wastes to a developed country where it can be treated properly or, of course, for Western Samoa to set up its own toxic waste dump (as is currently planned according to staff of the DEC, Department of lands, Surveys and Environment).

The location of the laboratories is mapped in figure 6.3. in chapter six.

6. Other pollution sources

Other pollution sources in Western Samoa are, in most cases, not simply point sources like the industries, tourist facilities and the laboratories, but are discharging their effluent on several not easily traceable places.

6.1. Domestic solid waste

The biggest part of the domestic solid waste contains organic materials. The amount of non-organic materials like cans, glass and plastics will increase because of accelerating import of such products from the developed countries and comprise mostly an abundant amount of packaging material. Also an increasing use of disposables (such as plastic cutlery, polystyrene cups and plates, etc.) will increase the amount of non-organic waste in the solid waste stream.

In the rural areas, some people dump their waste near their house or village but the most common way to get rid of the waste is to burn it. This is done individually, so there are

many incineration sites in a village. Villages along the coast frequently dispose of their rubbish in nearby mangrove areas or on the beach where it is taken away by the ocean at high tide (L.M. Taylor, 1991). This will cause direct problems to the marine environment. It is very difficult to make an inventory of the problems because it differs from village to village.

In Apia and its environs, the domestic waste is collected by Government contractors and dumped at a landfill in Vaitoloa. This landfill is located in a mangrove area so it is possible that hazardous materials in the waste will cause serious problems to the marine environment. The amount of waste that is dumped daily into the landfill is estimated to be 66 m^3 or 11.6 tonnes (P. Warren and W. Sisirich, 1992 / Ogawa). Not all people in the Apia region make use of the waste collection system. Many people are still burning their waste and, in several locations in the region, there are "private" illegal landfills.

6.2. Market area

There are two food and produce markets in Western Samoa. The biggest one, the Maketi Fou, is located in Apia, and the other smaller one is in Salelologa on Savai'i.

MAKETI FOU

The Maketi Fou is situated directly on the waterfront and the waste that is produced is for the biggest part organic. The waste is transported to the landfill at Vaitoloa, but also some (especially from the food stands at the back of the market) is directly dumped into the ocean. Next to the market place is the bus stand and some other shops and food joints. Some of these shops are also discharging their waste directly into the ocean and it is likely that there will be a run-off from oil and soot from the bus stand into the ocean. The impact on the marine environment at the market area is quite serious and aesthetically displeasing as it is adjacent to the Kitano Tusitala Hotel.

SALELOLOGA MARKET

The waste that is produced at the Salelologa Market contains mainly organic material. The waste is stored temporarily on a site next to the market prior to being transported to a site at Tafua-uta. The transport to Tafua is three times a week and the dumpsite is mainly used for the refuse from the Salelologa Market. During this survey, we could not manage to have a look at the site to see how big it was and if the location is near the ocean.

6.3. Domestic sewage

There is no communal sewage collection or disposal system in Western Samoa. Most village residents use septic tanks. Because of the high porousity of the soils and the low population density, there are not many problems expected in the rural areas (L.M. Taylor, 1991). However, according to Leon Zann (1991) who did a survey on the coastal environments of 'Upolu, many of Western Samoa's lagoons are, even in the rural areas, nutrient rich due to human wastes.

There are, as expected, major sewage problems in the Apia region because the population is concentrated in this area and the soils have low drainage capacity (L.M.

Taylor,1991; N. Convard 1992). The groundwater in the Apia region is highly contaminated from the septic tanks and other individual facilities like pit latrines (N. Convard,1992). The coastal zone of Apia (Apia Harbour, Vaiusu Bay) is probably polluted with nutrients and bacterial/viral contamination coming from the sewage.

6.4. Siltation

The main source of sediments, and therefore the biggest contribution to the siltation of lagoons in Western Samoa is believed to be from deforestation for wood production (mainly on Savai'i) and agricultural expansion on both islands. When the forests are cut, the roots of the trees and undergrowth can no longer hold the soil, which results in a run-off of sediments into the rivers that carry the silt into the lagoons where it causes problems to the marine environment. The same problems are caused by agriculture on steep slopes and river banks (L.M. Taylor,1991). Agriculture is also responsible for large areas of disappearing forests because the expansion of agricultural land causes the loss of the native forests.

Another source of siltation are dredging operations at the point of Mulinu'u Peninsula (d1), at Mulifanua Wharf (d2) and at Faga Beach near Tuisivi (d3) (Savai'i) which are taking sand out of the oceanfloor for construction work and cement.

6.5. Pesticides and fertilizers

The use of fertilizers in Western Samoa is, due to the natural fertility of the soil in most parts of Western Samoa, not very common and they are, therefore, not considered as an environmental danger.

Pesticides are, however, much more often used with 59 percent of all households using pesticides, which is not a very high level compared with world standards (N. Convard, 1992). Pesticides are available to anyone for purchase without any restrictions on quantity or use. Customers at the agricultural store can get advice about the pesticides from a trained technician at the store, but because the buyers of the pesticides are mostly not the ones which actually use the pesticides on the land this information often gets lost. It would therefore be useful if a label and a brochure, written in Samoan, could be added on the pesticide container.

The most popular pesticide that is used in Western Samoa is paraquat (Gramoxone and Agriquat), a herbicide which is not allowed in many developed countries. Paraquat is heavily used by farmers on banana and taro crops and does not readily biodegrade. Paraquat adheres to soil particles which can then flow into the rivers where it is transported to the ocean.

Some pesticides that are sold in Western Samoa at the Agriculture Store and Morris Hedstrom are (the quantities are import quantities for 1990 and 1991): Agriquat, 21,710 litres, Gramoxone, 88,120 litres, Bentazon, 100 litres (only 1991), Glyphosate, 7,040 litres, Pirimiphos-methyl, 625 kilogrammes (only 1991), p-m + permethrin 390 litres (1991 only), Bendiocarb, 1,425 kilogrammes, Carbofuran 200 litres (only 1990), Benomyl, 223 kilogrammes, Tridemorph, 980 litres, Propiosonazole, 220 litres, Oxyamyl, 1,000 litres, Brodifacoum, 590 kilogrammes and Flocoumaffen, 235,7 kilogrammes (L.M. Taylor, 1991).

