添付資料

８．バヌアツ国政府作成環境社会配慮報告書（2005 年 11 月）

“Report of the Monitoring / Mitigation on Social and Environmental Consideration on the Sarakata Hydropower Project”

GOVERNMENT OF THE
REPUBLIC OF VANUATU

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Our Ref: 264/05 – 304/10/lm
Notre Ref:

Date: 21st November, 2005

Mr. Yoshinori EBATA
Resident Representative
JICA Office
Private Mail Bag 9005
PORT VILA

SUBJECT: **Final Report of the Monitoring/Mitigation, Social And Environmental Considerations of the Sarakata Hydro Power Project**

Dear Sir,

Please find attached herewith two copies of the above mentioned report.

This is the final report produced by Government on most of the issues identified by the JICA Preparation Team that came in July-August of 2004. Two remaining issues that the Government is pursuing to complete are:

1. The formalisation of the land belonging to PRV and paying them their compensation of 2,422,500 Vatu.
2. The remedy works to the major landslides/land cracks.

The Government has committed itself on undertaking all the issues identified by the JICA Preparation Team.

Yours faithfully.

Leo MOLI
Principal Energy Officer

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REPORT of

THE MONITORING/MITIGATION ON SOCIAL AND ENVIRONMENTAL CONSIDERATION

ON

THE SARAKATA HYDROPOWER PROJECT

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Date: 15th November, 2005

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EXECUTIVE SUMMARY

The Sarakata Hydro Power Project is one of Vanuatu's major achievements in line to the Governments policy for a self supporting economy through the upgrading and expansion of the energy sector. Located in Fanafo area in Santo it provides 55.77% of electricity within Unelco's Concession area in Luganville.

Realizing the Government's lack of necessary human resources and financial constraints to provide for such scale hydro development, the Government of Vanuatu sought assistance from the Government of Japan. The first and second stages of the project were completed and commenced commercial operation in 1995.

Again further assistance was needed for Stage 3 development so the Government of Vanuatu requested the Government of Japan for assistance. In response the Government of Japan dispatched a preparatory study team to conduct studies on the site and hold discussions with relevant bodies concerning the project. Final discussions with officials from Government of Vanuatu resulted in the Signing of the Minutes of Discussion.

The signed Minutes of Discussion between officials from the Government of Japan and the Government of Vanuatu outlined that the Government of Vanuatu will be responsible for the Monitoring, Mitigation, Social and Environmental consideration of the project site for a period of six months. Hence the Technical Advisory Group (TAG) Committee proceeded with the following activities; Vegetation Survey, Investigation of Soil Erosion, Investigation of Land Cracks and Land Slides, Acquisition of Hydro Land, Hydrological Monitoring and Aquatic Life Assessment.

