Integrated Water Resource Management

Diagnostic Report Vanuatu

Volume 2 Appendices

March 2007

Prepared on behalf of
Department of Geology, Mines and Water Resources, Vanuatu
For SOPAC, Fiji

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Volume 2

Annexes

Appendix 1

Bibliography

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Appendix 2

In-Country Program

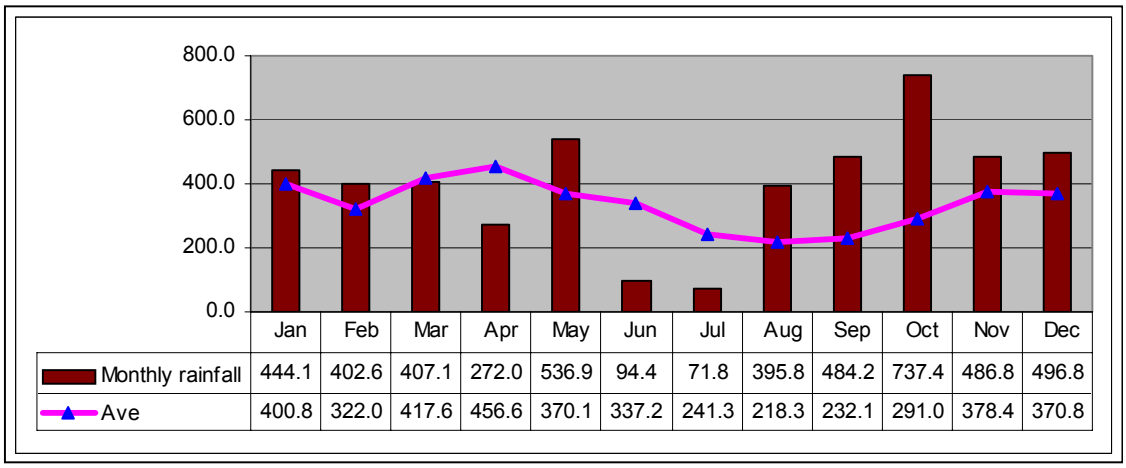
In-Country Program

Date 2007		Activity
03 March Saturday	PM	Arrive Port Vila from NZ. Meet with Erickson Sammy Manager Water Resources DGMWR
04 March Sunday	AM PM	Background Reading & preparation Meet with Jo & Peter Wan Smol Bag
05 March Monday	 AM PM	Holiday (Chiefs day) Preparation for mini Work Shop Wednesday Meet with Director DGMWR
06 March Tuesday	AM PM	Discussions with DGMWR staff – background info, preparation for National Water Resource Management Advisory Committee Meeting Wednesday
07 March Wednesday	8.30-am 12.00	National Water Resource Management Advisory Committee Meeting (see attached summary notes)
	PM	Follow up issues from workshop
08 March Thursday	8.30am	UNELCO Frederic Petit (Water Manager)
	9.30am	Meteorological Service Robson Tigona (PSO); William Worwor (senior forecasting officer); Brian Phillips (Climate Change specialist)
	10.30am	Environment Unit Ernest Bani
	11.30am	Ministry of Health Nellie Ham Muru (Environmental Health Officer)
	2.00pm	Live & Learn Emily Findlay; Fremden Shadrock
	3.00pm	SHEFA Provincial Office Amy Lynch (planner)
	4.00pm	DESD Thomas Bangalawi (Sector analyst); Jerry Labi (Strategist)
09 March	8.00am	Ministry of Lands & Natural Resources Mathew Temar (VANRIS Mapping)
	9.00am	Ministry of Agriculture, Forestry & Fisheries Anne Marie Sarisets (Forest Officer SHEFA), Judy Kalatop (Forest Officer Luganville)
	10.00	Ministry of Agriculture, Forestry & Fisheries
	11.00am	Ministry of Agriculture, Forestry & Fisheries Frazer B Lechi (Principal Agriculture Officer & Head of Research)
	2.00pm	PWD Port Vila Willie Watson Manager Projects
	3.00pm	Ministry of Lands & Natural Resources Russell Nari (Director General)
10 March	7.00am	Depart for NZ
	4.10pm	Arrive home in Bay of Islands New Zealand

Appendix 3

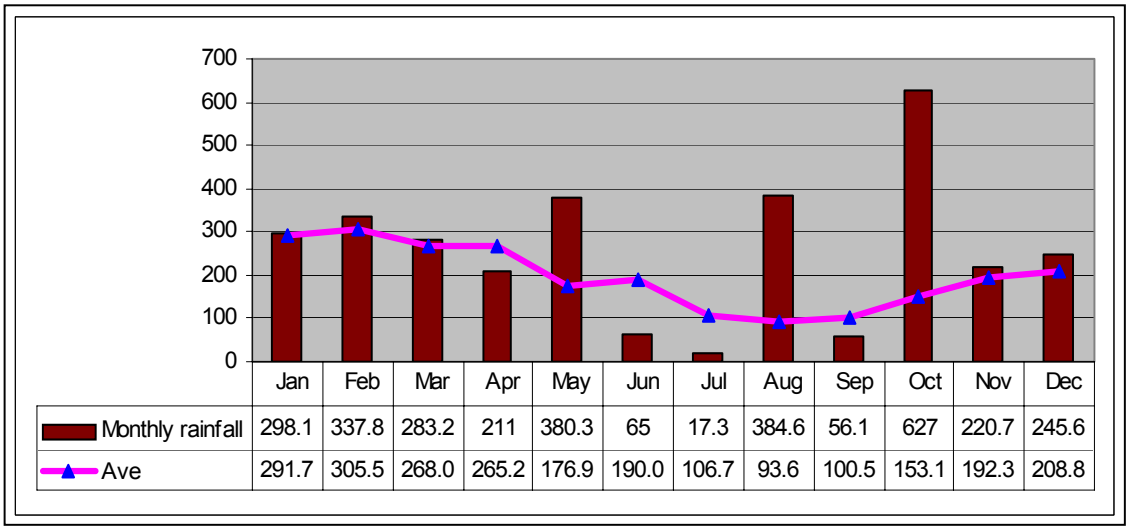
Rainfall Data

Rainfall Data Rainfall for Meteorological Sites in Vanuatu
Comparison between 2006 and 30 years average rainfall (measured in mm)



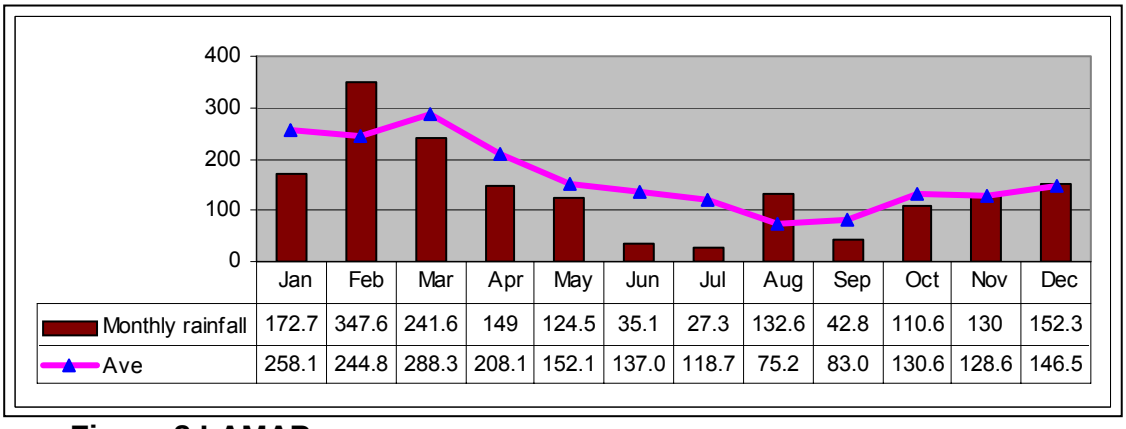
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly rainfall	444.1	402.6	407.1	272.0	536.9	94.4	71.8	395.8	484.2	737.4	486.8	496.8
Ave	400.8	322.0	417.6	456.6	370.1	337.2	241.3	218.3	232.1	291.0	378.4	370.8

Figure 1 SOLA (Banks Group)



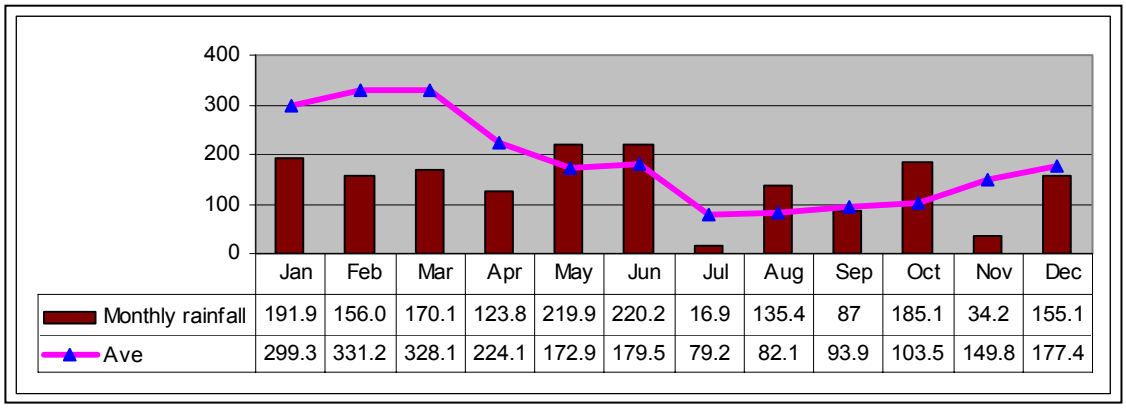
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly rainfall	298.1	337.8	283.2	211	380.3	65	17.3	384.6	56.1	627	220.7	245.6
Ave	291.7	305.5	268.0	265.2	176.9	190.0	106.7	93.6	100.5	153.1	192.3	208.8