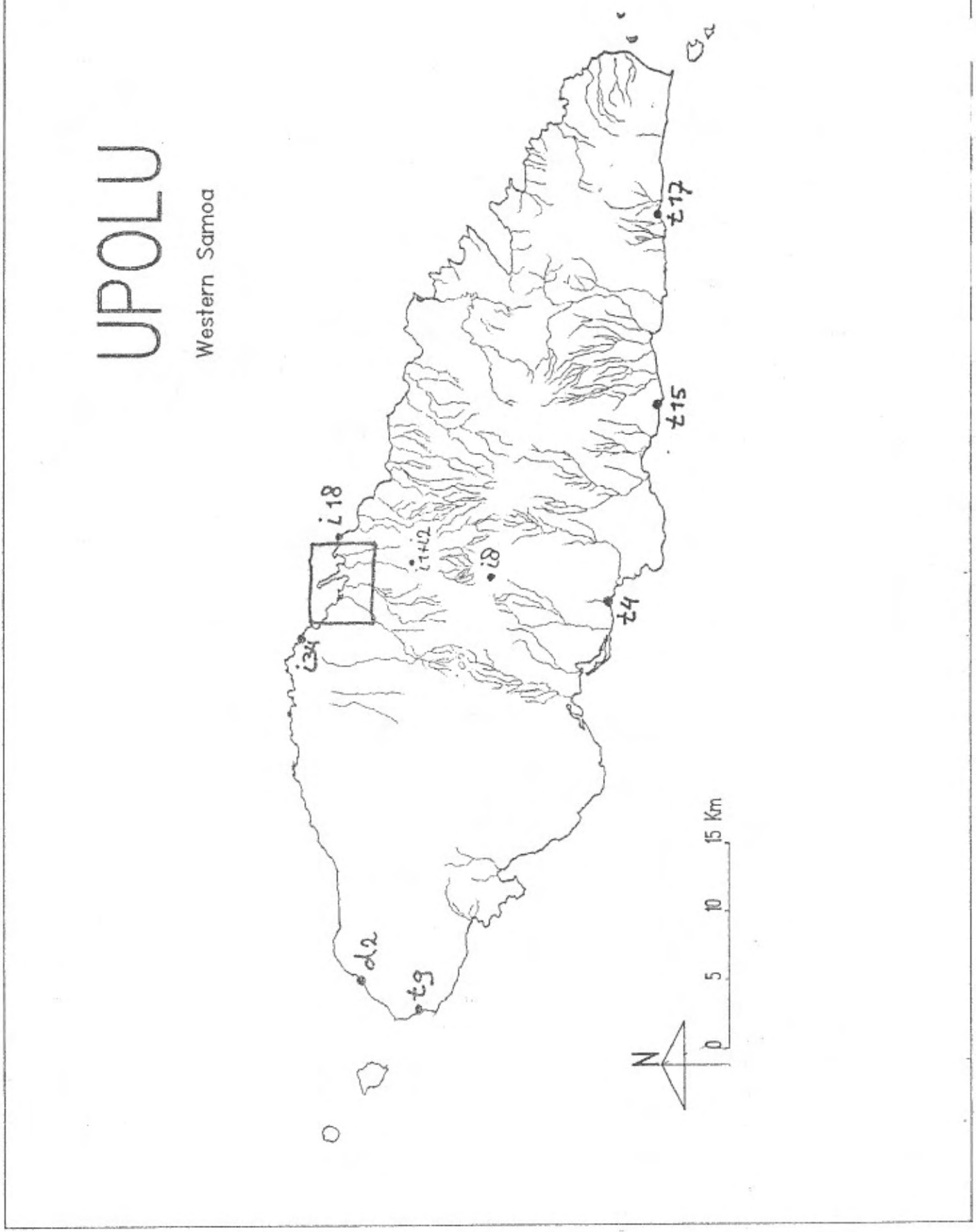


Figure 6.1. Hydrology map: Tourist facilities (t), industrial sites (i) and dredging operations (d) on 'Upolu. The sites which are located in the square around Apia are marked in figure 6.3. and figure 7.1.

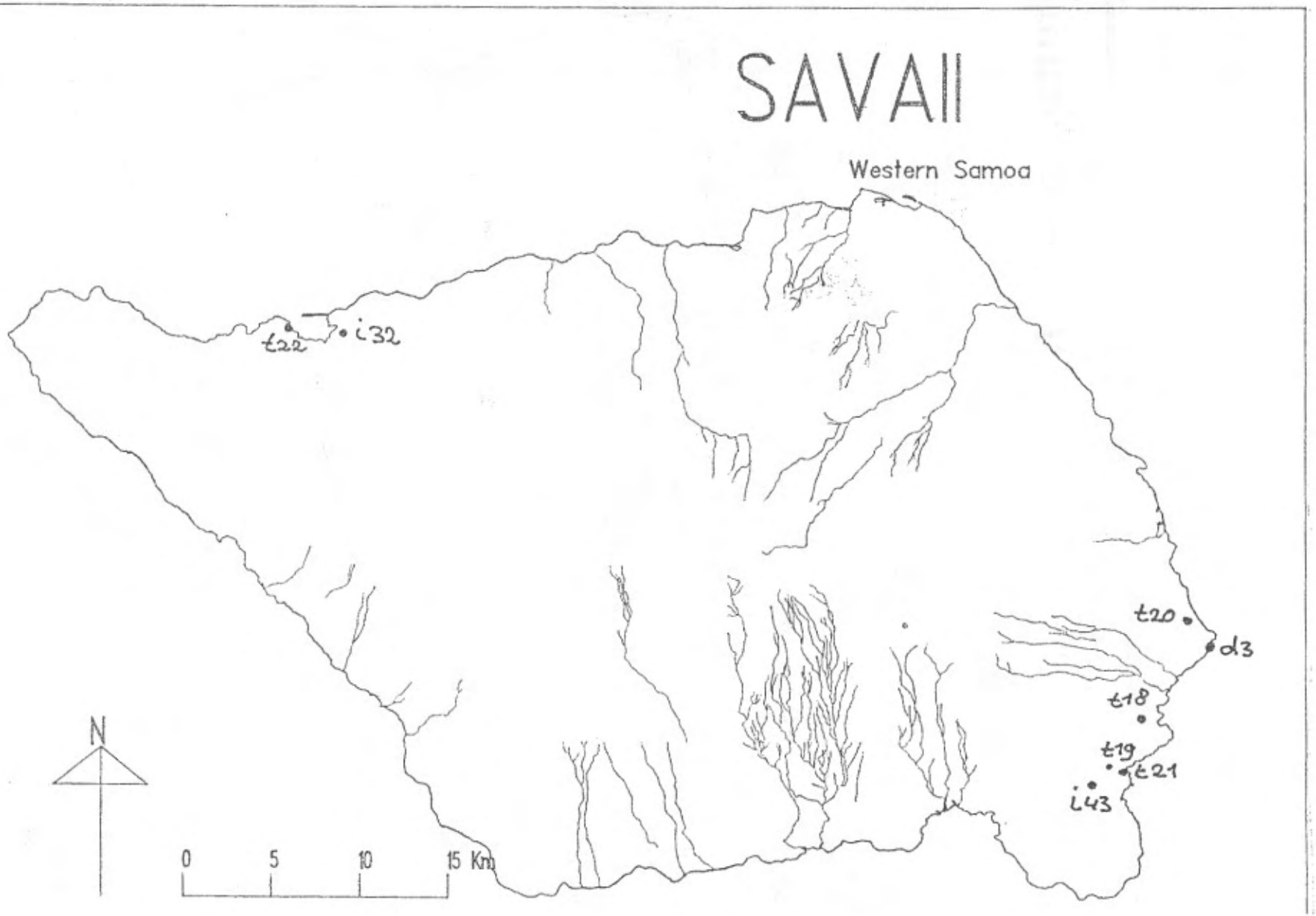


Figure 6.2. Hydrology map: Tourist facilities (t), industrial sites (i) and dredging operations (d) on Savai'i.