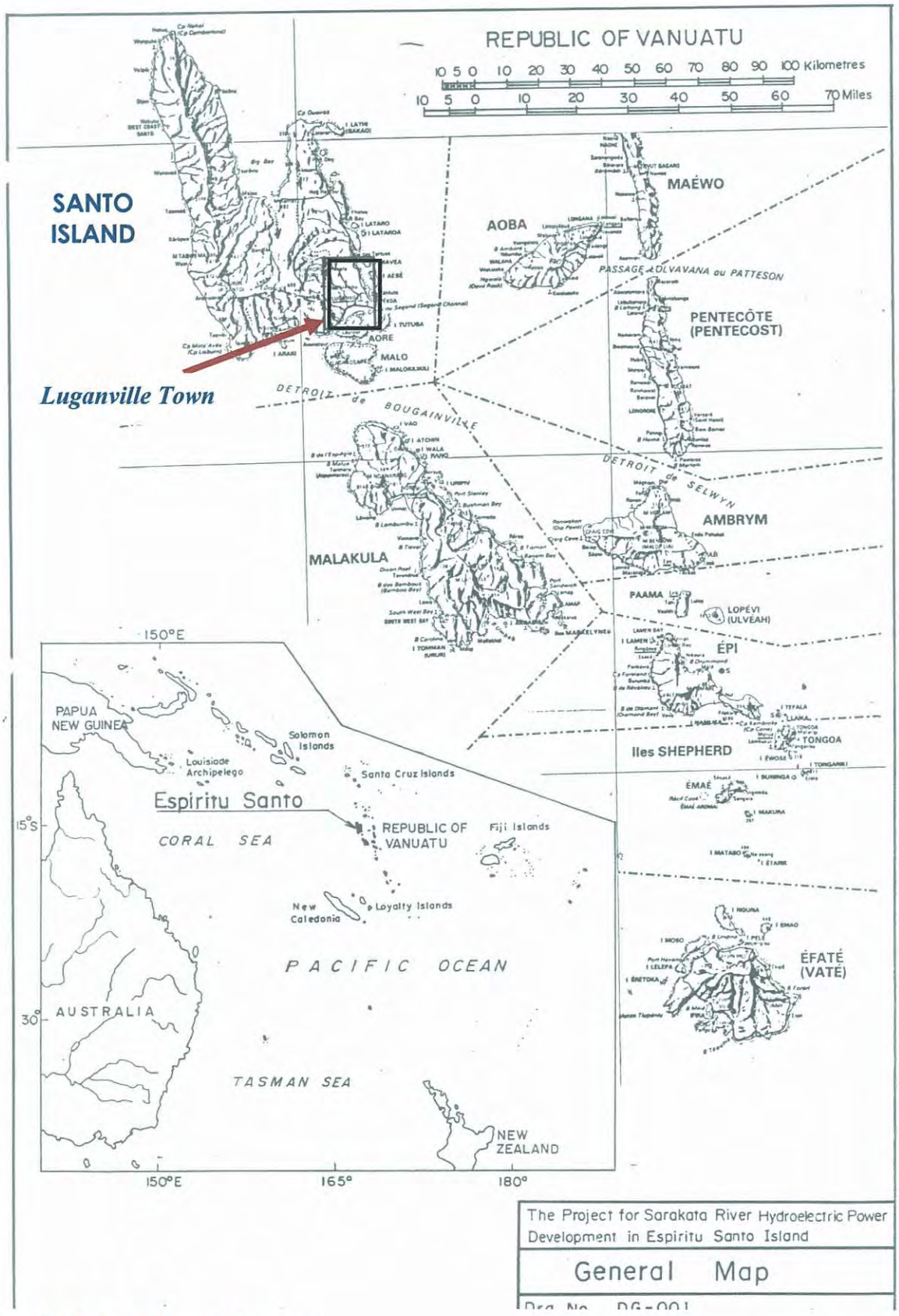

FIG.1 – **Map of Vanuatu**

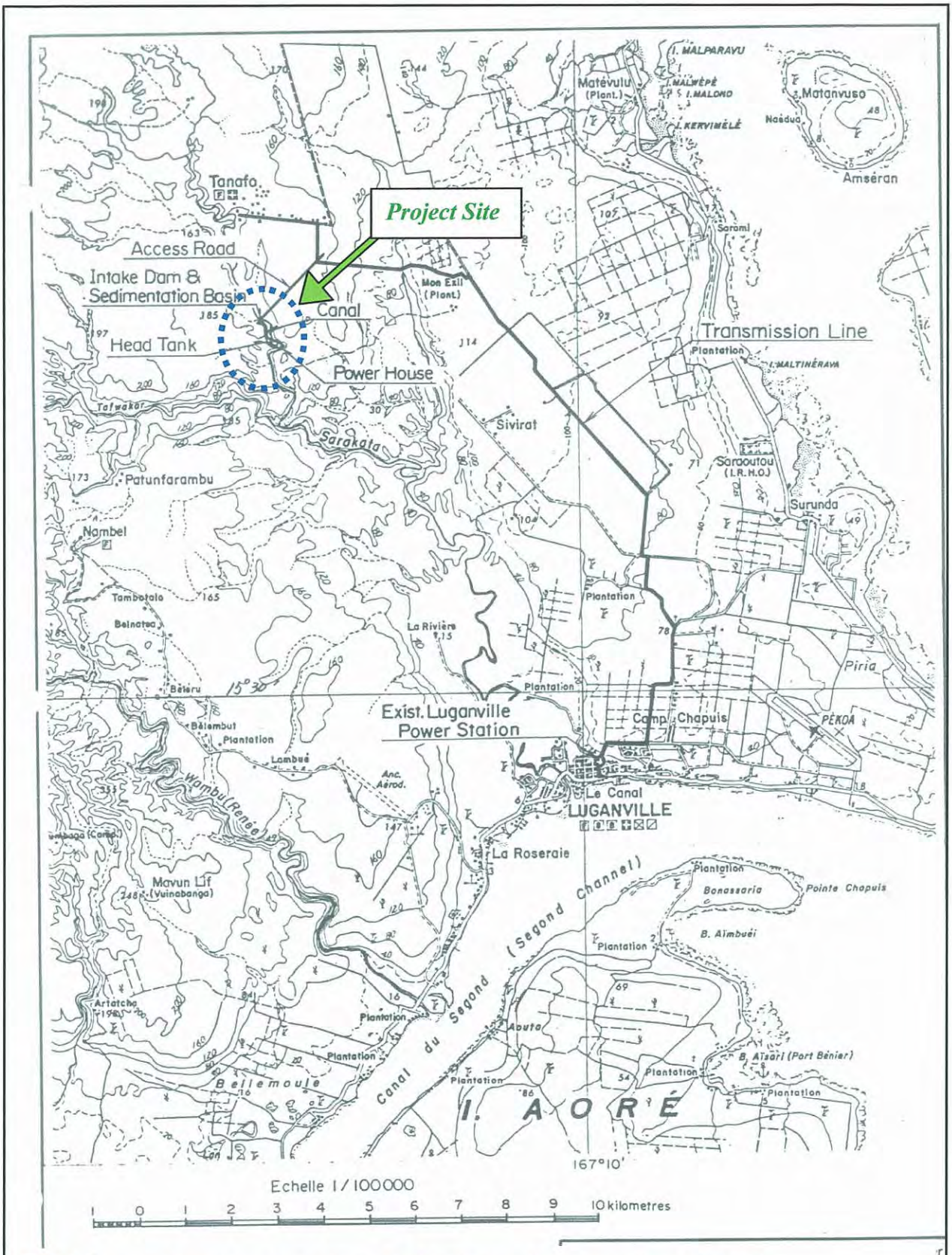

FIG.2 **Location of Sarakata Hydro Power Project on Santo Island**

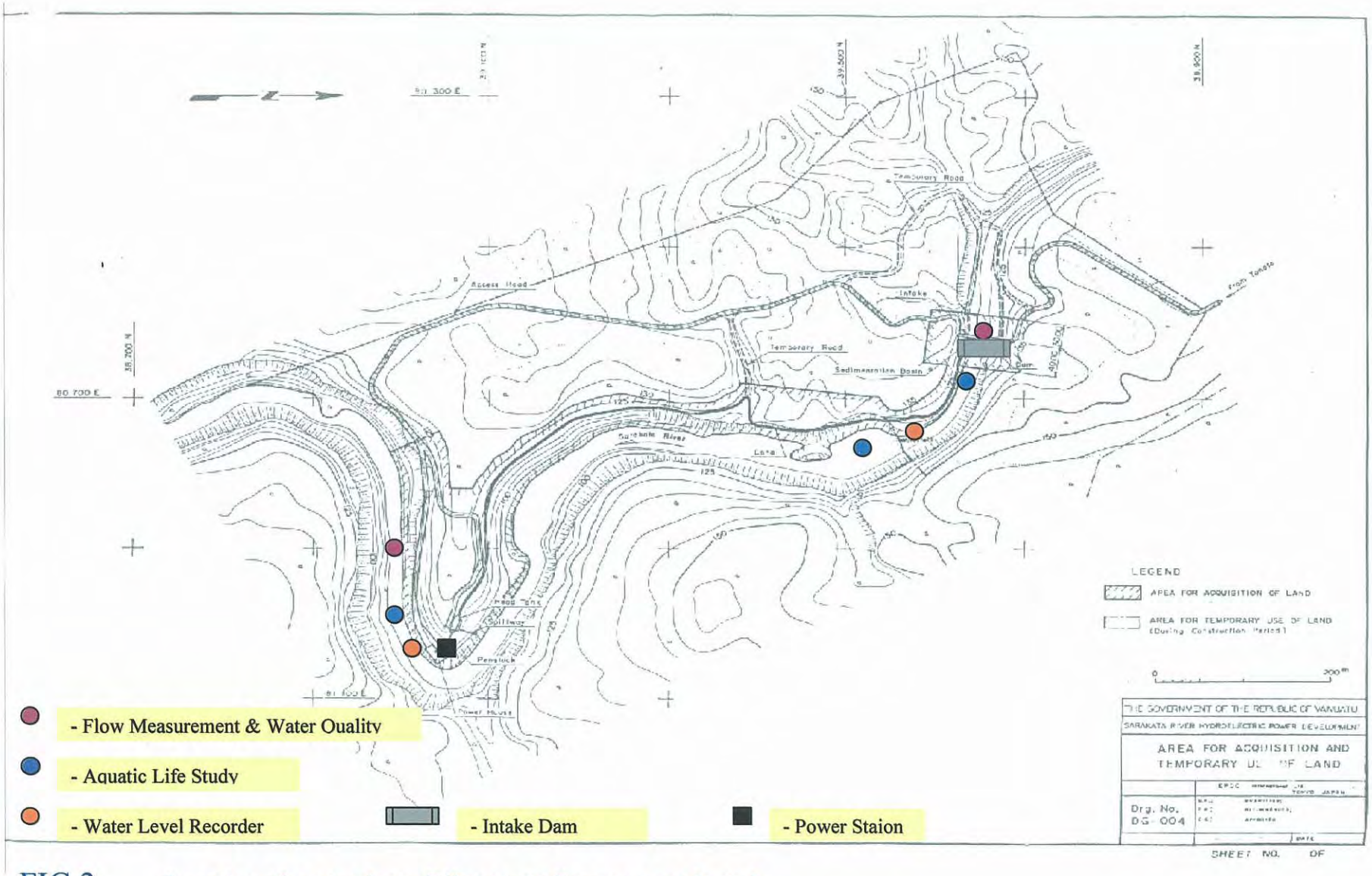

FIG.3 **Location of spots where different studies were conducted**

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1.0 INTRODUCTION

The country of Vanuatu is blessed with many rivers and streams which are often common sources of water for daily use. Many of these water sources descend from heights inland meandering their way and disposing off to the coast. Apart from just source of water, they possess the potential to generate energy for power development using the hydropower technology widely used throughout the world today. Hydropower development in Vanuatu has been progressing at a rather slow pace given the fact that the country lacks the human resources fully dedicated to it and the unfavorable fiscal scenario the country experiences. In the light of increasing prices of imported fuel and the international concern over environmental impacts associated with the emission of impurities from fuel combustion into the atmosphere, harnessing renewable energy sources have been stressed as the preeminent alternative in addressing these issues.

Apart from all international issues supporting the widespread use of hydro power, Vanuatu has become conscious that an improved economy can be achieved through the use of hydro power and other renewable energy sources.

Based on the policy of achieving a self-supporting economy, upgrading and expansion of the energy sector is one of the important items in the Vanuatu Government plan. To achieve this aim and progress into the development perspective of the nation, the government focused on developing the hydro-electric potential of rivers and one of these is the Sarakata River. Numerous hydro potential reconnaissance and feasibility studies have been conducted in several rivers throughout Vanuatu and Sarakata River in Santo was one of them.

1.1 Sarakata River

The Sarakata River commences its descend from the heights north of Luganville and meanders towards the southerly direction to the town of Luganville. Prior investigations for its development had indicated that the river's catchment covers an area of 97km^2. This catchment receives high rainfall, reading at 5,500 mm per annum. Highest rainfalls are recorded during the periods from November to April while May to October is the dry season. While the upper portion of the catchment records a high 5,500mm of rainfall the lower

part (Luganville town) receives 2,480mm of rainfall per annum. The mean rainfall recording ranges between 4,200 mm and 4,500 mm annually.

Within the hydro occupied area is an attractive waterfall, however, not many people visit this spot even before the construction of the hydropower in 1994. After the hydro power commenced operation the occupied land was restricted from the public.

1.2 Technical Corporation with the Government of Japan for the 1st and 2nd Stage of the Sarakata Hydro Project

Despite the primary indication that conditions were favorable, a lone effort by the Government of Vanuatu to develop Sarakata was impeded by the fact the country had insufficient number of indigenous engineers together with the unfavorable international trade and fiscal constraints. It was for these reasons that the Government of Vanuatu sought a grant aid Cooperation with the Government of Japan.

To confirm the justification of the request, the government of Japan through JICA conducted a preliminary study from 9th – 23rd December 1990. Based on the results of this study, JICA dispatched again a team which conducted a Basic Design Study from 22nd April to 23rd May 1991. On their return, further discussions were held between the Government of Vanuatu and the study team from 25th August to 8th September the same year.