Figure 2 PEKOA (Santo)



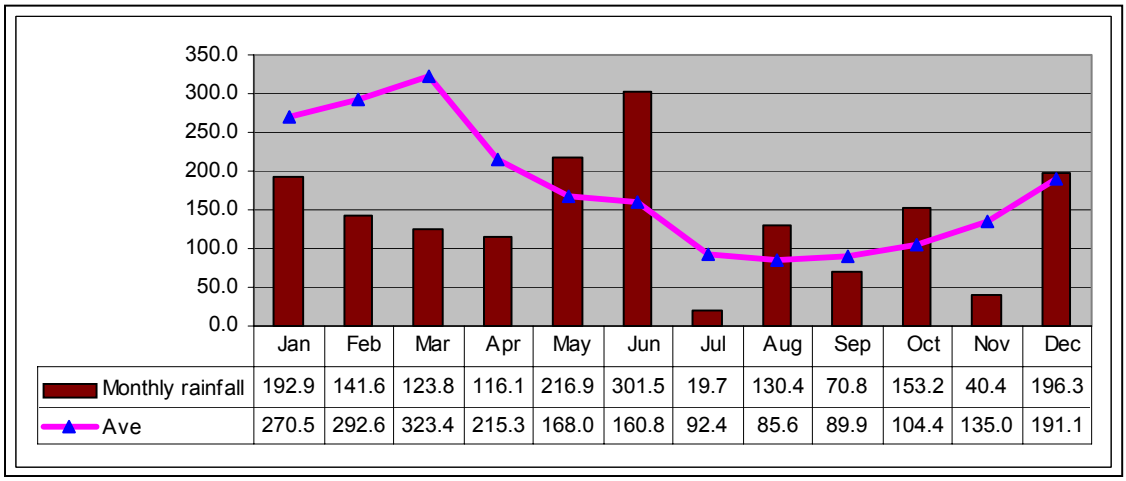
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly rainfall	172.7	347.6	241.6	149	124.5	35.1	27.3	132.6	42.8	110.6	130	152.3
Ave	258.1	244.8	288.3	208.1	152.1	137.0	118.7	75.2	83.0	130.6	128.6	146.5

Figure 3 LAMAP



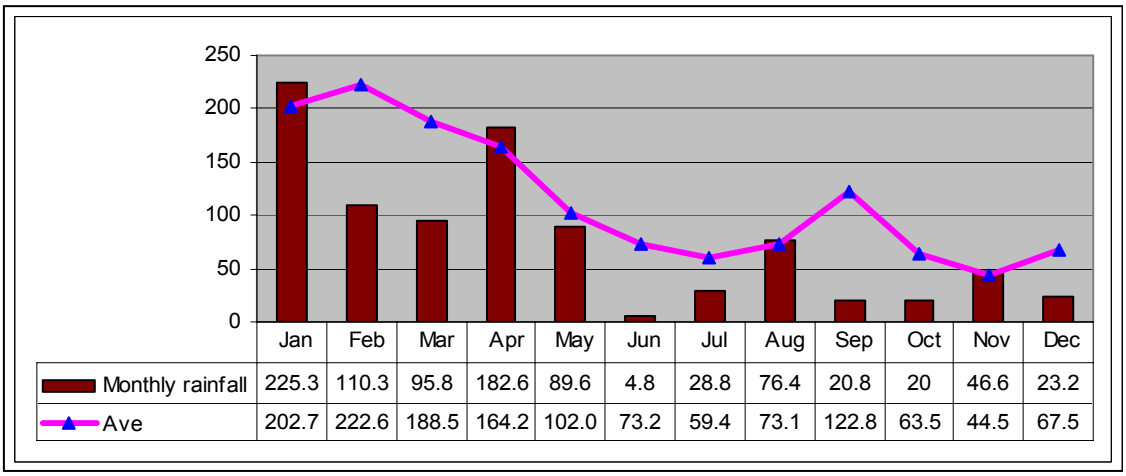
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly rainfall	191.9	156.0	170.1	123.8	219.9	220.2	16.9	135.4	87	185.1	34.2	155.1
Ave	299.3	331.2	328.1	224.1	172.9	179.5	79.2	82.1	93.9	103.5	149.8	177.4

Figure 4 Bauerfield (Efate)



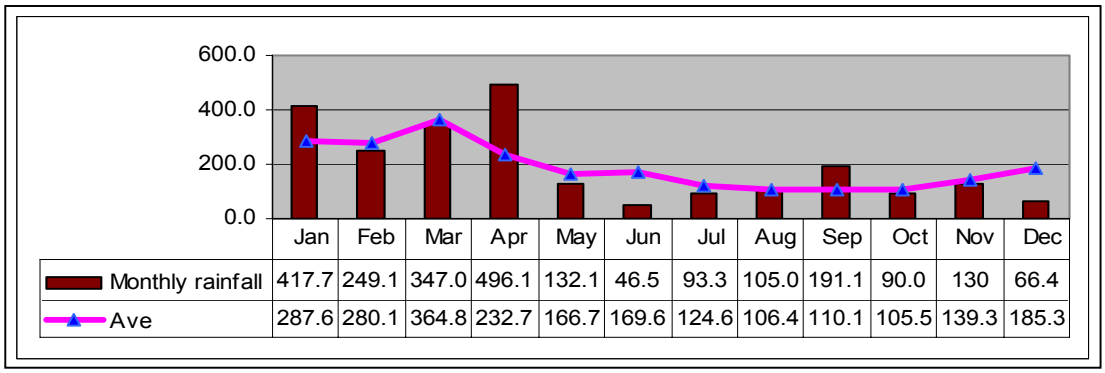
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly rainfall	192.9	141.6	123.8	116.1	216.9	301.5	19.7	130.4	70.8	153.2	40.4	196.3
Ave	270.5	292.6	323.4	215.3	168.0	160.8	92.4	85.6	89.9	104.4	135.0	191.1

Figure 5 NAMBATU (Efate)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly rainfall	225.3	110.3	95.8	182.6	89.6	4.8	28.8	76.4	20.8	20	46.6	23.2
Ave	202.7	222.6	188.5	164.2	102.0	73.2	59.4	73.1	122.8	63.5	44.5	67.5

Figure 6 Whitegrass (Tanna)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly rainfall	417.7	249.1	347.0	496.1	132.1	46.5	93.3	105.0	191.1	90.0	130	66.4
Ave	287.6	280.1	364.8	232.7	166.7	169.6	124.6	106.4	110.1	105.5	139.3	185.3

Figure 7 ANALGAUHAT (Aneityum)

Extreme Rainfall Days

Stations	Maximum Precipitation in 24 hrs					Number of Rain-days in 2006			
	2006		Historical Records						
	Amount	Date	Past Record	Date	Period	>=0.2mm	>=1mm	>=10mm	>=50mm
Sola	147.8	14/04, 04/12	309.4	4/2/1967	1954-04	292	256	115	21
Pekoa	163.4	05/8	327	9/3/1987	1973-04	197	266	65	9
Lamap	103.6	21/2	354.2	3/10/1973	1961-04	205	151	43	6
Bauerfield	185.9	06/6	**538.8**	20/01/1999	1985-04	204	144	44	5
Port Vila	63.8	20/1	377.4	20/01/1999	1948-04	201	140	41	5
Whitegrass	96	18/4	124.8	22/02/2000	1998-04	141	84	26	2
Anelgauhat	198.2	04/6	346.6	26/02/1989	1952-04	213	163	60	10

Appendix 4

Tagabe River Management Data

Tagabe River Management

Summary of Activities within the Tagabe River Watershed

The Tagabe River Watershed Catchment Area (TRW) is located north of Port Vila, just outside the municipality's boundaries. Although this watershed is the only source of water to Port Vila and villages such as Erakor, Eratap, and Pango to the east, urban drift has inflated pressure to develop in the area and Port Vila's residential districts have slowly been expanding into the watershed. This expansion heightens the risk of contaminating the very water source on which the town depends. Areas downstream, like the Blacksands community, are most vulnerable to this contamination as they collect their water directly from the river or from shallow wells in highly permeable soil. Agricultural and livestock activities occurring within the watershed are also endangering the area's water quality and must be addressed.

A private company called UNELCO manages the municipality's water supply. Their pump station is located within the watershed close to the encroaching residential districts. While these districts pose no immediate threat, their rapid expansion and high population growth (due to urban drift and a high birth rate) could pose a problem in the near future. With the knowledge that it will take time and money to find an alternative water source, in 2003 the Tagabe River Management Committee (TRMC) was formed and charged with:

- Formulating and implementing a land use management plan for the TRW.
- Using this plan as a template for planning multiple land use activities within watersheds around the country of Vanuatu.

The TRMC has a wide breadth and depth of knowledge from which to draw to protect the Tagabe River as it includes representatives from the Departments of Geology and Mines, Lands, Forestry, Agriculture, Livestock & Quarantine, and Health as well as Shefa Province and the Ministry of Lands. Other members include Live and Learn Environmental Education, Wan Smol Bag (both NGOs), and UNELCO.