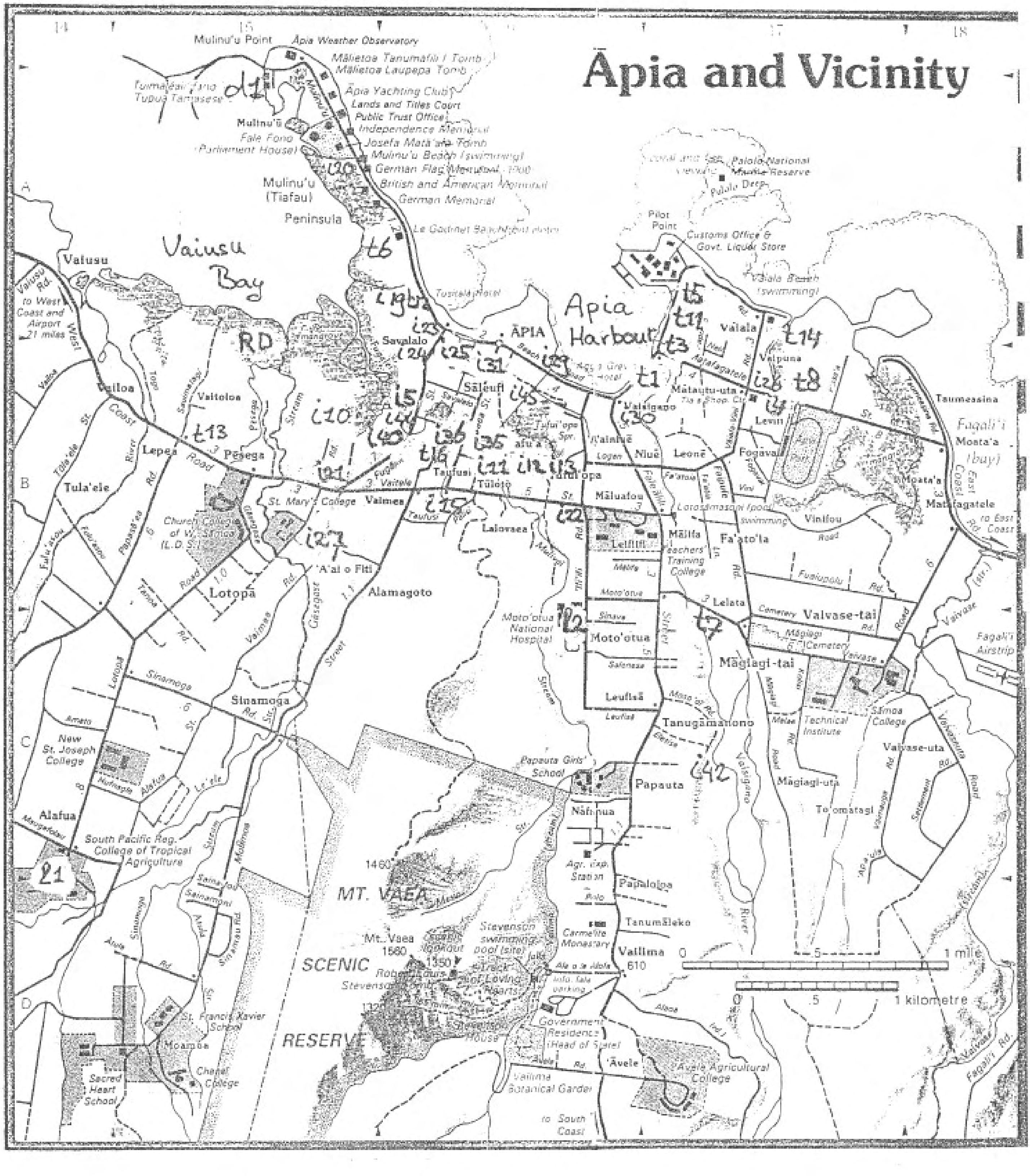


Figure 6.3. Tourist facilities (t), industrial sites (i), laboratories (l) and dredging operations (d) in the Apia area. RD is Rubbish Dump.

PART TWO: MARINE ENVIRONMENT

In this second part is discussion of the effects on the marine environment which are caused by the pollution sources that were referred to in Part One. This part is divided into a chapter that discusses the several expected effects on the environment and the sites where they are expected. Also a chapter that discusses the ecological characteristics of the polluted spots and a chapter that describes the effects that are actually observed at the four sites which were expected to be polluted.

7. Potentially polluted sites and the effects on the environment

7.1. Definitions

Before describing the polluted sites and the probable effects on the environment, it is important to give the definitions of some of the words used like marine pollution, health hazards, environmental hazards, acute hazards and chronic hazards. These definitions are taken from R.H. Chesher (1984).

7.1.1. Marine pollution

The Intergovernmental Oceanographic Commission defines marine pollution as: "The introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources; hazards to human health; hindrance to marine activities including fishing; impairing the quality for use of seawater and reduction of amenities." (UNESCO, 1982).

7.1.2. Health hazards

Pollutants which directly endanger human health through contamination of food or water, including:

- Microbial pollutants including viral, bacterial, fungal and parasitic organisms generally from sewage discharges.
- Organic chemicals including pesticides, medicines, drugs, industrial dyes, petroleum products and PCB plasticizers used for road surfacing, electrical transformers, newspaper print, etc
- Metallic poisons such as lead, mercury, cadmium and arsenic which may accumulate in the foodchains.

7.1.3. Environmental hazards

Pollutants which endanger the health and productivity of marine and terrestrial ecosystems. These are also hazardous to human beings because of the resultant loss of essential life-support functions including food, shelter and circulation of nutrients. Economic loss may also result from ecosystem degradation when valuable plants or animals are lost.

7.1.4. Acute hazards

Cases in which pollution has already exceeded critical levels and action is required immediately. In terms of human health, this would indicate pollution which is of immediate danger. In cases of environmental hazards, this indicates conditions in which the environmental capacity has been exceeded and critical targets are in rapid decline. Acute condition also refers to poisoning or illness which may result in death.

7.1.5. Chronic hazards

Cases in which pollution is causing long-term degradation. In terms of human health, this would include low level poisoning from lead in paints and pesticide build-up. In environmental hazards it refers to trends in environmental degradation such as siltation of harbour areas and subsequent ecosystem decay. In general, chronic conditions are less obvious and require longer periods of treatment.