From the findings of the Basic Study Team, JICA then dispatched a supplementary team to Vanuatu from the 9th – 15th May 1993. This team continued discussions particularly with the Government of Vanuatu and UNELCO and the MINUTES OF DISCUSSION was signed in Port Vila on the 13th of May 1993. The signed Minutes formed the basis of the grant aid and the obligation of each part involved in the project.

1.3 The Sarakata Hydro Project

The Sarakata Hydropower Project is located approximately 20 kilometers north of Luganville town, 4 kilometers south from Fanafo Village and 5 kilometers west from Mon Exil. The electricity produced by the hydro plant contributes to 55.77% of the total electricity distributed within UNELCO's concession area in Luganville while the remaining 44.23 % (2004 figures) is supplied by fuel generators. The first and second phase development was completed by March of 1995 and the hydro electric facility began commercial operation. It is a low head scheme of 28m and

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has the maximum capacity of producing 1,200 kW of electricity (currently 1st & 2nd stages are producing only 600 kW).

1.4 Technical Corporation with the Government of Japan for the 3rd Stage of the Sarakata Hydro Project

The Government of Vanuatu had again requested for further assistance from the Government of Japan for the development of the 3rd Stage. In response another Preparatory Study Team was dispatched to Vanuatu from 26th July to 26th August of 2004. The team held discussions with Government officials and conducted several field surveys on the project site before finally signing the MINUTES OF DISCUSSION with the Government of Vanuatu on the 11th of August 2004.

During the course of discussions and field surveys, the Study Team and the Government of Vanuatu agreed that environment and social assessment of the project was vital. It then became the responsibility of the Government of Vanuatu to ensure that the things agreed upon in the signed MINUTES OF DISCUSSION were completed and in accordance to a set work schedule in a given time frame. These included social consideration, environmental consideration, hydrological monitoring, control measures to affected land patches, acquisition of land and awareness to local communities in preparation for the implementation of the 3rd Stage.

1.5 Technical Advisory Group(TAG)

The Technical Advisory Group (TAG) composes of representatives from different government departments. In the agreement of the signed Minutes of Discussion, the activities to be carried out falls into different fields therefore requires a collective effort across different government departments.
The Technical Advisory Group is basically made up of the following:

- Environment Unit
- Fisheries Department
- Forestry Department
- Geology & Mines Department
- Lands Department
- Public Works Department
- State Law Office (legal advisors)

The TAG overlooks all the issues concerning the Sarakata Hydropower Project.

2.0 ENVIRONMENTAL AND SOCIAL CONSIDERATION

2.1 Vegetation Study

To establish baseline information on the vegetation cover within the occupied land, a vegetation survey was conducted by the Forestry Department.

See APPENDIX A-1 for full Report

2.2 Soil Erosion

Soil erosion has occurred at some points along the water channel. The Forestry Department was assigned the task of developing control measures to prevent further erosion through replanting of certain plant species, such that have the ability to prevent soil movements during heavy rainfalls.