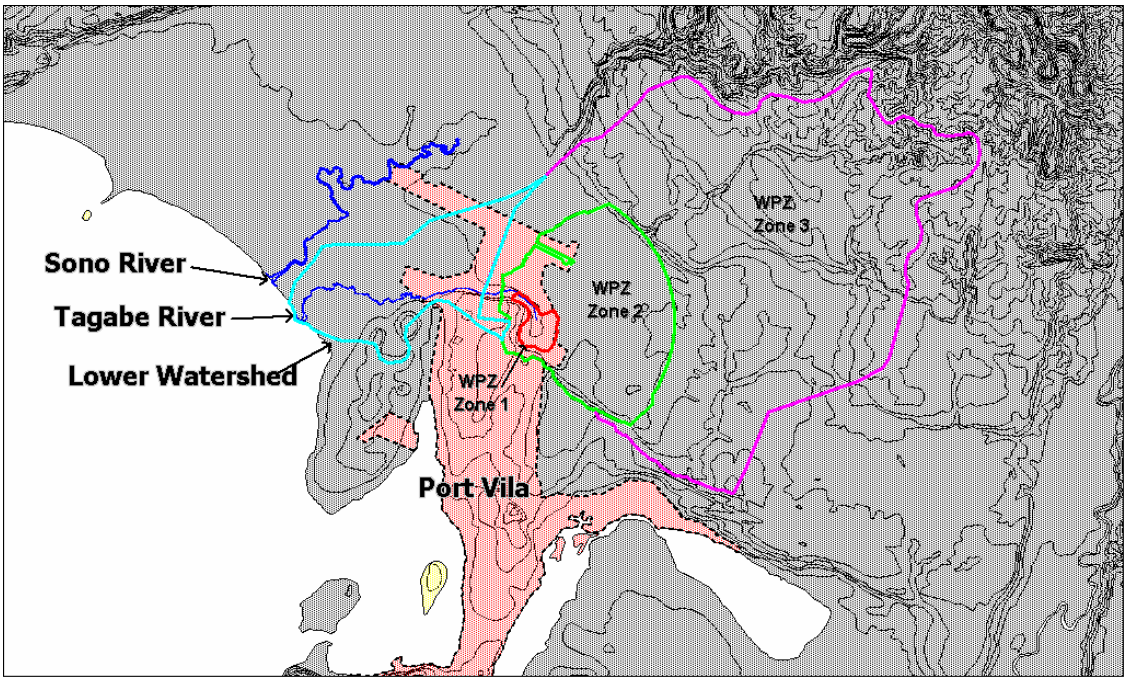


Figure 1. The Matnakara Water Protection Zone and divisions into sub-zones.
Source: SHEFA Province representative on TRMC

With the above listed objectives in mind the TRMC's first step was to work with the Ministry of Lands and Natural Resources to create the Matnakara Water Protection Zone (Figure 1.) This Zone is composed of 3 sections, each with different land use restrictions. For example: Zone 1 is the pump station and buffer around the riparian area of the river and has very strict use restrictions while Zone three includes the outer reaches of the watershed and allows for small scale high intensity agriculture and sealed roads.

The TRMC currently has several projects in Zone 1 and Zone 2. Zone 3 will be included in time as consultations are held with leaseholders in that area. The TRMC has no current plans to do projects in the lower watershed, although awareness will likely be done in that area and projects may arise. The main objective of the TRMC is to protect drinking water and the lower watershed area, while a water quality concern due to high population, does not have as large an impact as areas upstream and in the headwaters.

In addition to the Matnakara Water Protection Zone, multiple land use activities were chosen to demonstrate the various sustainable land use options within a watershed. These activities are currently in the implementation stage and will be followed by monitoring and evaluation as the final step in the process of rehabilitation for the Tagabe watershed. Lessons learned from the experience will be used to meet objective two of the TRMC and hopefully create a "template for planning multiple land use activities within watersheds around the country of Vanuatu."

Current TRMC projects include:

- Botanical Garden – Creates needed "green space" close to Port Vila while also providing a travel destination for eco-tourists. Carefully selected species for re-vegetation protect water quality, reduce evaporation, improve soil porosity for increased water retention, and prevent residents nearby from using the river to wash laundry.
- Forestry Seed Bank –The creation of a seed bank close to Forestry Department offices provides for convenient field research and more efficient reforestation. It also contributes to the ecological benefits listed for the botanical garden.
- Agriculture/Agro-Forestry Project – Establish demonstration plots in areas currently cultivated illegally by communities bordering these lands for the joined benefits of increased food production, field research for extension officers, and decreased deforestation in the watershed.
- Dairy/Livestock Demonstration Farm – Relocate and improve the current livestock yard, which is located very close to the river, to prevent any polluted runoff from entering the river. It, when completed, will also provide an area close to the Livestock offices for field research, and an environmentally sound demonstration for small scale farmers throughout Vanuatu.
- Floriculture - By providing several hectares near the river for flower cultivation, the floriculture encourages the vegetating of areas near the river and encourages women to participate in watershed protection.
- Land allocated for the specific use of UNELCO – Protects area close to the pumps, tanks and wells that supply Port Vila.

In order to judge the efficacy of these methods, in 2004 the TRMC began a water testing program. In partnership with UNELCO, who provides staff and laboratory

facilities for testing, the TRMC chose 12 testing sites. The first site is just before the UNELCO pump station, and the last is in Blacksands. Each of these sites is tested every month. Due to personnel changes and setbacks, testing has been somewhat hit or miss for the last several years, but recent efforts have been made to test as regularly as possible.

For more information contact the Department of Geology, Mines, and Rural Water Supply at 22423.

Maknakara Water Zone restrictions

Zone I - Pump Station and Well Field (Red Line)

Activities permitted within this zone:

- Collection of fruits, nuts, and leaves from existing trees and/or bushes for eating, medicinal or custom purposes
- Replanting of trees to help rehabilitate the area
- Any other activities approved by the TRMC that do not endanger the water quality of the groundwater aquifer or the Tagabe River
- Collection of water from the river

Any activities not listed above are considered not permitted within the boundaries of this zone. This includes but is not limited to:

- Any livestock activities (i.e. pigs, chickens, cattle, sheep, goats)
- Felling of any trees for firewood or logging
- Any agricultural or horticultural activities
- Clearing bush (i.e. with fire, bush knife)
- Construction of residential houses
- Construction of sanitation facilities

<u>Existing Leaseholders (prior to June 30, 2004):</u>

- Any of the restricted activities that are occurring on a leaseholder's lease located within this zone are permitted to continue until the TRMC can perform one of the following:
  - → Purchase the portion of the lease located within the zone at fair market value.
  - → Work with leaseholder to identify alternative land use activities that do not negatively affect water quality or limit land use rights.
  - → Convince leaseholder to block area as a reserve contributing to the protection of water quality.

Anyone living within this zone without a proper lease will be relocated with the help of the Government.

Zone II – Buffer Zone of Light Agriculture (Green Line)

Activities permitted within this zone:

- Organic agriculture or horticulture
- "Free range" non-intensive livestock activities

- Unsealed roads
- Replanting of trees to help rehabilitate the area and/or for logging
- Any other activities approved by the TRMC that do not endanger the water quality of the groundwater aquifer or the Tagabe River.

Any activities not listed above are considered not permitted within the boundaries of this zone. This includes but is not limited to:

- "Feed lot" intensive livestock activities
- Application of herbicides, pesticides and/or chemical fertilizers
- Sealed Roads
- Quarries or mining
- Cemeteries
- Landfill sites
- Sewage treatment ponds

<u>New subdivisions:</u>

No new subdivisions, where more than 50% of the area of an individual lot is located within this zone, will be permitted. Lots with less than 50% of their area located within this zone can be developed under the following conditions:

1. Minimum lot sizes for land zoned residential: 1000 m^2
2. Minimum lot sizes for land zoned agricultural: 2000 m^2
3. Only one house or dwelling can be constructed on these lots.
4. All proper sanitation facilities must be located outside of this zone. The house can be located within the zone so long as all proper sanitation facilities are located outside of the zone. Proper sanitation facilities include:
    a. Septic tank with soil absorption leach lines
    b. Septic tank with evapotranspiration trench
    c. Composting toilet
    d. Biogas digester toilet
    e. Any facilities that prevent wastewater from entering the ground or partially clean wastewater before entering the ground. Refer to TRMC or Environment Unit for details.
5. Sanitation facilities not permitted within this zone include:

a. Septic tank with soakaway pit
    b. Pit toilet
    c. VIP toilet
    d. Any facilities that release wastewater in or on the ground or within the river without any secondary treatment. Refer TRMC or Environment Unit for details.

6. The leaseholder agrees to abide by the rules governing land use activity within this zone through the management plan drafted and managed by the Tagabe River Management Committee (TRMC) under the guidance of the Environment Unit.

Only subdivided lots zoned agricultural will be permitted, where more than 50% of the area of an individual lot is located within this zone, under the following conditions:

1. Minimum lot size: 10,000 m^2
2. Only organic agricultural and horticultural activities are permitted that do not use herbicides, pesticides or chemical fertilizers.
3. Only one house or dwelling can be constructed on the lot.
4. Proper sanitation facilities are constructed to limit the possibility of pollution into the groundwater aquifer.