Chronic condition also refers to levels of poisoning or illness which do not result in death but may lower growth rates, reproductive ability, resistance to other stresses or slowness to response.

7.2. The sites

From the pollution sources which are discussed in Part One it is clear that the potentially polluted spots in Western Samoa are all concentrated in the Apia region. More specifically this includes the coastal area commencing from the industrial zone at Vaitele to the east of Apia Harbour. Of minor importance, but nevertheless worthy of mention will be the coastal area to the east of Apia because, in Vailele, the WSTEC slaughterhouse is situated which discharges its effluent untreated into the ocean.

The most impacts on the environment are expected in the Apia - Vaitele area (Vaiusu Bay, Falefa area) because this area will receive the effluent coming from the Vailima and Manuia Brewery, Apia Concrete Products, Mobil, British Petroleum, the dredging operation at Mulinu'u, the landfill at Vaitoloa and from several smaller factories in Apia which may have some effluent run-off into the sea. There will also be some noticeable nutrient and bacterial enrichment from the discharge of sewage from the Kitano Tusitala Hotel and other domestic sources into Vaiusu Bay.

Apia Harbour will mostly receive sewage coming from domestic facilities (directly via the shoreline, the Vaisigano River and the Mulivai Stream), ships, and the National Hospital (via the Vaisigano River). Oil pollution from ships and harbour facilities is also imaginable. At the moment (September 1992) due to construction work of the new government building near the coast in the Harbour, there is probably a siltation problem.

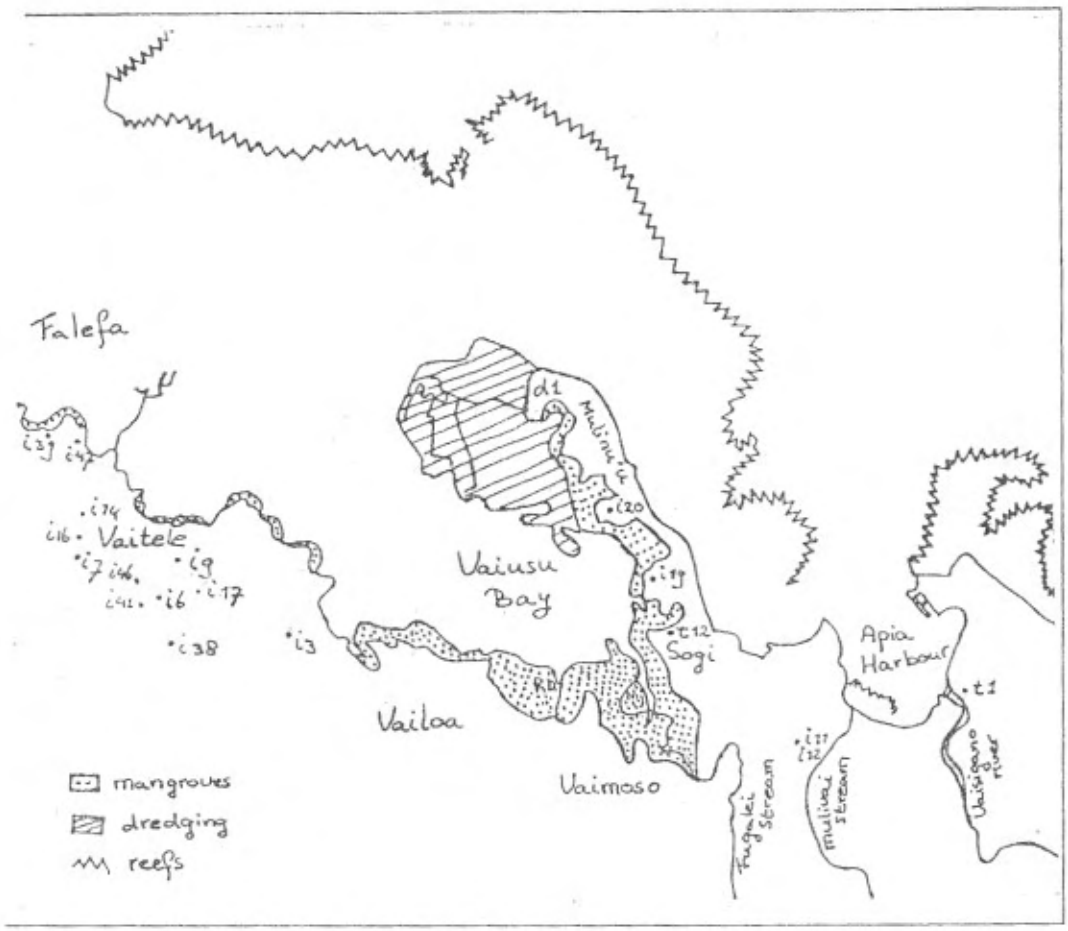


Figure 7.1. Ecological characteristics of Vaiusu Bay and Apia Harbour

7.3. Expected effects on the marine environment

There are three expected effects on the marine environment. These are siltat caused by the sediment runoff at the concrete factory and the dredging company, eutrophication caused by the sewerage discharge and brewery effluent and, in a smaller species and habitat loss caused by oil pollution from the oil storage tanks at Mulinu'u Peninsula.

7.3.1. Eutrophication

Sewage which is released into the sea increases the amount of nutrients, particularly nitrates (NO_3^-) and phosphates (PO_4^{3-}). Apart from sewage, the breweries also big contributors of nutrients. They discharge nutrients such as sugars and yeast dir into Vaiusu Bay.

Increased nutrient levels reduce water transparency with the increase of pla biomass and particulate organic carbon. With decreased light, coral growth and carbon production decreases. The increase of phytoplankton and algal blooms are also respons the higher consumption of oxygen causing phytoplankton and fish mortality resulting ir and a damaged ecosystem (M.King,1989; J.E.Brody,et al., 1990). Eutrophication in co ecosystems can lead to overgrowth of algae with can smother the corals. Another expe problem is an increasing population of the crown-of-thorns starfish (*Acanthaster planc*

planci can cause problems because phytoplankton blooms provide food for the *A. planci* larvae which can cause outbreaks of *A.planci* about three years later. Because *A.planci* feeds on corals, large outbreaks can lead to the destruction of extensive areas of coral reefs (J.E. Brody, et al., 1990). Such outbreaks have been recorded in Western Samoa over the past twenty years in specific locations (P. Zann, 1991).

7.3.2. Siltation

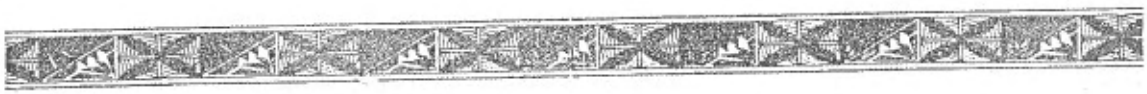
The siltation effects are for a part related to the eutrophication problems. Sedimentation also causes nutrient enrichment to the water (with all the eutrophication problems) and the decrease of light caused by increased turbidity is inhibiting photosynthesis in primary producers such as the symbiotic algae of coral polyps. This, in turn, slows coral growth. Sedimentation also smothers living coral, and silt hinders the settling of coral larvae (A.T. White,1987).