FIG.1. Eroded soil along the water channel

See APPENDIX A-2 for full report

2.3 Land Cracks and Land Slides

Cracks have also developed on the soil between the channel and the river. The Public Works Department investigated the scene and had proposed both long and short term control approaches. See report in Appendix

FIG 2: Land Cracks

See APPENDIX B for Full Report on Slope Stabilization

2.4 Hydrological Monitoring

The performance of a hydro power system depends heavily on the availability of sufficient quantity of water flow for which it is designed. Therefore keeping a regular account of the flow data is very important. The Hydrology Division of the Department of Geology, Mines and Water Resources installed monitoring devices and stations which recorded and stored water level data through the six month period from February to July. They were also assigned to carry out monthly water quality tests and water flow measurement at three points along the river within this period.

Full Report for these studies is in APPENDIX C

APPENDIX C-1: Study conducted in February
APPENDIX C-2: Study conducted in March
APPENDIX C-3: Study conducted in April
APPENDIX C-4: Study conducted in July

2.5 Acquisition of Hydro Land

The intention of the Government of Vanuatu is to acquire the hydro occupied land. However there are several issues which have to be cleared before this can be achieved. The project has occupied two parcel of land with separate ownerships. The Department of Lands was responsible for the resolving of land issues.

See APPENDIX D for full report

2.6 Aquatic Life Study

The Fisheries Department conducted aquatic life studies on several points along the different. To get an all season representation two studies were conducted, one during the dry season and the other during wet season. This will also become the baseline information on the aquatic species in the river with the hydro occupied line.

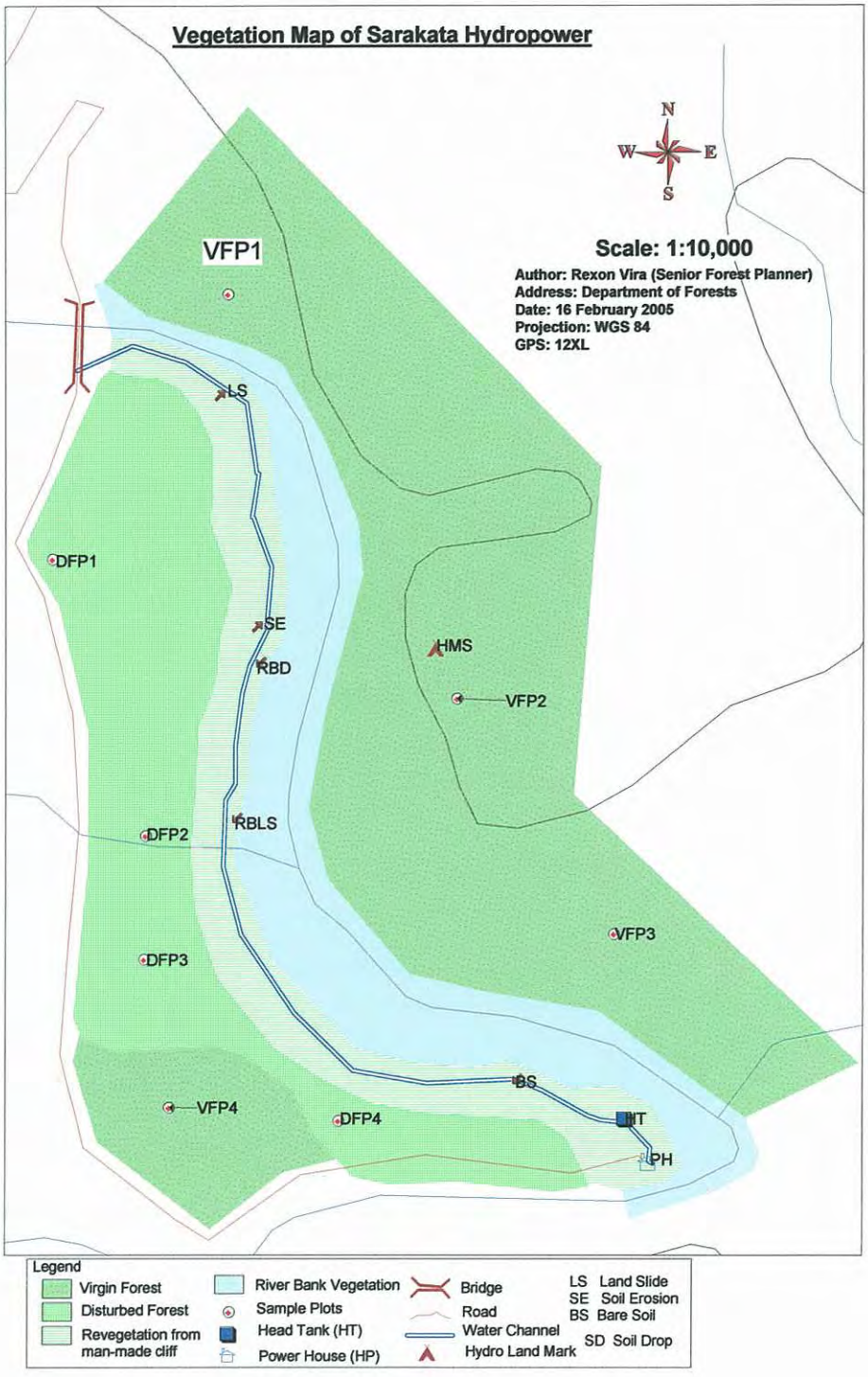
See APPENDIX E for Full Report

APPENDIX A-1

VEGETATION SURVEY REPORT

By: Forestry Department

1.0 Vegetation Map of Sarakata Hydropower



2.0 Acknowledgement

I wish to convey my gratitude to the following people for their great assistance on one way or another making it possible to successfully complete this study. Philemon Ala (Assistant Botany Curator) for identifying the plants in the field, Cathrine Malosu (EIA Environment Officer), Tarer Karae (Forestry Officer, Santo), and Christion Tuku (Principal-Volovuhu Primary School, West Ambae) for assisting in the data collections and Sam Chanel (Forestry Botanist) for classifying the plant species to their respective families and life forms.

3.0 Abstract

A vegetation study was carried within the Sarakata Hydropower (HP) water catchments area aiming to compare the vegetation compositions and structure of different vegetation types for future monitoring/mitigation of the area. The area was stratified into four vegetation types before sampled. Quadratic sampling methods was done in the virgin forest and disturbed forest while observation in the river bank vegetation and man-made cliff vegetation due to the stiffness of the area that makes it impossible to establish quadratic plots.

Virgin forest is a tropical rainforest with perfect structure, composition and regeneration of meso-phanerophytes and high resource volume while low resource volume in the disturbed forest with high regeneration of micro-phanerophytes especially pioneer species that regenerate fast once the forest canopy is disturbed.