Existing Leaseholders (prior to June 30, 2004):

- Any of the restricted activities that are occurring on a lease located within this zone are permitted to continue until the TRMC can perform one of the following:
  - → Purchase the portion of the lease located within this zone at fair market value.
  - → Work with leaseholder to identify alternative land use activities that do not negatively affect water quality or limit land use rights.
- Any residential lease within the zone with a lot size smaller than 1000 m^2 and over 50% of the lease area located within this zone will be subject to the following conditions:
  - → If a house exists on the lot, the TRMC will work with the leaseholder to ensure that only one house will be constructed on the lot and proper sanitation facilities will be constructed for the house as described above for new subdivisions.
  - → If a house has not been constructed, the TRMC will work with the Government and the leaseholder to purchase the lease at the fair market value.
  - → If the lease was recently subdivided and has not been sold to another party, the TRMC will work with the Government and the leaseholder to reimburse the lessee the costs of subdividing and reverse the creation of the lease.

Anyone living within this zone without a proper lease will be relocated with the help of the Government.

Zone III – Water Catchment Protection Area (Purple Line)

Activities permitted within this zone:

- Organic agriculture or horticulture
- Application of chemical fertilizers
- Application of organic herbicides and/or pesticides
- Small scale “Feed Lot” intensive livestock activities
- Sealed roads
- Replanting of trees to help rehabilitate the area and/or for logging
- Any other activities approved by the TRMC that do not endanger the water quality of the groundwater aquifer or the Tagabe River.

- Small scale cemeteries (10 gravesites per hectare)

Any activities not listed above are considered not permitted within the boundaries of this zone. This includes but is not limited to:

- Application of chemical herbicides
- Quarries or mining
- Landfill sites
- Sewage treatment ponds

New subdivisions:

New subdivisions located within this zone can be developed under the following conditions:

1. Minimum lot sizes for land zoned residential: 1000 m^2
2. Minimum lot sizes for land zoned agricultural: 2000 m^2
3. Only one house or dwelling can be constructed on these lots.
4. Proper sanitation facilities are constructed to limit the possibility of pollution into the groundwater aquifer. Refer to zone 2.
5. The leaseholder agrees to abide by the rules governing land use activity within this zone through the management plan drafted and managed by the Tagabe River Management Committee (TRMC) under the guidance of the Environment Unit.

Existing Leaseholders (prior to June 30, 2004):

- Any of the restricted activities that are occurring on a lease located within this zone are permitted to continue until the TRMC can perform one of the following:
  - → Purchase the portion of the lease located within this zone at fair market value.
  - → Work with leaseholder to identify alternative land use activities that do not negatively affect water quality or limit land use rights.

Anyone living within this zone without a proper lease will be relocated with the help of the Government.

All Zones – Special Conditions

Requests for changes in zoning (i.e. from agricultural to residential) must pass through the TRMC for comments and recommendations.

Activities temporarily permitted until alternatives are identified:

- Washing of clothes/body in the river
- Swimming/playing in the river

Perennial and Ephemeral Streams, Creeks and Rivers (SCRs):

- No land use activities permitted within 10 meters of the edge of any SCRs. Land located within this area should be replanted with species selected by the Department of Forestry Herbarium staff for reforesting. These areas are defined as riparian zones.
- All livestock should be restricted from access to riparian zones.

- All houses, sanitation facilities, and gravesites should be located at least 20 meters from the edge of riparian zones.
- Damming any SCR, no matter how small, is not permitted.
- Collection of food (i.e. fruits, fish), water and leaves (i.e. laplap, natangura) from the riparian zones are permitted.

The justification for the land use restrictions within the defined water protection zones varies from lease to lease and are discussed in general below:

Justification for Zone 1

- Hydrology
- Depledge report (1994) suggests 10 metres surrounding wells, spring field and perennial flowing section of Tagabe River. Suggests extending Zone 1 within the spring field to allow for organic agriculture within Zone 2.
- TRMC drafted Zone 1 with 30 metre setback from perennial flowing section of Tagabe River. Also, covered three tributary sources upstream and the surrounding area.

Justification for Zone 2

- Geology
  - → Limestone cliffs south and southwest of Zone 1 support medium to high-density settlement resulting in the potential for pollution of the aquifer from inadequate sanitation leaching through the highly porous limestone.
  - → Alluvium soil within the valley is not as porous. Some treatment takes place in the soil before leaching into the groundwater.
- Hydrology and Topography
  - → Runoff from agricultural practices can lead to potential contamination of the water supply. Also, runoff from residential areas that dispose of their rubbish on the premises can contribute to potential contamination from runoff.
  - → Groundwater flow within the zones plays an important role in their determination. From data collected in the field, groundwater flows generally toward the southwest or from Rangorango area to the water pumps. The 2 km radius from borehole EF135a, the well closest to the water source, is based on a 50 day travel time within the aquifer at 40 m/d determined from the Depledge report (1994).
- Lease Boundaries and Land Use

  It is easier to establish the boundaries in the field if we use existing survey points and follow existing property lines. This will also make it easier for the property owner to understand which zone they fall under rather than the boundary line crossing randomly through their property following topography, hydrology or geology.

Justification for Zone 3

- Topography

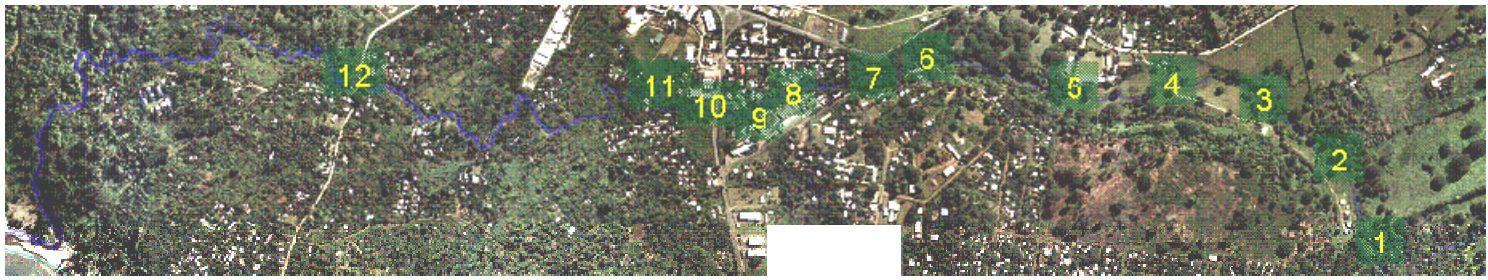
This zone encompasses the limits of the watershed. This is largely determined by topography following the peaks and ridges of the hills and mountains naturally determining the watershed. Where the natural land use activities focus on potential contamination from runoff. Any activities that have the potential to pollute the water source from runoff will be restricted. Groundwater contamination from sanitation is not as serious within this zone allowing for low-density development within the area.

- Lease Boundaries and Land Use

  It is easier to establish the boundaries in the field if we use existing survey points and follow existing property lines. This will also make it easier for the property owner to understand which zone they fall under rather than the boundary line crossing randomly through their property following topography, hydrology or geology.

Tagabé River Water Analysis 2006

Sampling sites



Date	Site	pH	Suspend Solids	Nitrates mg/l	NaNO2 mg/l	Nitrites mg/l	Ammonium mg/l	COD mg/l	Total Coliforms	Faecal Coliforms	Faecal Streptococci
13-Sep-06	1	7.32	0	6.5	0.085	0.057	0.00	0	45	19	27
	2	7.34	3	4.9	0.080	0.053	0.00	1	>100	>100	>100
	3	7.43	1	2.8	0.104	0.07	0.00	1	>100	>100	>100
	4	7.48	1	5.3	0.076	0.051	0.00	7	>150	>150	>150
	5	7.47	1	4.1	0.071	0.048	0.00	2	>150	>150	>150
	6	7.59	6	5.5	0.080	0.053	0.00	8	>150	>150	>150
	7	7.59	5	6.5	0.069	0.046	0.00	1	>200	>200	>200
	8	7.68	9	4.1	0.073	0.049	3.00	9	>200	>200	>200
	9	7.83	9	4.1	0.061	0.04	0.00	15	>200	>200	>200
	10	7.74	9	3.7	0.077	0.052	0.01	18	>200	>200	>200
	11	7.82	14	4.5	0.072	0.048	0.00	15	>200	>200	>200
	12	7.80	38	4.1	0.054	0.036	0.06	21	>200	>200	>200

Date	Site	pH	Suspend Solids	Nitrates mg/l	NaNO2 mg/l	Nitrites mg/l	Ammonium mg/l	COD mg/l	Total Coliforms	Faecal Coliforms	Faecal treptococci
11-Oct-06	1	7.40	2	0.8	0.097	0.065	0.17	0	15	12	13
	2	7.47	2	0.5	0.072	0.048	0.07	0	29	24	32
	3	7.48	3	0.4	0.065	0.044	0.06	1	95	98	86
	4	7.50	4	0.4	0.079	0.053	0.03	0	>100	>100	97
	5	7.55	4	0.6	0.067	0.044	0.01	3	>100	>100	>100
	6	7.56	9	0.8	0.093	0.062	0.05	1	>200	>200	>200
	7	7.63	5	0.8	0.080	0.053	0.01	2	>200	>200	>200
	8	7.65	11	0.8	0.080	0.053	0.01	15	>200	>200	>200
	9	7.69	28	1.0	0.066	0.044	0.01	22	>200	>200	>200
	10	7.72	20	0.8	0.055	0.037	0.02	21	>200	>200	>200
	11	7.68	15	1.5	0.205	0.137	0.51	23	>200	>200	>200
	12	7.81	33	1.3	0.115	0.077	0.12	19	>200	>200	>200