Excessive siltation can result in stress what can cause the rapid death of the whole coral colony. This reaction is named Shut-Down-Reaction (S.D.R.) because the coral colony seems to stop critical physiological reaction and the tissue comes off the skeleton in long strings.If these strings of dying tissue come in contact with other corals which are also under stress, the other corals begin to undergo the same S.D.R. and die (R.H. Chesher, 1984). The increase in suspended sediments can also affect other benthic organisms like crabs, fish and shellfish.

7.3.3. Oil pollution

The impacts of spilled oil on the marine and coastal plants and animals of the Pacific islands vary with the natural system involved. All petroleum products bio-degrade naturally. When oil does reach coastal areas, its effects depend on the coastal ecosystem present. Mangroves are particularly susceptible to oil floating on the watersurface because of their intertidal location and air breathing roots (R.A. Carpenter and J.E. Maragos, 1989). Evidence shows that oil kills reef fish and has detrimental effects on the reproduction, growth rate, colonization, feeding and behaviour responses of corals (A.T. White, 1987).

The persistence of oil in the marine environment depends on the amount and type of oil spilt and the wind, wave, current, and weather conditions. Aviation fuel and gasoline (petrol) are "lighter" and vaporize quickly into the atmosphere, creating less of a pollution problem. However, because they are more toxic and highly flammable, special care must be taken if a large amount is spilled in shallow areas or is trapped under shore structures (like Vaiusu Bay). Diesel, distillate and refined oils are more of a problem because they are more persistent (R.A. Carpenter and J.E. Maragos, 1989).



8. Ecological characteristics of the potentially polluted sites

The sites which are expected to be polluted are all in the Apia region. In this region are two dominating marine ecosystems: coral reefs and mangrove wetlands. Before there is a discussion in the next chapter about the pollution in these areas (Vailele area, Apia Harbour, Vaiusu Bay and Falefa area) there will be a discussion in this chapter about some ecological characteristics of these dominating ecosystems in the area.

8.1. Coral reefs

8.1.1. Fringing reefs

The reefs that are surrounding the islands of Western Samoa are for the biggest part fringing reefs. Only the reef part at the Asau Bay in Savai'i is tending a bit more to be a barrier reef (Paul Holthus, personal comments). Fringing reefs grow at the edges of continents and islands (M. King, 1988). Most shores are sandy beaches, mangrove forest and rocky cliffs or intertidal areas. Sloping gently away from this shore is a shelflike reef flat of variable width and depth. It usually consists of a combination of sand, mud, rocks, seagrass, algae and scattered corals. The mean water depth of the reef flat is often no more than one meter, and extreme low tides can leave large areas of it exposed. At the outer edge of the reef flat is the reef crest which is often the most diverse and productive zone being exposed to waves, currents, clear and shallow water. Below the reef crest is the more tranquil reef slope (A.T. White, 1987).

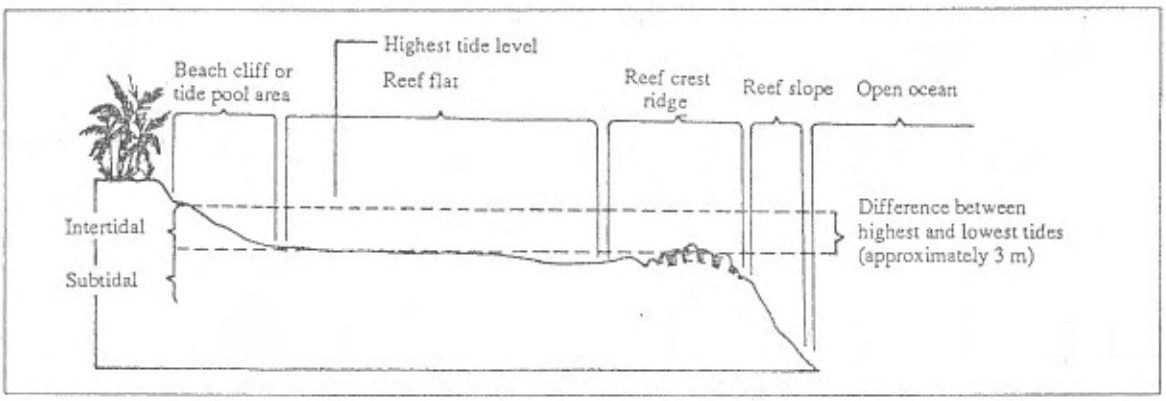


Figure 8.1. Zonation of a fringing reef (taken from A. T. White,1987)

8.1.2. Productivity

The primary productivity of coral reefs equals or surpasses all other natural ecosystems, and one reef may support as many as 3000 species. The tropical waters that overlie coral reefs are nearly devoid of nutrients such as nitrates and phosphates. The high primary productivity of coral ecosystems results principally from flowing water over the reef, their efficient biological recycling and high retention of nutrients.The coral polyps have symbiotic algae, zooxanthellae, within their tissues, which process the polyps' waste products before they are excreted, thus retaining such vital nutrients as phosphates.
Coral reef communities obtain their supplies of fixed or useable nitrogen, which is essential to phytoplankton and algae for photosynthesis, from algae on adjacent reef flats and bacteria in reef sediments, sea grass beds and mangroves. At Vaiusu Bay an important supplier of nutrients is the mangrove swamp nearby.

The physical complexity of a reef contributes to its diversity and productivity. The great number of holes and crevices in a reef provide abundant shelters for fish and invertebrates, and are important fish nurseries. In addition, highly specialized creatures such as parrotfish, butterflyfish and nudibranchs have become dependent for their survival on the reef. The reef provides a solid substrate for many bottom-living organisms (e.g. clams, sponges, tunicates, sea fans, anemones and algae) to settle and grow (A.T. White, 1987).

8.1.3. Role in the coastal environment

Fringing and barrier reefs are natural breakwaters which protect low lying coastal areas from erosion and other destructive action by the sea. Coral reefs also contribute to terrestrial expansion by providing sand for beaches and low islands. These reef functions naturally protect thousands of coastal villages, low-lying coastal plains and coastal engineering structures built behind the outer edges of reefs along tropical coasts (A.T. White, 1987).

8.2 Mangroves

Mangrove swamps are classified as vegetated tidelands. Mangroves serve as the vehicle for storage and transfer of nutrients from upland sources which are partly used and recycled within the tidelands system, but ultimately transported into the coastal waters to provide basic nutrients for the food web system. The vegetation plays a key role in converting nutrients and sunlight into the stored energy of plant tissue. About half the plant tissue created at a mangrove swamp is flushed out into the foreshore providing nutrients for the other ecosystems (e.g. coral reefs).