Species composition at the river bank is normal according to the observation while at the man-made cliff the species composition varies largely with shallow rooted species thus soil erosion and land slide already occurring. It is recommended that man-made cliff vegetation required enrichment planting with deep rooted species to compact the soil, vegetation study to be carried out in the water catchments before the bridge and to carryout awareness in the nearby villages on how to manage their resources to ensure the water quality and quantity still maintained.

4.0 Introduction

Vegetation study of Sarakata Hydropower (SH) was carried out following the report and terms of reference developed by SH Technical Advisory Group (TAG) in the progress report of monitoring/mitigation on environmental & social consideration of SH. The terms of reference is basically requesting an observation and identification of the vegetation within the recommended area however, because there wasn't any baseline study made prior to the construction of SH we have decided to established sampling plots to collect adequate information to enhance decision makings on monitoring/mitigation on environment within the area in the future. The main aim of this vegetation study was to compare the species composition and structure within the different vegetation types exist in the area.

The study was done at Sarakata Hydropower area 20 kilometres north of Luganville town, 4 kilometres south from Fanafo Village and 5 kilometres west from Mon Exil Village covering a total area of 30 hectares leased by Sarakata Hydropower Project. The general slope of the area range from 5 degrees to >100 degrees.

5.0 Methods

5.1 Reconnaissance Survey

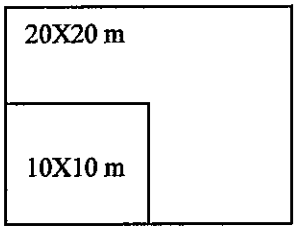
A reconnaissance survey was done within the first two days to determine sampling design and intensity required. Four vegetation types were identified existed within the proposed study site and were stratified using Global Positioning System (GPS) with sample plots randomly located in each vegetation types. The vegetation was stratified into to;

- Virgin Forests,
- Disturbed Forests
- River Bank Vegetation
- Man-made cliff Vegetation

5.1.1 Sampling design

Quadrat sampling methods was used at the virgin forests and disturbed forests while observation was done at the river bank vegetation and Man-made cliff vegetation due to the stiffness of the area that makes it impossible to establish quadratic sample plots.

Figure 1 Plot design
Plot design



Size of quadrat was determined by constructing a species/area curve thus 10X10 meters plot for undergrowth and 20X20 meters for canopy trees. In 10X10 plots all phanerophytes were counted while chemaephytes and hemicryptophytes were recorded with their abundance in percentage from observation. And in 20X20 plots all canopy phanerophytes with 10 cm diameter breast height over bark (DBHOB) and above were counted and measured.

Raunkaier's life forms (Specht 1972, Specht & Specht in press) was used to classify the plants community types are often characterized by the proportion of each Raunkaier type. This is as follows.

1. phanerophyte (tree or tall shrub, lianes + epiphytes): buds borne on aerial shoots> 25cm above ground, e.g. *Eucalyptus, Pinus*

mega-phanerophyte	>30m	trees
meso-phanerophyte trees	8-30m	
micro-phanerophyte	2-8	shrubs
nano-phanerophyte	25cm-2m	shrubs

2. chamaephyte (shrub) buds < 25cm above ground, e.g. small shrubs with stems that fall and can root along their length, Kunzea, cushion plants etc.
3. hemicryptophyte (perennial herb) bud at ground surface, above-ground plants die back at onset of unfavourable conditions, e.g. rosette plants (with basal leaves), non-rosette plants (without basal leaves), such as many perennial grass, for instance, Mitchell grass.

6.0 Results

6.1 Virgin Forests & Disturbed Forests

Because of the large degree of error and bias that is inherent in qualitative evaluations, it is always better to use quantitative measures to describe vegetation components of the ecosystem. The three absolute measures of abundance

are density, cover and frequency. Quantitative measure of abundance was done only on meso/micro/nano-phanerophyte since each species could be easily singled out and counted while species under chamaephyte and hemicryptophyte life forms were observed and recorded without counting due to difficulties in identifying single stems.

Such measurement depends largely on the species growth form, distribution pattern and sampling techniques used for instance large tree species would have relatively high cover value but low density and frequency while fern growing in small clumps of many individuals would have low cover and frequency but high density and vine growing on the trunks of most of the trees would have similar density and frequency to the tree but much lower cover. Thus a single value called an importance value is calculated which is an average of relative density, relative cover and relative frequency.

Figure 2:Quantitative Measure of Abundance Virgin Forests

Date: 21/02/2005								
Site:Vigin Forests								
Total number of Quadrats sampled: 4								
Area of each Quadrat: 10 X 10 metres								
Life Form	*No.of species*	*Density (m2)*	*Relative Density (%)*	*Cover (%)*	*Relative Cover (%)*	*Frequency (%)*	*Relative Frequency (%)*	*Importance Value (%)*
Meso-phanerophyte		2.19	0.566	25	11	100	57	23
Micro-phanerophyte		0.91	0.235	15	16	100	24	13
Nano-phanerophyte		0.77	0.199	5	6	100	20	9
Chamaephyte	9							
Hemicrytophyte	7							

Figure 3: Quantitative Measure of Abundance for Disturbed Forests

Date: 21/02/05								
Site:Disturbed Forests								
Total number of Quadrats sampled: 4								
Area of each Quadrat: 10 X 10 metres								
Life Form	*No.of species*	*Density (m2)*	*Relative Density (%)*	*Cover (%)*	*Relative Cover (%)*	*Frequency (%)*	*Relative Frequency (%)*	*Importance Value (%)*
Meso-phanerophyte		0.53	0.32	5	3	100	32	12
Micro-phanerophyte		0.71	1.0	15	9	100	43	18
Nano-phanerophyte		0.42	0.25	3	2	100	25	9
Chamaephyte	17							
Hemicryptophyte	14							

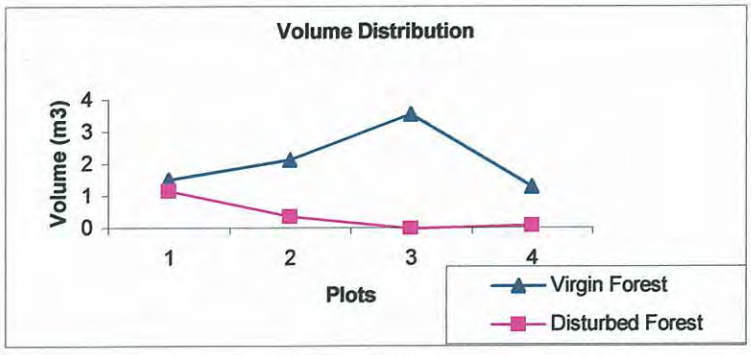
6.1.1 *Understorey*

Comparing the abundance of life forms within the virgin forests and disturbed forests importance value is high in meso-phanerophyte in the virgin forests and low in the disturbed forests. However, more number of species occurs in chameaphyte and hemicryptophyte in the disturbed forests while less in the virgin forests. Elastostema *macrophyllum* and Pteris *pacifica* under hemicryptophyte life form dominated the forest floor cover in the virgin forests with high regeneration of meso-phanerophyte compared to disturbed forests.