Date	Site	pH	Suspend Solids	Nitrates mg/l	NaNO2 mg/l	Nitrites mg/l	Ammonium mg/l	COD mg/l	Total Coliforms	Faecal Coliforms	Faecal Streptococci
7-Dec-06	1	7.48	4	0.7	0.094	0.062	0.09	0	13	9	15
	2	7.47	2	0.6	0.078	0.052	0.05	0	32	24	28
	3	7.48	5	0.2	0.071	0.041	0.04	1	>100	>100	>100
	4	7.52	4	0.6	0.072	0.048	0.03	1	>100	>100	>100
	5	7.55	7	0.8	0.061	0.049	0.02	3	>100	>100	>100
	6	7.54	10	1.0	0.084	0.062	0.10	4	>200	>200	>200
	7	7.60	22	0.9	0.082	0.062	0.09	6	>200	>200	>200
	8	7.66	16	0.8	0.710	0.052	0.04	24	>200	>200	>200
	9	7.72	28	1.0	0.071	0.056	0.01	27	>200	>200	>200
	10	7.78	29	1.0	0.084	0.068	0.04	29	>200	>200	>200
	11	7.61	24	1.9	0.214	0.156	0.74	34	>200	>200	>200
	12	7.90	36	1.6	0.128	0.098	0.24	25	>200	>200	>200

Date	Site	pH	Suspend Solids	Nitrates mg/l	NaNO2 mg/l	Nitrites mg/l	Ammonium mg/l	COD mg/l	Total Coliforms	Faecal Coliforms	Faecal Streptococci
1-Feb-07	1	7.52	3	0.5	0.091	0.048	0.10	19	24	16	28
	2	7.49	5	0.7	0.078	0.059	0.08	19	32	45	56
	3	7.48	6	0.4	0.054	0.067	0.07	22	87	76	78
	4	7.47	5	0.6	0.072	0.061	0.05	18	>100	>100	>100
	5	7.51	8	0.8	0.081	0.058	0.04	28	>100	>100	>100
	6	7.51	14	0.8	0.084	0.059	0.01	21	>200	>200	>200
	7	7.60	18	1.0	0.082	0.051	0.08	36	>200	>200	>200
	8	7.59	24	0.8	0.078	0.052	0.01	28	>200	>200	>200
	9	7.61	28	0.8	0.075	0.048	0.01	23	>200	>200	>200
	10	7.78	35	1.0	0.084	0.061	0.02	20	>200	>200	>200
	11	7.89	39	4.5	0.812	0.024	1.26	162	>200	>200	>200
	12	7.87	34	3.1	0.815	0.032	0.78	16	>200	>200	>200

Appendix 5

Sectoral Adaptation Measures to Climate Change

Sectoral Adaptation Measures to Climate Change

Adaptation Opportunities for Vulnerable Islands and Villages in Vanuatu[1]

1. Agriculture

- Diversification of cash crops, if aimed at reducing dependence on a few monocultural crops, will help reduce adverse effects on the environment and increase the resilience of such systems to climatic extremes. Enhancing of traditional agriculture systems by diversifying subsistence crops, promoting agroforestry, encouraging sustainable practices, and developing economic opportunities, would contribute to environmental protection and resilience.
- Encouragement of sustainable land-use practices would provide long-term benefits to the economy and environment of Vanuatu.
- Introduction of drought resistant crops is a specific adaptation measure, which could be introduced to drought affected areas. However, this is a higher cost, more reactive, adaptation option.
- Increased shift to imported food would be a less desirable adaptation measure, because it is not cost-effective and would increase dependency of Vanuatu on external support, particularly in times of stress.

2. Human Health

- Awareness program would help reduce public health risk of diseases such as malaria. This is an on-going, low cost, adaptation measure, which benefits both humans and the environment.
- Mosquito nets as protection against malaria have proven to be effective and their continued use should be encouraged and supported.
- In most areas a mosquito eradication program is not a practical option and may have high environmental and public health costs.
- Reduction of artificial breeding sites would be an effective measure to reduce the risk of malaria in some areas with the added benefit of improving the environment.
- Improvement of medical facilities and services provides health benefits to local communities but is presently, and is likely to continue to be, dependent on foreign aid.

3. Water Resources

- Increased rainwater storage capacity through the use of water tanks and small-scale dams is expensive, but will benefit the community in times of water shortage especially extreme events such as cyclones and droughts.
- A wide range of methods could be implemented to maintain and enhance quality of surface and ground water resources.
- Measures to enhance and protect sensitive watersheds would both maintain water quality and moderate the impact of extremes in rainfall. There would also be wider environmental benefits, such as reduced erosion and soil loss and maintenance of biodiversity and land productivity.

[1] From "Vanuatu National Statement on Vulnerability and Adaptation", prepared by Nelson Rarua, Patricia Mawa, Russell Nari and Atchinson Marav Smith. Undated

- Improved water supply in urban areas, being relatively low cost, would help reduce health problems from poor water quality.

4. Coastal Environment

- Conservation of mangrove systems would help increase the ability of these systems to cope with the stresses of climate change and sea level. It will also maintain the natural storm and erosion protection that they offer and their productivity as a resource.
- Conservation of coral reef systems would also help increase the ability to cope with the stresses of climate change and sea-level rise. This may involve a range of both direct and indirect measures that could be implemented from watersheds to the coast.
- Sustainable use of marine resources would ensure maintenance of ecological integrity and thus be of benefit to the marine environment as a whole in protecting against adverse effects from climate and sea-level change.
- Replanting of littoral forests would help protect sensitive coastal environments.
- Building of sea walls is a high cost option, which would only be of value for very specific areas and would be impractical on large scale.

Appendix 6

National Water Resources Advisory Committee Meeting

National Water Resource Advisory Committee Minutes

Mini Workshop of the National Water Resource Advisory Committee
7 March 2007 at DGMWR
8.30am to 12.00pm

Purpose

1. Update Members on the Integrated Water Resource Management Project
2. Identify and discuss issues and concerns within the IWRM themes
3. Begin discussions on what IWRM might look like for Vanuatu i.e. measures that could address the issues and concerns
4. Begin discussions on Hotspot analysis

Present

A full list of those attending the workshop is attached including a list of permanent members. Additional government representatives were invited who it was felt would be important members of an Integrated Water Resource Management Strategy such as Environment Unit and Fisheries but they were unable to attend.

Format

1. IWRM Goal and Objectives
2. Program
3. Theme Groups
   - What Awareness and advocacy is currently in place for these themes
   - What are your deepest issues and concerns for these theme areas
   - What would IWRM look like in Vanuatu – how would it address these issues and concerns
4. Feedback
5. Brain storming Hot spots

The IWRM program was introduced to the National Water Resource Advisory Committee at its last meeting in 2006. Since then the program has made no further progress in Vanuatu. Maximum use needed to be made of the short time available for group discussion, learning from and inspiring each other, and data gathering. It was decided that the best use of this workshop was to generate discussion and thinking on key issues and concerns and measures that could address them in an integrated water resource management program[2].

1. Objectives

The Director DGMWR introduced the objectives of the PDF (Project Development Fund) B Process as:

To collect necessary information to support a full project submission to the GEF Secretariat and Council. In particular:

[2] A World Café format was successfully applied: Juanita Brown and David Isaacs, 2005. World Café: Shaping Our Futures Through Conversations that Matter. BK San Francisco.

- Completion of National IWRM and WUE Diagnostic Reports
- Identification of National Priority Hotspots
- Section of National/Local IWRM WUE Demonstrations
- Adopting appropriate indicators for monitoring and evaluation
- Provision of necessary national information upon which to build the project Incremental Cost Assessment (justification of GEF funding).

2. Program

Further explanations were provided by the facilitator on the need for and concept of an IWRM program; the requirements for the Diagnostic Report which is being addressed now and the timetable to do that.

The group then broke into three groups. Each group had three theme topics and three key questions to discuss. Twenty minutes was given before the groups rotated so that everyone had a chance to contribute to each theme issue[3]. The themes were organised slightly differently to the six themes of the diagnostic report since the facilitator recognised that awareness is undertaken for many of the themes and is therefore a cross cutting issue. Due to the short time available and the small numbers at the workshop, institutional arrangements and financing would be addressed during personal interviews.

The themes were:

- Water resource management
- Island vulnerability
- Technology
- Health and hygiene
- Landuse and agriculture
- Habitats and ecosystems

The three questions were:

- What awareness and advocacy programs are in place for these themes?
- What are your deepest issues and concerns in these areas?
- What would an integrated Water Resource Management system look like in Vanuatu – i.e. how would it address these concerns?

3. & 4. Theme Group Results

Water Resource Management

a. Awareness and advocacy

- By NGOS – Wan Smol Bag (various), Live & Learn (various)
- Tagabe Water Catchment Management Committee
- UNELCO sends annual report to Government and information to DGMWR

[3] The logic for this is provided in World Café 2005. It is recognized that systems are extraordinarily complex and we are better able to find more intelligent answers to compelling issues by connecting more of the system to itself in dialogue.