The vitality of a mangrove swamp depends upon the quality and quantity of freshwater inflow that it receives from drainage or adjacent shorelands. Development which accelerates runoff and channels discharge water down drainage conduits may result in rapid sporadic flow that bypasses the mangrove swamp, carrying nutrients through the estuary too fast to yield their full benefit.

Mangroves, which have the capacity to treat runoff water, are capable of purifying nitrogenous wastes. As they grow, tidelands vegetation also remove toxic materials and excess nutrients from estuarine waters.The vegetation also slows the surge of flood waters and may help the severity of flooding. Mangrove trees not only preserve shorelines by preventing erosion, but actually can extend the land's edge by trapping sediments and building seaward. Although vegetated tidelands can assimilate a reasonable amount of contaminants, they do have a limit and so must be protected from gross pollution from both land runoff and estuarine sources, and, in particular, from oil and other toxic substances.

The vegetated tidelands serve as an essential habitat, nutrient producer, water purifier, sediment trap, aesthetic attraction, storm barrier, shore stabiliser and as an energy storage unit for the ecosystem (J. Clark, 1974).

8.2.1. Mangroves at Vaiusu Bay

Tomlinson (1986) states that there are four species of mangroves in Samoa. These are *Bruguiera gymnorrhiza, Excoecaria agallocha, Heritiera littoralis* and *Rhizophora samoensis.* The specie that occur in Vaiusu Bay, and thus has to cope with the pollution from the landfill, sewage and industrial activities is *Rhizophora samoensis* (red mangrove). Although there are also some trees of *Bruguiera gymnorrhiza* noticed at this site there are only a few specimens (personal comments, Department of Agriculture, Forests and Fisheries). The *Rhizophora* species is characterised by its aerial stilt roots, perfect flowers; often depauperate, scrubby, and much branched in marginal habitats (P.B. Tomlinson, 1986).

9. Effects on the marine environment

In this chapter the effects on the marine environment in the Apia region are discussed because this is the only region where the effects from industrial activities are concentrated. This does not mean that along the other shorelines of Western Samoa no environmental impacts caused by human activities are noticed. Those impacts are, however, caused by agricultural runoff, reclamation or illegal fishing activities (dynamite fishing, fish poisoning, reef gleaning). These activities are not discussed in this report, and therefore this chapter is restricted to the places which are polluted by industrial activities.

9.1. Vailele area

The large, wide reef off Vailele is less disturbed. The inner lagoon is dominated b seagrasses (beds of *Syringodium* are expanding, possibly because of discharges from the WSTEC slaughterhouse). Coral cover is moderate in the outer lagoon, but areas of dead standing microatolls indicate recent degradation. Sedimentation has occurred on the reef adjacent to the Letogo stream.

Because of cyclone Ofa (1990) and probably also cyclone Val (1991), all of the seaward reeftop here is now covered by high, wide cyclone banks. The extent of the banks here and along the Apia reefs reflects the accumulated dead coral and rubble on the reef slope resulting from past reef disturbances.

Probably from the effluents of the WSTEC farm and slaughterhouse, the inner lagoon at Vailele is eutrophic and seagrasses are expanding, resulting in major degradation inshore.Other human impacts in this area are reclamation of the marshes and wetlands. The marshes and wetlands are also being cut off from the sea by road construction. There is high sedimentation from the Letogo and other small streams entering the foreshore area. Seawall construction in the vicinity also creates serious erosion (L. Zann, 1991).

9.2. Apia Harbour

The fringing reef in Apia Harbour has been almost entirely reclaimed as a result o material dredged from the harbour. This reef is now completely dead. Siltation from the Vaisigano River (resulting from poor agricultural practices in the watershed) has caused the shoaling of the harbour by about 1.7 metres between 1975-1981. The silt, excessive nutrients and urban pollution are probably largely responsible for the degradation of the reefs.

Apia Harbour is deep, but poorly protected from the north. A breakwater was constructed in 1990-1991 to shelter the wharf. Oil tanks moor in the outer harbour and discharge by a submerged line. Occasional oil spillages are inevitable. Much of the pollution and sediments from the Harbour are carried westwards by the prevailing southeast winds into the northwestern lagoons.

The adjacent reefs off Pilot Point and Vaiala are mostly dead. This is probably largely due to urban run-off, harbour works and dredging for the Royal Samoan Hotel construction site at the east of Pilot Point (L. Zann 1991). What is remarkable is that off Pilot Point is Western Samoa's only marine protected area. This area, called Palolo Deep Marine

Reserve, is approximately 22 ha in area and has a moderately diverse coral cover and fish community. Some areas of the Deep are dead or affected with algae. Especially in a protected area, human impacts should be prevented.

Damage from cyclone Ofa, and probably also cyclone Val, was very severe. Long wide emergent cyclone banks were formed along almost all of the reef crest and tops, and the reef slope was scoured of almost all live corals.

9.3. Vaiusu Bay

Off Vaiusu, seagrass beds (*Halophila* and *Syringodium*) dominate the inner and outer lagoon. They are expanding because of the lagoon's increasingly eutrophic conditions. The outer lagoon off Vaiusu and Mulinu'u has a wide coral rubble zone with a narrow zone of live corals along the back reef. Aerial photographs indicate that the coral rubble has expanded since the 1960s and the coral zone has contracted.

Human impacts on Vaiusu Bay have caused major degradation to the marine environment. Vaiusu mangrove wetlands (65 ha) are partially cleared for roads, buildings and the rubbish dump at Vaitoloa. Circulation of Vaiusu Bay is blocked by causeways used for lagoon mining off Vaitele and Mulinu'u (see figure 7.1.). Ocean exchange is also now restricted by cyclone banks. The lagoon is very turbid from lagoon mining and the discharge of the Fugalei stream. The lagoon is seriously polluted by domestic and industrial wastes which enter via storm drains, freshwater springs, and agrochemicals entering via Fugalei Stream. Very high nutrient levels and faecal coliform bacterial counts have been reported. The lagoons are eutrophic: seagrasses and mangroves are expanding and corals are dying. Prevailing lagoon currents carry Apia's pollution westwards into the wide north western lagoon. The construction of breakwaters, seawalls and causeways for mining of the lagoons have interrupted natural sediment transportation, thus creating serious erosion.

Vaiusu Bay was formerly a major nursery ground for mullet, but has been seriously degraded by the pollution in the area. The annual mullet catch has declined ten fold in the past five years. The likelihood of bacterial and heavy metal pollution make the consumption of seafoods from the Bay a health hazard, especially shellfish that are caught from this area (L. Zann 1991). Children are, however, selling baskets of shellfish on the street which are caught in Vaiusu Bay.