6.1.2 *Overstorey*

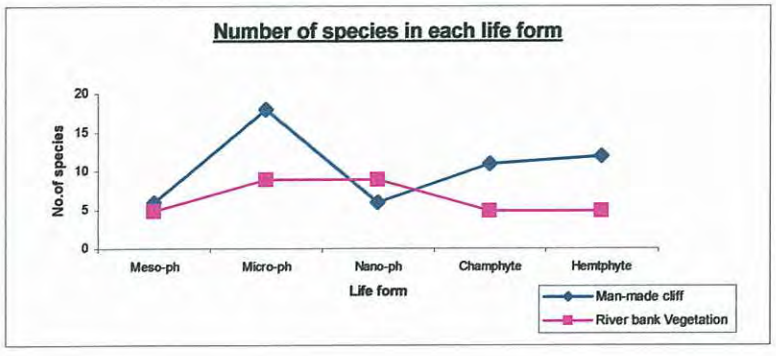
In the virgin forests the volume varies largely among the sample plots with highest recorded in plot 3 and lowest in plot 5. According to the disturbed forest volume trend decreases from plot 1 to 4 and even zero volume in plot 3.

Figure 4: Line graph showing volume distribution in each plots within the virgin forests and disturbed forests



6.2 River bank vegetation & Man-made cliff vegetation

Figure 4: Line graph showing the species distribution in the river bank vegetation and man-made cliff vegetation



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More number of species in micro-phanerophyte observed in the man-made cliff vegetation while in the river bank vegetation micro-phanerophyte and nano-phanerophyte and the distribution trend is much stable than the man-made cliff vetegation. Number of species observed in Chamaephyte and hemicryptophyte were almost the same. However, the most dominant species in both sites are Piper *aduncum*, Spatahoglottis *petri*, ficus *adenospermum*, Mutingia *callabura*, Meramia *peltata* and Trichomonace *humile*.

7.0 Discussion

7.1 Virgin Forests & Disturbed Forests

7.1.1 Understorey

Undergrowth in the virgin forests is very healthy and well structured with adequate canopy cover allowing high regeneration of meso-phanerophyte especially Myristica *fatua*, Pangium *edule*, Syzygium *richii* and Burckella *obovata*. While in the disturbed forests there is a high abundant of micro-phanerophyte especially pioneer species such as Magaranga *dioca*, Hibiscus *tiliaceus*, and Meryta *neo-ebodicum* that regenerate faster than meso-phanerophytes once the forest is disturbed. Also a high number of chamaephytes and hemicryptophytes reduce the chances of meso-phanerophytes regeneration.

7.1.2 Overstorey

Plot number 1& 4 in the virgin forests have less volume because they were located adjacent to the construction having high chances of same trees being removed during the HP construction while plots 2 & 3 are further away from the construction site. Most species measured are meso-phenerophytes with Myristica *fatua*, Pangium *edule* and Antiaris *toxicaria* being the dominant species with considerable stand of Endospermum *medullosum* and Terminalia *sepicana*. Volume distribution in the disturbed forests is low as expected since most large trees were removed during the HP construction. Plot number 3 falls within the power line clearing thus no volume recorded.

7.2 River bank vegetation and Man-made cliff vegetation

In the man-made cliff vegetation number of species varies largely among the different life forms that, indicate that the vegetation is not well structured. Healthy vegetation normally has number of layers in its structure in other

words different life forms as they depend on each other for nutrients, shade, support, etc to survive. Species that dominated the site are shallow rooted plants thus, a number of areas already experiencing soil erosions and land slide causing great danger on the water channel.

8.0 Recommendations

- Vegetation studies should be carried out in the areas before the bridge as it is the water catchments area for the water that channeled to the power house.
- Carryout awareness in the villages especially Fanafo, Butmas and Stone Hill on how to properly manage their forests to ensure the water quality and quantity is sustained.
- Enrichment planting of deep-rooted meso-phaneropytes within the man-made cliff to avoid further soil erosion and land slide.

Reference

Specht R.L. (1972). The Vegetation of South Australia. Second Edition. Government Printer, Adelaide.
Specht R.L. and Specht A. (in press) Australia Plant Communities, Structure, growth and biodiversity Oxford Univ. Press, Australia.

Appendices

Appendix 1 Virgin Forest (20X20) Measurements

Virgin Forest plot 1 (20X20)

Family	Genus	Species	DBHOB	Bole Hight (m)	Volume(m^3)
Bixaceae	Pangium	*edule*	36	8	0.102
Bixaceae	Pangium	*edule*	35	10	0.096
Bixaceae	Pangium	*edule*	32	8	0.080
Bixaceae	Pangium	*edule*	45	15	0.159
Bixaceae	Pangium	*edule*	60.2	7	0.285
Bixaceae	Pangium	*edule*	65.4	6	0.336
Moraceae	Antiaris	*toxicaria*	25	20	0.049
Myrtaceae	Syzygium	*clussifolium*	14.1	12	0.016
Sapindaceae	Pometia	*pinnata*	26.2	5	0.054
Sapindaceae	Pometia	*pinnata*	13.9	10	0.015
Sapindaceae	Pometia	*pinnata*	30	14	0.071
Monimiaceae	Hedycaria	*sp*	11.4	8	0.010
Sapotaceae	Burckella	*obovata*	28.9	9	0.066
Euphorbiaceae	Macaranga	*dioica*	13.9	3	0.015
Euphorbiaceae	Macaranga	*dioica*	18.4	5	0.027
Myristicaceae	Myristica	*fatua*	16.1	12	0.020
Myristicaceae	Myristica	*fatua*	17	10	0.023
Myristicaceae	Myristica	*fatua*	15.8	15	0.020
Myristicaceae	Myristica	*fatua*	13.4	6	0.014
Meliaceae	Aglia	*eleagniodea*	30.2	17	0.072
					1.528

Virgin Forest plot 2 (20X20)