- Rural Water Supply – village water committee training
- Campaigns and exhibitions – e.g. Communities in Catchment Management (2001-2004); Water Safety Plan Epule (Efate), Talise (Maewo), Fanafo (Santo); Hydrology Environment and Life Policy (HELP UNESCO)

b. Issues and concerns

- Concern by UNELCO for water availability – never been short but groundwater levels have been low; and water quality is threatened (settlements in catchment zone).
- Comprehension and enforcement of Water Resource Management Act 2002 poor
- Poor Groundwater Monitoring nationally
- ENSO effects
- Disrespect for water resources
- Islands with only one water supply i.e. islands with no ground or surface water rely on rainwater e.g. Mataso and Buninga (Shepherds Group), all of Torres group, small islands off Malekula and Santo.

c. IWRM measures

- Integrate rainfall forecasting with decision making sectors
- Provide water resource conservation and protection
- Excellent communication – up-down-sideways
- Water meters for all
- Water safety plan expanded to whole country

Island Vulnerability

a. Awareness and Advocacy

- Radio programs/TV
- Cyclone tracking map
- Exhibitions and campaigns
- MET service seasonal outlooks
- Climate change monitoring project
- Water Safety Plan

b. Issues and concerns

- No effective awareness program in place
- Telecommunication and media challenges to outer islands

c. IWRM measures

- Need to be proactive rather than reactive
- Disseminate water resource information to communities
- Integrate traditional practices

- Develop water resource databases – Tideda (quantity – NIWA); Water Quality database (SOPAC – Port Vila, Luganville, bores and wells)
- Develop vulnerability hazard map
- All stakeholders work together

Technology

a. Awareness and advocacy

- Rural Water Supply construction standards manual
- Campaigns and awareness programs (World Water Day, World Health Organisation)
- Rural Water Supply - Community Development Training / plumbers training / water committee training
- NGO materials and radio programs
- Compost toilet promotion and Tagabe Water Committee
- Committee Training Manual translated to Bislama

b. Issues and concerns

- No proper sanitation system for CBD
- No government agency responsible for sanitation
- Funding more proportionally distributed to rural population
- Encourage/educate communities to build appropriate toilets for location
- Encourage and enforce treated sewerage system for hotels and developments
- No effective enforcement of Water Resource Management Act and Public Health Act

c. IWRM Measures

- Develop system for administering and enforcing legislation
- All stakeholders work together
- All stakeholders to develop community based programs

Health and Hygiene

a. Awareness and advocacy

- Environmental health community awareness training –Save the Children Village Health worker training;
- Wan Smol Bag - drama and radio plays - (Family Blong Sera)
- UNELCO schools awareness, water analysis,
- World Water Day
- Live & Learn programs
- FSP programs

b. Issues and concerns

- Significant delays occur between when the problem happens, it is detected, a solution is found and then something is done about it.
- Very little awareness training goes to remote areas
- Most awareness training is donor funded and short term

c. IWRM measures

- Need to share experiences, data,
- Communication – up-down-sideways
- Secure a safe water supply
- Integrate water related institutions
- Expand water safety plan to all islands

Landuse and Agriculture

a. Awareness and advocacy

- Annual (one-week) awareness programs and tours e.g. World Water Day, World Health Day
- Wan Smol Bag awareness on waste and water
- Some communities are forming water committees and water catchment committees e.g. Tagabe
- Some information in school curriculum (agriculture)

b. Issues and concerns

- VANRIS (Vanuatu Natural Resource Information System) still in use but data is poor, no information has been added for some years, and difficult to access. Does not include any water data.
- Poor team work
- Need bigger budget for community awareness and need to continue not stop when funding stops.
- Many projects not sustainable because they stop as soon as funding stops. Three or four year “projects” are not sustainable.

c. IWRM measures

- VANRIS needs upgrading and expanding and made accessible – integrate all information – agriculture, forestry, water, met service
- Make provision in legislation for departments to work together and roles to be clearly defined
- Make budget available for existing tasks e.g. water committee
- Community involvement is a must
- Government needs to be more involved in materials development and awareness
- All stakeholders working together
- Key community people trained

- Make awareness more systematic and ensure it reaches everybody.

Habitats

a. Awareness and advocacy

- Annual environment week
- EIA for development projects
- Curriculum for teachers on biodiversity and conservation (Live & Learn)
- Wan Smol Bag turtle monitoring and clean ups
- Land conservation initiative – environment unit/forestry

b. Issues and concerns

- Lack of information sharing
- Lack of research/studies and knowledge of habitats, threatened/endangered species.
- Lack of community knowledge and involvement
- Little information in school curriculum
- Land conservation initiative is donor funded and in its present form not sustainable

c. IWRM measures

- All stakeholders need to work together and responsibilities need to be defined better
- Need a central data base system with accessible scientific data on habitats and ecosystems (VANRIS)
- The concept of “projects” needs to be converted to long term government or community programs

Common Threads

Concerns

- Information/data collection is sporadic, disjointed and not well distributed.
- Lack of communication throughout Vanuatu (lack of understanding need to communicate, and about what, physical difficulty of communication without services)
- Funding not allocated according to population base i.e. more funding allocated to urban areas.
- Government responsibilities have been undertaken as projects (often funded by donors) rather than as government long term programs of core business. Donor-funded projects are often not sustainable because of the short funding timeframe.
- Lack of supportive legislation and lack of enforcement of existing legislation.

IWRM measures

- Need to work together in coordinated manner
- Need the legislative and institutional framework under which to do this
- Needs to be proactive
- Collate and share information – update VANRIS, share between departments

- Distribute resources equitably
- Ensure outside “projects” support Vanuatu Government core responsibilities and direction

6. Hot Spot Brain Storm

- Storm water Port Vila
- Sanitation Port Vila
- Communication across sectors
- Research, data gathering and collation
- Management and monitoring of water catchments (e.g. continuing development and settlements in Rain Water Catchment Zones)
- Sustainable assistance to departments and country (supporting country core programs rather than by donor project basis)
- Mele Bay/Blacksands – sewerage pollution and rubbish
- Sea level rise e.g. Tegua
- Deforestation in Tagabe Catchment
- Increase in water borne diseases

It was recognised that this was a very “quick look” at the hotspots and a fuller picture needed be developed. Further research identified work undertaken by the Meteorological Service for the Regional Pacific Island Climate Change Assistance Program (PICCAP) which identified vulnerable islands; the Capacity Building Development Measures for Pacific Island Countries (CBDMPIC) which identified water as the main issue of concern; the National Adaptation Plan of Action (NAPA); and specific proposals for Aniwa and Ra Island desalination plants (AusAID Small Grants Scheme). Information collected under each of these separate programs needs to be brought together to undertake a comprehensive hotspot analysis.

People Attending National Water Advisory Committee & Mini Workshop on IWRM

Name	Position	Organisation	Telephone	Email
Robson Tigona	PSO	Met Service	23866	rstigona@meteo.gov.vu
Frederic Petit	Water Manager	UNELCO	22211 / 53013	frederic.petit@unelco.com.vu
Anne-Marie Sarisets	Forest Officer Shefa	Forestry Department	23171/23856	Annemarie.Sariets2@yahoo.com.vu
Theophile Gaston	Water Lab Technician	UNELCO	22211/41747	gaston.theopile@unelco.com.vu
Morris Stephen	Water Technician	DGMWR	22423	Malawmorris@yahoo.co.uk
Ericson Sammy	Water Resource Manager	DGMWR	22423	amapelao@yahoo.com
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Amy Lynch	Planner/Adviser	Shefa Province	22752/44486	amyjo.lynch@gmail.com
Chris Ioan	Director	DGMWR	22423	christopher.loan@student.uts.edu.au
Ruth Marsh	Facilitator	Our Common Future	+64 9 407 1399	ruthmarsh@clear.net.nz

Permanent Members

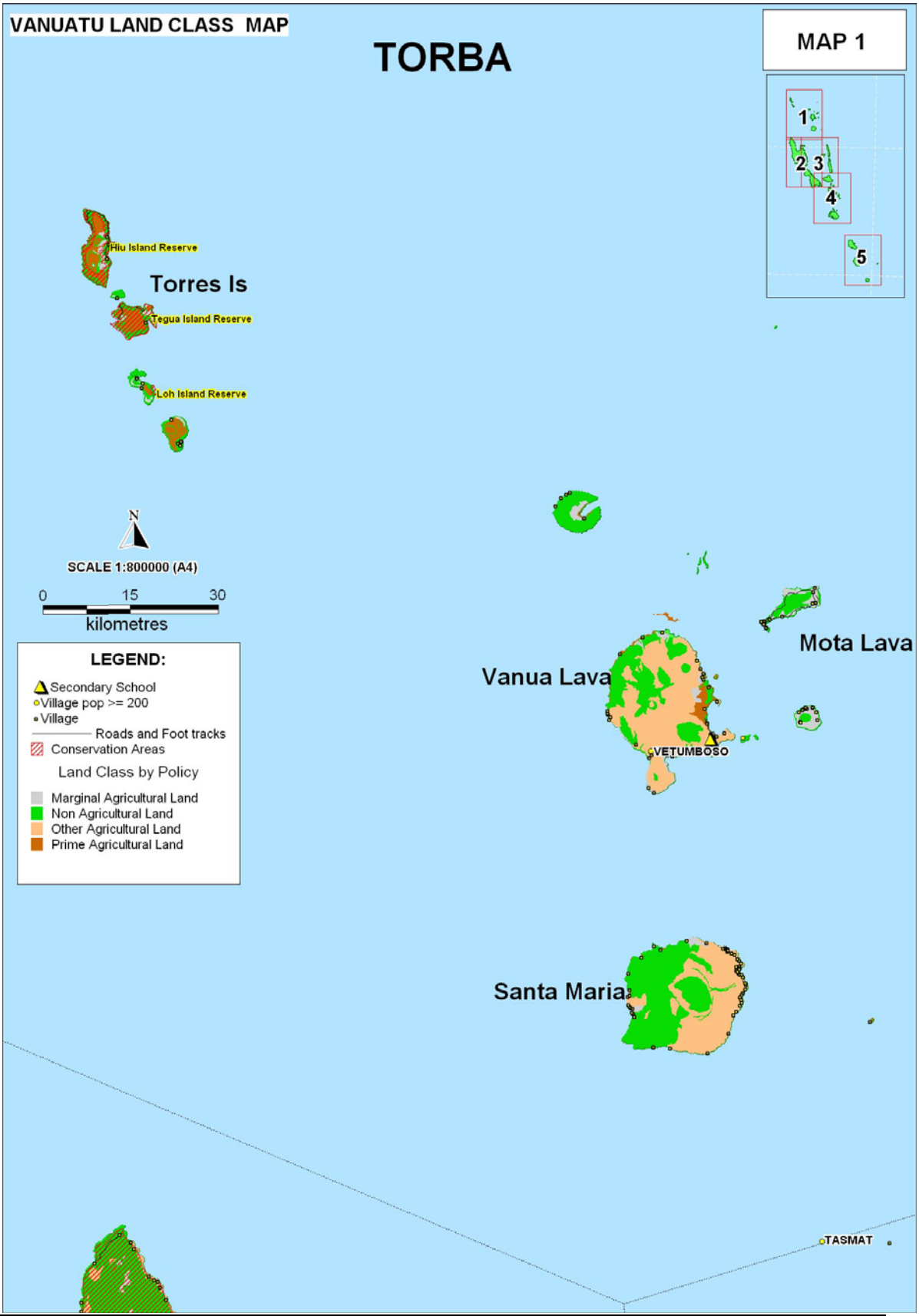
National Water Resource Advisory Committee