9.4. Falefa area

This area is northwestern from Vaiusu Bay and lies between the villages of Vaitele and Malie. The shore is very sheltered, consisting of lava rocks and mud, with a narrow (50 m) mangrove fringe. The inner lagoon is muddy, turbid and very shallow (0.5-1.0 m). It is dominated by seagrasses (especially *Syringodium* clumps), macroalgae and sponges. Dead standing *Porites* microatolls indicate that it once supported corals. The outer lagoon is sandy and very shallow (0.5-1.0 m), with several deep 'blue holes' to 15 metres in depth. It is dominated by seagrasses (*Halophila* and *Syringodium* patches) and scattered corals (*Porites*). A narrow discontinuous zone of live coral (*Porites* microatolls and *P. cylindrica*) lies along the back reef but has contracted greatly since 1954. The upper reef slope has been stripped of most live coral (L. Zann, 1991).

The human impacts are major in this area. All six marshes and wetlands in the area have been degraded or destroyed because of road construction along foreshores. Runoff of domestic wastes via water table and springs, and point source discharges of wastes from the

industrial zone at Vaitele (e.g. the brewery) inputs nutrients and other wastes into the area (because of the current). Prevailing lagoon currents from the Apia area also carry pollution into this lagoon. The lagoon is strongly eutrophic with expanding seagrasses and declining corals. Algal blooms and accumulations of rotting benthic and planktonic algae occurred in Afega in October 1991, creating a severe odour problem and great concern in the district. Possible contamination of the inner lagoon by micro-organisms from Apia and Vaiusu pose a very high public health risk. The use of Derris poisoning (poisoning with the pounded root of the *Derris elliptica*) which kills adult fish, juvenile fish, shellfish and corals in this area is relatively common as a fishing technique.

There has been an outbreak of the crown-of-thorns starfish (*A. planci*) off Afega in 1982, and moderate to high densities on the semi-detached reef off Afega in mid-1991 (L. Zann, 1991). It is possible that these crown-of-thorns outbreaks are a result of the eutrophication problems in this area.

9.5. Conclusions

All the sites which were expected to be polluted (the potentially polluted sites mentioned in chapter 7) are in fact polluted. Major pollution problems in the area are eutrophication (nutrient enrichment), siltation, erosion and bacterial contamination (which is the main health hazard). These problems are caused by some of the industrial sites and the high population density in the Apia region. Another important pollution problem in this area which is also due to urbanisation is road construction and reclamation. Effects that are noticed on the marine environment are the decline in the living coral area because of eutrophication and siltation, the decline of the healthy mangrove area as a result of siltation, reclamation and road construction and the expansion of the seagrass beds (at the expense of other species) as a result of the nutrient enrichment.

10. Conclusions

10.1. Pollution sites

Most industries in Western Samoa are secondary industries and are therefore not big polluters. There are, however, some industries which are discharging large amounts of waste water into the marine environment. These industries are mainly the Vailima Brewery at Vaitele and the Manuia Brewery at Vaimea which are discharging large amounts of nutrient rich waste water into Vaiusu Bay and the Falefa area. The two oil storage sites from Mobil and British Petroleum which are situated both at Sogi, are discharging periodically large amounts of oil-contaminated water into Vaiusu Bay. At the eastern side of Apia Harbour, at Vailele, there is a nutrient rich waste water flow coming from the WSTEC slaughterhouse which is directly discharged into the lagoon without treatment. The smaller factories are discharging relatively small amounts of waste water and are all situated in or near Apia. The larger factories are mostly situated at Vaitele. The waste water will, for the biggest part, run into Vaiusu Bay and the Falefa area, a smaller part will run into the Apia Harbour area.

It is not likely that the hotels are causing much marine pollution. The hotels which are spread over the country are very small and can, therefore, not be considered as concentrated spots of sewage discharge into the ocean. The bigger hotels are all located in Apia, and the Tusitala Hotel may be the only hotel which causes major marine pollution because its effluent goes directly into Vaiusu Bay.

Because of the high population density in the Apia region there is also a domestic waste as well as a sewage problem. The domestic waste is often burned, privately dumped or dumped at the landfill at Vaiusu Bay causing pollution problems in the Bay. Sewage can run off the land due to poor drainage soils in the area thus polluting the lagoons in the Apia area.

10.2. Marine environment

In this report four spots in the Apia region which are affected by pollution coming from the pollution sources identified in Part One, have been examined in detail. These four sites are the Vailele area, Apia Harbour, Vaiusu Bay and the Falefa area. Ecological characteristics of these sites are coral reefs (fringing reefs) and mangrove forests (*Rhizophora samoensis* and *Bruguiera gymnorrhiza*). Major pollution problems are eutrophication, siltation and bacterial contamination. An important problem caused by the increasing population in Apia is the construction of roads and reclamation of land. Pollution caused by oil spillages are not noticeable.

Effects on the marine environment that are noticed are the decline of the living coral areas because they are suffering from eutrophication and siltation. A natural cause of the decline in living coral are the two cyclones, Ofa and Val, in 1990 and 1991 respectively. It is questionable if the impact of the cyclones on the marine environment would have been so dramatic if the environment had been in a healthy state before the cyclones struck the island. Because of siltation, reclamation and road construction, the area of healthy mangrove forest is also declining. The only vegetation types that are increasing are the seagrass beds which are profiting from the increasing amounts of nutrients. Ecologically, this is not a healthy trend because species-rich ecosystems are turned into ecosystems with only very few different

s. Fortunately, the recent launching of the South Pacific Bio Diversity Conservation amme is opportune, and attention must be given to reversing the biodiversity trends in ost affected sites.

11. Recommendations

1. Instead of giving waste oil to customers who will use it for conservation of wood and the marking of sports grounds it would be better to collect the waste oil and recycle it. In Western Samoa this is possible at the recycling plant of Tony Hill. Of course, the discharge of waste oil at the EPC plants on 'Upolu and Savai'i into the environment should be stopped, and the oil recycled.

2. Glass and aluminium from aluminium window production, broken glass bottles, empty aluminium cans, old car batteries,etc. should not be dumped on the landfill but all these materials can be re-used as a raw material for the production of new materials. The person in Apia who collects these materials for recycling in New Zealand is Tea Schmidt.

3. The burning of plastics and other wastes can cause health problems to employees and neighbours because it is possible that carcinogenic and toxic fumes arise in the burning process. Instead of burning the wastes it would be better to dispose of them safely. For example, on a properly designed landfill.

4. Toxic wastes coming from the National Hospital, the USP laboratory, printing and photo shops and individuals (e.g. cosmetics, batteries) should be carefully collected separately from the other domestic waste. Then it should be sent to an overseas country which can manage such kinds of wastes, or it should be dumped in a properly designed toxic waste dump in Western Samoa.

5. The landfill in the mangroves of Vaitoloa should be closed and a new landfill should be designed on a less ecologically sensitive site. Of course, this new landfill should be properly designed, so there will not be an effluent running into the ocean or the ground water supply.