Family	Genus	Species	DBHOB	Bole Hight (m)	Volume(m^3)
Myristicaceae	Myristica	*fatua*	13.8	6	0.015
Myristicaceae	Myristica	*fatua*	21.1	11	0.035
Myristicaceae	Myristica	*fatua*	10.3	5	0.008
Myristicaceae	Myristica	*fatua*	25.7	7	0.052
Myristicaceae	Myristica	*fatua*	18.2	9	0.026
Myristicaceae	Myristica	*fatua*	28.1	12	0.062
Myristicaceae	Myristica	*fatua*	19.5	10	0.030
Myristicaceae	Myristica	*fatua*	34	13	0.091
Myristicaceae	Myristica	*fatua*	28	12	0.062
Myristicaceae	Myristica	*fatua*	31.5	15	0.078
Myristicaceae	Myristica	*fatua*	13	6	0.013
Myristicaceae	Myristica	*fatua*	14.8	5	0.017
Myristicaceae	Myristica	*fatua*	22.5	9	0.040
Myristicaceae	Myristica	*fatua*	13.1	9	0.013
Myristicaceae	Myristica	*fatua*	28.1	12	0.062
Myristicaceae	Myristica	*fatua*	25	11	0.049
Combretaceae	Terminalia	*sepicana*	20.1	10	0.032
Combretaceae	Terminalia	*sepicana*	16.5	8	0.021
Combretaceae	Terminalia	*sepicana*	21.1	9	0.035

Araliaceae	Osmoxylon	*orientalis*	26.1	9	0.054
Araliaceae	Osmoxylon	*orientalis*	18.6	6	0.027
Moraceae	Antiaris	*toxicaria*	70	20	0.385
Moraceae	Antiaris	*toxicaria*	23.6	13	0.044
Moraceae	Antiaris	*toxicaria*	22.5	12	0.040
Moraceae	Antiaris	*toxicaria*	28.4	11	0.063
Anacardiaceae	Semecarpus	*vitiensis*	36.6	9	0.105
Euphorbiaceae	Endospermum	*medullosum*	85.3	20	0.571
Sapotaceae	Burckella	*obovata*	38.5	17	0.116
					2.147

Virgin Forest plot 3 (20X20)

Family	Genus	Species	DBHOB	Bole Hight (m)	Volume(m^3)
Sapindaceae	Pometia	*pinnata*	19.7	7	0.030
Bixaceae	Pangium	*edule*	21.3	9	0.036
Myrtaceae	Syzygium	*malaccence*	12.6	8	0.012
Anacardiaceae	Dracontomelon vitiensis	*vitiensis*	23.4	6	0.043
Anacardiaceae	Dracontomelon vitiensis	*vitiensis*	41.8	16	0.137
Euphorbiaceae	Endospermum	*medullosum*	74.7	23	0.438
Sapotaceae	Palaquium	*sp*	12.5	5	0.012
Meliaceae	Dysoxyllum	*sp*	30.6	19	0.074
Myristicaceae	Myristica	*fatua*	26.1	15	0.054
Myristicaceae	Myristica	*fatua*	23.4	13	0.043
Myristicaceae	Myristica	*fatua*	15.5	8	0.019
Myristicaceae	Myristica	*fatua*	22.1	11	0.038
Myristicaceae	Myristica	*fatua*	26.9	12	0.057
Moraceae	Antiaris	*toxicaria*	55	21	0.238
Moraceae	Antiaris	*toxicaria*	60	24	0.283
Moraceae	Antiaris	*toxicaria*	19.6	12	0.030
Moraceae	Antiaris	*toxicaria*	62	25	0.302
Moraceae	Antiaris	*toxicaria*	35.5	15	0.099
Moraceae	Antiaris	*toxicaria*	49.9	17	0.196
Moraceae	Antiaris	*toxicaria*	50.1	20	0.197
Moraceae	Antiaris	*toxicaria*	60	23	0.283
Moraceae	Antiaris	*toxicaria*	30	19	0.071
Moraceae	Antiaris	*toxicaria*	60	23	0.283
Moraceae	Antiaris	*toxicaria*	65	20	0.332
Moraceae	Antiaris	*toxicaria*	17.5	9	0.024
Leguminosae	Entada	*phaseloides*	12.8	5	0.013
Moraceae	Ficus	*wassa*	14.6	6	0.017
Sapotaceae	Burckella	*obovata*	35.6	12	0.100
Combretaceae	Terminalia	*sepicana*	33.2	13	0.087
Leguminosae	Pteorocarpus	*indicus*	14.8	7	0.017
					3.563

Virgin Forest plot 4 (20X20)

Family	Genus	Species	DBHOB	Bole Hight (m)	Volume(m^3)
Euphorbiaceae	Bischofia	*javanica*	67.2	19	0.355
Bixaceae	Pangium	*edule*	22.4	9	0.039
Bixaceae	Pangium	*edule*	24.1	12	0.046
Bixaceae	Pangium	*edule*	20.5	8	0.033
Bixaceae	Pangium	*edule*	27.7	5	0.060
Bixaceae	Pangium	*edule*	15	6	0.018
Bixaceae	Pangium	*edule*	18.2	5	0.026
Bixaceae	Pangium	*edule*	11.5	8	0.010
Bixaceae	Pangium	*edule*	40.3	14	0.128
Bixaceae	Pangium	*edule*	33	11	0.086
Bixaceae	Pangium	*edule*	41.1	10	0.133
Bixaceae	Pangium	*edule*	33.7	9	0.089
Myristicaceae	Myristica	*fatua*	20.9	13	0.034
Myristicaceae	Myristica	*fatua*	17.4	9	0.024
Myristicaceae	Myristica	*fatua*	15.6	7	0.019
Myristicaceae	Myristica	*fatua*	18.1	8	0.026
Myristicaceae	Myristica	*fatua*	11.9	5	0.011
Myristicaceae	Myristica	*fatua*	13.9	6	0.015
Euphorbiaceae	Endospermum	*medollusum*	25.1	18	0.049
Leguminosae	Pteorocarpus	*indicus*	11.3	7	0.010
Araliaceae	Osmoxylon	*orientalis*	12.8	6	0.013
Myrtaceae	Syzygium	*malaccense*	16.2	9	0.021
Leguminosae	Entada	*phaseloides*	10.3	7	0.008
Anacardiaceae	Dracontomelon	*vitiensis*	19.3	10	0.029
Anacardiaceae	Semecarpus	*vitensis*	18.9	13	0.028
					1.310

Appendix 2 Disturbed Forest (20X20) Measurements

Disturbed Forest plot 1 (20X20)