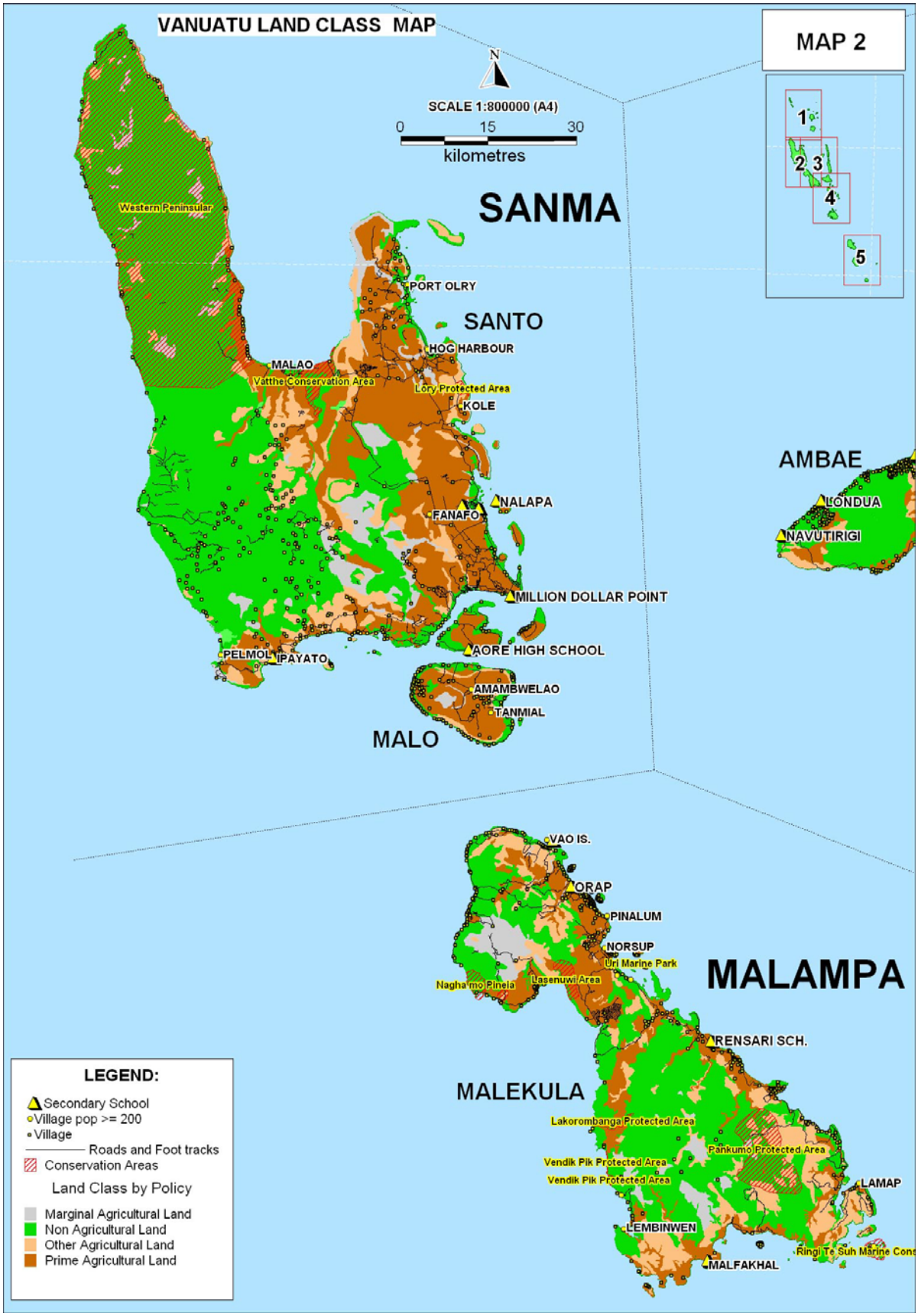
Mr. Christopher Ioan (Chairman)	Director (DGMWR)
Mr. Erickson Sammy (Vice-Chairman)	Water Resources Manager (DGMWR)
Mrs. Nelly Waloseje (Secretary)	Public Health
Ms. Rosette Kalmet (Vice-Secretary)	Hydro-geologist (DGMWR)
Mr Kalparam Gershom	Rural Water Supply
Mr. Frederick Petit	UNELCO
Mr. Kaston Theophile	UNELCO
Ms. Amy Lynch	SHEFA Province
Mr. Robson Silas	Meteorology Department
Mrs. Annemarie Sariset	Forestry Department
Mr. Amos Kalo	Live & Learn
Andre Latipu	Public Works Department