6. Environmental regulations should be enforced. There are quite a lot of environmental regulations in Western Samoa, but none of them are carefully regulated. A better co-operation between the several Departments which are involved would be necessary and also the local village governments and women's committees could encourage the enforcement of the legislation.

7. Family planning should be encouraged in Western Samoa. This can be done with the assistance of awareness workshops and brochures. Many children in a family is very usual. Overpopulation and centralisation on one spot is a major cause of sewage and domestic waste problems. When the population declines, environmental problems will also decrease.

8. Industries with insufficient treatment systems like the Vailima Brewery and the Kitano Tusitala Hotel should be encouraged or forced to repair their treatment system or install a sufficient one.

9. New industries that want to settle in Western Samoa and other major activities which are planned in Western Samoa should undergo an Environmental Impact Assessment (EIA) before the activity takes place, as well as during the performance of the activity.

10. To decrease the level of nutrients in the lagoons of Western Samoa it would be very desirable to design a sewage collection system. After collecting the sewage, it would be quite easy to treat the sewage and reduce the amount of nutrients in it. After treatment, the effluent is relatively clean and can be discharged into the ocean. Especially for the Apia region, sewage collection would be highly recommended. For the more rural areas it would be very difficult and expensive designing a sewage collection system. In these areas, thought should be given to development of individual facilities (e.g. bio-composting toilets).

11. Add labels and a brochure in Samoan to the containers of pesticides when they are sold at the agriculture store, so that the user of the pesticides knows how he has to use the poisons in a way which will cause least problem to the environment and human health.

Acknowledgements

There are many people who I want to thank for making my work and my stay Western Samoa as comfortable as I experienced it. To begin with, I want to thank Vili Fu the Director of the South Pacific Regional Environment Programme, for making my probationary term at SPREP in Western Samoa possible. He was the one who responded positively on my request for work experience with SPREP in the period May until Octobe 1992. I would also like to thank Neva Wendt, Team Leader / National Environment Management Strategies. She is a really wonderful woman who, when the work was tendin stagnate made it possible for me to continue the work with more interesting possibilities. A thanks to Laisiasa Tulega, the Environmental Contaminants Officer at SPREP for his advic and Bismarck Crawley, the SPREP Geographic Information System Officer for the provide maps of Western Samoa. I am also very grateful to Steve Brown, the Environment Officer the Office for Tokelau Affairs, who gave me very useful information according to my resea and whom I assisted on the two most interesting trips to Tokelau in August and September. my home base I want to thank Pieter Biezenaar, my supervisor at the Professor H.C. van H Instituut, to whom I could write the many frustrations which appeared during my work in Western Samoa.

Personal thanks to Livi (Faaiu) who introduced me in the Fa'a Samoa (the Samo Way) and his Samoan family Popa at Taga, Savai'i. Also thanks to Lex, the person with who I could eat Dutch hotchpotch and who could explain to me some remarkable Samoan behaviours from a Dutch point of view.

And of course I want to especially thank the people who I left behind in the Netherlands for over five months, and who comforted me with their letters. Most important during this period were my parents, Petra and Jules, my brother Boris and of course Marit, m girlfriend.

I thank everybody who reads this report and uses its information for resolving environmental problems in Western Samoa or other countries. When reports are only written without being used for improving the environment, we should perhaps stop writing them and use our spare time for ecological farming instead of buying canned, environmentally unsound products in the shop and walking instead of driving our big diplomat.

References

Bell, Lui A.J. 1985. Coastal zone management in Western Samoa. Fisheries Division. Department of Agriculture, Forests and Fisheries. Western Samoa.

Brodie, J.E, C. Arnould, L. Eldredge, L. Hammond, P. Holthus, D. Mowbray and P. Tortell. 1990. State of the Marine Environment in the South Pacific Region. UNEP Regional Seas Reports and Studies No. 127; and SPREP Topic Review No. 40.

Carpenter, Richard A. and James E. Maragos (editors). 1989. How to assess environmental impacts on tropical islands and coastal areas. SPREP training manual; prepared by Environment and Policy Institute, East-West Center; sponsored by Asian Development Bank

Chesher, Richard H. 1984. Pollution sources survey of the kingdom of Tonga. SPREP Topic Review No. 19. South Pacific Commission, Noumea, New Caledonia.

Clark, John. 1974. Coastal Ecosystems: Ecological considerations for management of the coastal zone. The Conservation Foundation. Washington D.C. in cooperation with National Oceanic and Atmospheric Administration Office of Coastal Environment, U.S. Department of Commerce.

Convard, Nancy S. 1992. Western Samoa land based pollution survey draft summary of information. unpublished.

Dahl, Arthur Lyon. 1981. Coral Reef Monitoring Handbook. South Pacific Commission, Noumea, New Caledonia.

Humphries, Stella and David Collins, with assistance from David James. 1991. Tokelau country report for the United Nations Conference on Environment and Development 1991. Department of Agriculture and Fisheries, Office of Tokelau affairs. Apia, Western Samoa.

Johannes, R. 1982. Reef and lagoon management in Western Samoa. unpublished.

King, Michael. 1988. Coral reefs in the South Pacific: Handbook. SPREP; South Pacific Commission.

King, Michael. 1989. Coastal environments in the South Pacific. SPREP; South Pacific Commission.

Naidu, S., W.G.L. Aalbersberg, J.E. Brodie, V.A. Fuavao, M. Maata, M. Naqasima, P. Whippy, R.J. Morrison. 1991. Water quality studies on selected South Pacific lagoons. UNEP Regional Seas Reports and Studies No. 136; and SPREP Reports and Studies No. 49.

Pearsall, Sam H. and W. Arthur Whistler. 1991. Terrestrial ecosystem mapping for Western Samoa: Summary project report and proposed national park reserves plan. Prepared for the government of Western Samoa by the South Pacific Regional Environment Programme and the East-West Center, Environment and Policy Institute.

Taylor, Laura M. 1991. Western Samoa: An investigation into the sources and regulations of marine pollution. Unpublished.

Tomlinson, P.B. 1986. The botany of mangroves. Cambridge University Press; New York.

White, Alan T. 1987. Coral reefs: valuable resources of Southeast Asia. International Center for Living Aquatic Resources Management on behalf of the Association of Southeast Asian Nations / United States Coastal Resources Management Project.

Warren, Paula and Warren Sisarich. 1992. Legal consultancy for dept. of environment and conservation in Western Samoa. Environment and conservation department of New Zealand.

Wauthy, B. 1986. Physical ocean environment in the South Pacific Commission Area. UNEP Regional Seas Reports and Studies No. 83. prepared in co-operation with SPC, SPEC and ESCAP.

Zann, Leon P. 1991. The inshore resources of 'Upolu, Western Samoa: Coastal inventory and fisheries database. FAO/UNDP: Sam/89/002. field report No. 5.