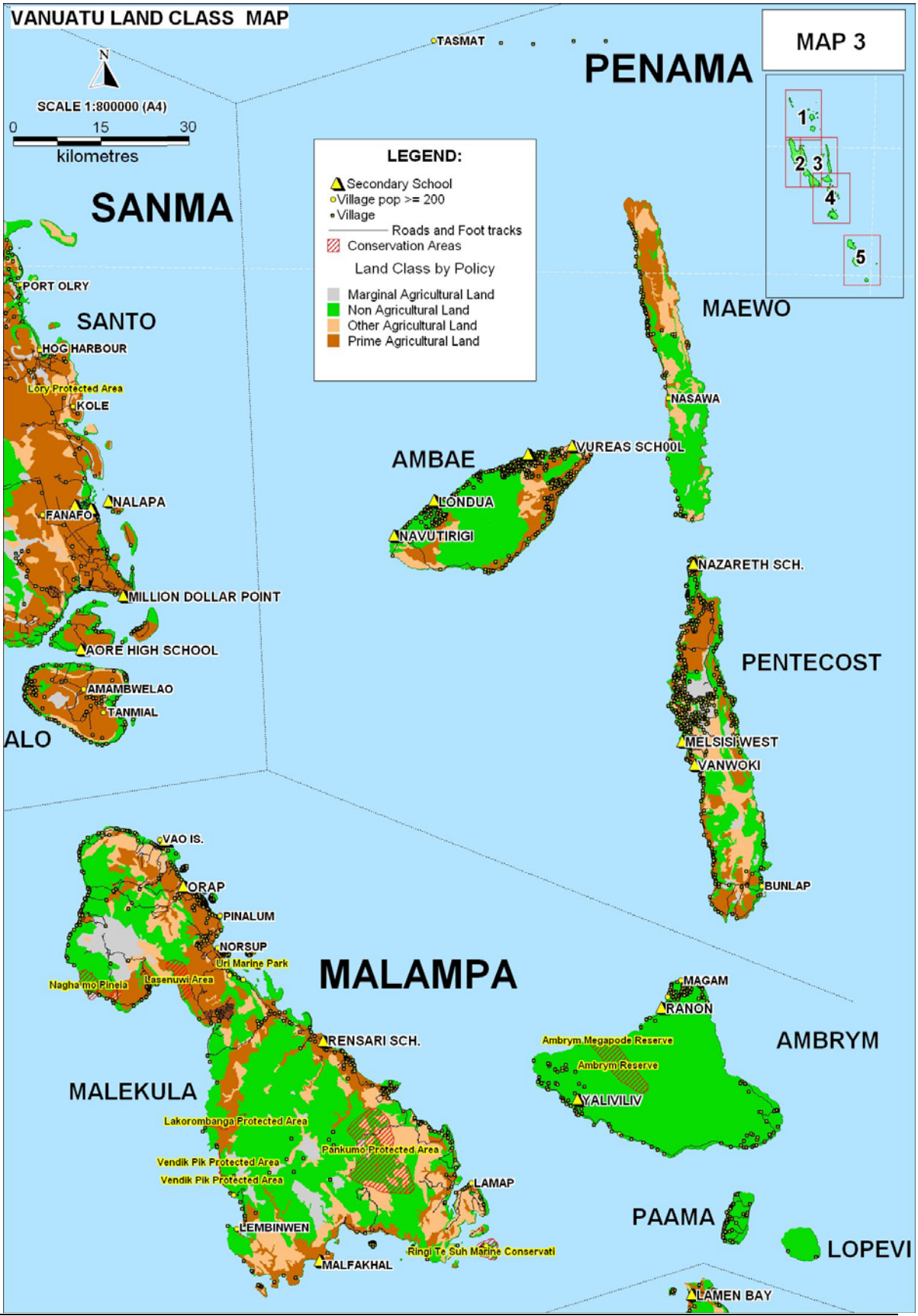
- Not complete -

Appendix 7

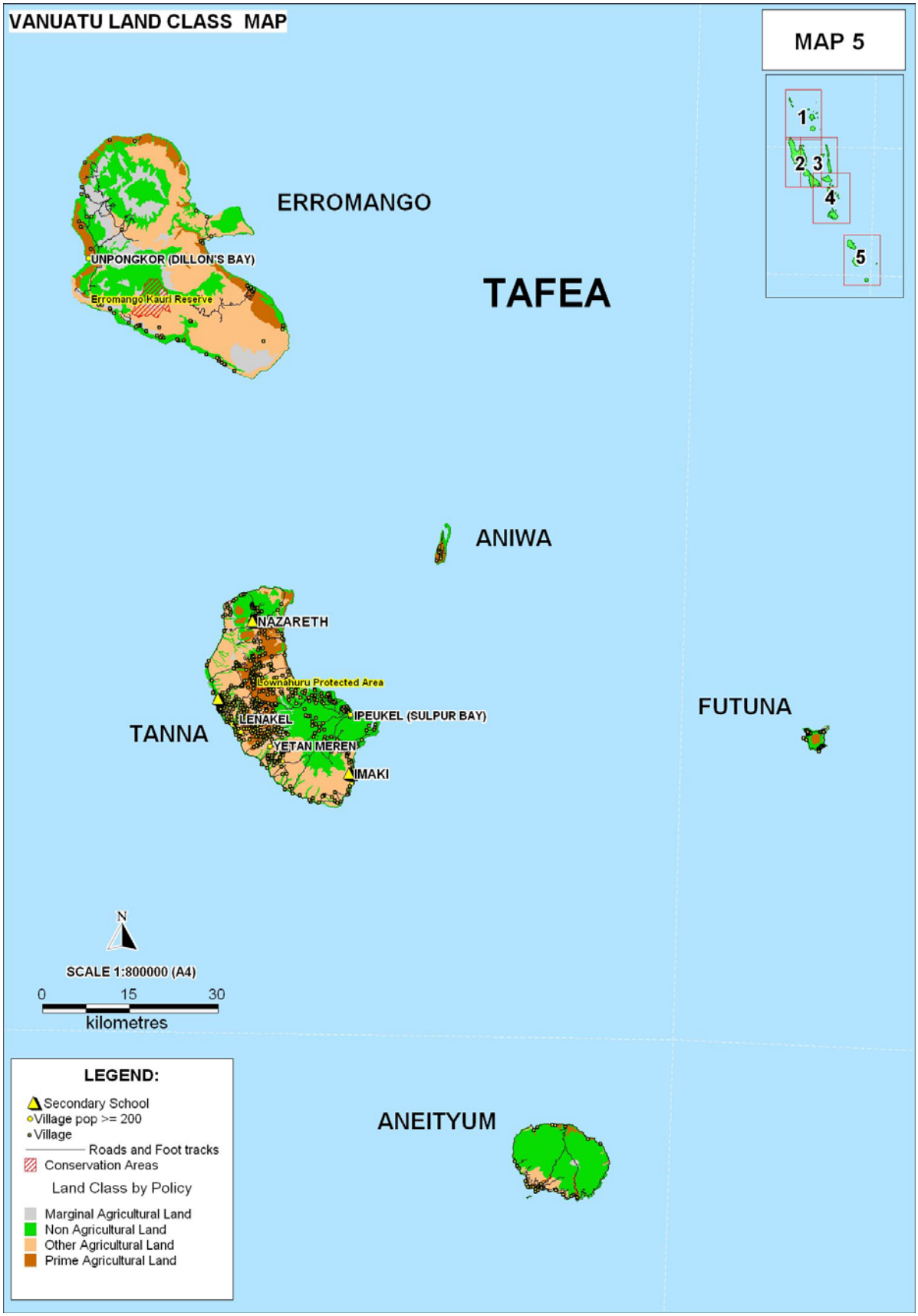
Land Class Maps Vanuatu


VANUATU LAND CLASS MAP
TORBA
MAP 1
1
2
3
4
5
Hiu Island Reserve
Torres Is
Tegua Island Reserve
Loh Island Reserve
N
SCALE 1:800000 (A4)
0
15
30
kilometres
LEGEND:
Secondary School
Village pop >= 200
Village
Roads and Foot tracks
Conservation Areas
Land Class by Policy
Marginal Agricultural Land
Non Agricultural Land
Other Agricultural Land
Prime Agricultural Land
Vanua Lava
Mota Lava
VETUMBOSO
Santa Maria
TASMAT


VANUATU LAND CLASS MAP
MAP 2
N
SCALE 1:800000 (A4)
0 15 30
kilometres
1
2 3
4
5
SANMA
Western Peninsular
PORT OLRY
SANTO
HOG HARBOUR
MALAO
Vatthe Conservation Area
Lory Protected Area
KOLE
AMBAE
NALAPA
FANAFO
LONDUA
NAVUTIRIGI
MILLION DOLLAR POINT
AORE HIGH SCHOOL
PELMOL
IPAYATO
AMAMBWELAO
TANMIAL
MALO
VAO IS.
ORAP
PINALUM
NORSUP
Uri Marine Park
Nagha mo Pinela
Lasenuwi Area
MALAMPA
RENSARI SCH.
MALEKULA
Lakorombanga Protected Area
Pankumo Protected Area
Vendik Pik Protected Area
Vendik Pik Protected Area
LAMAP
LEMBINWEN
Ringi Te Suh Marine Cons
MALFAKHAL
LEGEND:
Secondary School
Village pop >= 200
Village
Roads and Foot tracks
Conservation Areas
Land Class by Policy
Marginal Agricultural Land
Non Agricultural Land
Other Agricultural Land
Prime Agricultural Land


VANUATU LAND CLASS MAP
MAP 3
SCALE 1:800000 (A4)
0 15 30
kilometres
LEGEND:
Secondary School
Village pop >= 200
Village
Roads and Foot tracks
Conservation Areas
Land Class by Policy
Marginal Agricultural Land
Non Agricultural Land
Other Agricultural Land
Prime Agricultural Land
TASMAT
PENAMA
SANMA
PORT OLRY
SANTO
HOG HARBOUR
Lory Protected Area
KOLE
NALAPA
FANAFO
MILLION DOLLAR POINT
AORE HIGH SCHOOL
AMAMBWELAO
TANMIAL
ALO
MAEWO
NASAWA
AMBAE
VUREAS SCHOOL
LONDUA
NAVUTIRIGI
NAZARETH SCH.
PENTECOST
MELSISI WEST
VANWOKI
BUNLAP
VAO IS.
ORAP
PINALUM
NORSUP
Uri Marine Park
Nagha mo Pinela
Lasenuwi Area
MALAMPA
RENSARI SCH.
MALEKULA
Lakorombanga Protected Area
Vendik Pik Protected Area
Vendik Pik Protected Area
Pankumo Protected Area
LAMAP
LEMBINWEN
MALFAKHAL
Ringi Te Suh Marine Conservati
MAGAM
RANON
Ambrym Megapode Reserve
Ambrym Reserve
YALIVILIV
AMBRYM
PAAMA
LOPEVI
LAMEN BAY


VANUATU LAND CLASS MAP
MALAMPA
MAP 4
MAGAM
RANON
AMBRYM
Ambrym Megapode Reserve
Ambrym Reserve
YALIVILIV
RENSARI SCH.
Pankumo Protected Area
LAMAP
Ringi Te Suh Marine Conservati
MALFAKHAL
PAAMA
LOPEVI
LAMEN BAY
MAGANUA (NGALA)
EPI
SHEPARD IS.
MATANGI
MANGARISU
SHEFA
EMAE
EFATE
ONESUA SCHOOL & SOAP FACTORY
NATAPAO
EPAO
Central Efate (Teouma)
MONTMARTRE
ETON
PANGO
ERATAP
N
SCALE 1:800000 (A4)
0 15 30
kilometres
LEGEND:
Secondary School
Village pop >= 200
Village
Roads and Foot tracks
Conservation Areas
Land Class by Policy
Marginal Agricultural Land
Non Agricultural Land
Other Agricultural Land
Prime Agricultural Land


VANUATU LAND CLASS MAP
MAP 5
1
2 3
4
5
ERROMANGO
UNPONGKOR (DILLON'S BAY)
Erromango Kauri Reserve
TAFEA
ANIWA
NAZARETH
Lownahuru Protected Area
LENAKEL
IPEUKEL (SULPUR BAY)
YETAN MEREN
IMAKI
TANNA
FUTUNA
ANEITYUM
N
SCALE 1:800000 (A4)
0 15 30
kilometres
LEGEND:
Secondary School
Village pop >= 200
Village
Roads and Foot tracks
Conservation Areas
Land Class by Policy
Marginal Agricultural Land
Non Agricultural Land
Other Agricultural Land
Prime Agricultural Land