Family	Genus	Species	DBHOB	Bole Hight (m)	Volume (m^3)
Araliaceae	Osmoxylon	*orientale*	35.5	10	0.099
Araliaceae	Osmoxylon	*orientale*	53.5	12	0.225
Araliaceae	Osmoxylon	*orientale*	33.6	11	0.089
Araliaceae	Osmoxylon	*orientale*	35.6	9	0.100
Araliaceae	Osmoxylon	*orientale*	38.5	13	0.116
Araliaceae	Osmoxylon	*orientale*	29.8	9	0.070
Moraceae	Ficus	*Scabra*	10.9	4	0.009
Moraceae	Ficus	*Scabra*	12.9	5	0.013
Euphorbiaceae	Macaranga	*tanarius*	20	6	0.031
Euphorbiaceae	Macaranga	*tanarius*	25.5	4	0.051
Euphorbiaceae	Macaranga	*tanarius*	22.3	5	0.039
Euphorbiaceae	Macaranga	*tanarius*	11.8	3	0.011
Euphorbiaceae	Macaranga	*tanarius*	13.4	4	0.014
Myristicaceae	Myristica	*fatua*	25	8	0.049
Myristicaceae	Myristica	*fatua*	15.8	7	0.020
Myristicaceae	Myristica	*fatua*	11.2	7	0.010
Myristicaceae	Myristica	*fatua*	10.8	9	0.009
Myristicaceae	Myristica	*fatua*	12.7	6	0.013
Myristicaceae	Myristica	*fatua*	13.4	7	0.014
Urticaceae	Dendrocnide	*latifolia*	27.9	5	0.061
Combretaceae	Terminalia	*sepicana*	15.8	6	0.020
Bixaceae	Pangium	*edule*	35.1	5	0.097
Bixaceae	Pangium	*edule*	10.2	5	0.008
Bixaceae	Pangium	*edule*	15.6	6	0.019
					1.186

Disturbed Forest plot 2 (20X20)

Family	Genus	Species	DBHOB	Bole Hight (m)	Volume (m^3)
Myristicaceae	Myristica	*fatua*	18.2	6	0.026
Myristicaceae	Myristica	*fatua*	14.4	7	0.016
Myristicaceae	Myristica	*fatua*	18.4	5	0.027
Myristicaceae	Myristica	*fatua*	15.3	6	0.018
Myristicaceae	Myristica	*fatua*	17.3	7	0.024
Myristicaceae	Myristica	*fatua*	12.2	4	0.012
Myristicaceae	Myristica	*fatua*	13.4	5	0.014
Myristicaceae	Myristica	*fatua*	10.2	6	0.008
Bixaceae	Pangium	*edule*	18.4	9	0.027
Bixaceae	Pangium	*edule*	22.2	8	0.039
Bixaceae	Pangium	*edule*	17.2	6	0.023
Bixaceae	Pangium	*edule*	31	10	0.075
Bixaceae	Pangium	*edule*	30.4	9	0.073
					0.381

Disturbed Forest plot 3 (20X20)

Nill

Disturbed Forest plot 4 (20X20)

Family	Genus	Species	DBHOB	Bole Hight (m)	Volume (m^3)
Euphorbiaceae	Macaranga	*tanarius*	10.7	3	0.009
Euphorbiaceae	Macaranga	*tanarius*	11.3	4	0.010
Euphorbiaceae	Macaranga	*tanarius*	15.4	4	0.019
Euphorbiaceae	Macaranga	*tanarius*	10.2	3	0.008
Euphorbiaceae	Macaranga	*tanarius*	12.8	5	0.013
Euphorbiaceae	Macaranga	*tanarius*	18.4	4	0.027
Moraceae	Ficus	*adenosperma*	13.9	5	0.015
					0.100

Appendix 3 Virgin Forests (10X10) Measurements

Life form	Family	Genus	Species	Distribution	Plot 1	Plot 2	Plot 3	Plot 4	Total
Meso-phanerophyte	Flacourtiaceae	Pangium	*edule*	Native	42	2	10	18	**72**
	Myrtaceae	Syzygium	*richii*	Native	15		6	8	**29**
	Myrtaceae	Syzygium	*clussifolium*	Native		2	3		**5**
	Caesalpiniaceae	Inocarpus	*fagifer*	Native	2		1		**3**
	Myristicaceae	Myristica	*fatua*	Native	8	2	17	15	**42**
	Urticaceae	Dendrocnide	*latifolia*	Native	3		3	15	**21**
	Sterculiaceae	Sterculia	*banksiana*	Endemic			1		**1**
	Papilionaceae	Pteorocarpus	*indicus*	Native			1		**1**
	Meliaceae	Chichoseton	*rex*	Endemic				4	**4**
	Sapotaceae	Burckella	*obovata*	Native		8	4	10	**22**
	Combretaceae	Terminalia	*sepicana*	Native		4			**4**
	Meliaceae	Dysoxyllum	*gaudichaudianum*	Native		3	5		**8**
	Ancardiaceae	Semecarpus	*vitiensis*	Native		3	2		**5**
	Ancardiaceae	Dracontomelon	*vitiensis*	Native				2	**2**
									219
Micro-phanerophyte	Myrsinaceae	Tapeinaspermum	*scrobiculatum*	Native	6	6	4	3	***19***
	Moraceae	Ficus	*wassa*	Native	4	4	2	8	***18***
	Moraceae	Ficus	*scabra*	Native	3		1		***4***
	Ulmaceae	Celtis	*baniculata*	Native	2		1	4	***7***
	Rutaceae	Murraya	*paniculata*	Native	5				***5***
	Malvaceae	Hibiscus	*tiliaceus*	Native		2	2		***4***
	Verbenaceae	Premna	*serratifolia*	Native		2			***2***
	Leguminosae	Edycaria	*dorsteniodes*	Native	7				***7***
	Apocynaceae	Ervatamia	*obtusiuscula*	Native		3	1		***4***
	Meliaceae	Aglaia	*elagnoides*	Native		2			***2***
	Monimiacea	Micromelum	*minutum*	Native		19			***19***
									91
Nano-phanerophyte	Piperaceae	Piper	*aduncum*	Introduce	12	14			**26**
	Agavaceae	Cordyline	*fruticosa*	Native		15			**15**
	Rubiaceae	Psychotria	*aneityensis*	Endemic		14	12	10	**36**
									77
									387
Chamaephyte	Araceae	Epiprenum	*pinnatum*	Native	X	X	X	X	
	Araceae	Calamus	*vanuatuensis*	Endemic	X	X	X	X	
	Flagellariaceae	Flagellaria	*indica*	Native	X		X	X	
	Liliaceae	Smilax	*vetiensis*	Native	X				
	Convolvulaceae	Meremia	*peltata*	Introduce		X			
	Mimosaceae	Entada	*phaseoloides*	Native		X		X	

	Moraceae	Malaisia	*scandens*	Native		X		X
	Compositae	Mikania	*micrantha*	Introduce	X		X	X
	Rhamnaceae	Ventilago	*Austrocaledonicum*	Native		X		X
Hemicrytophyte	Selaginellaceae	Selaginella	*durvillei*	Native	X		X	
	Pteridaceae	Pteris	*pacifica*	Native	X	X	X	X
	Aspleniaceae	Asplenium	*nidus*	Native		X	X	X
	Aspidiaceae	Diplazium	*sp*	Native	X	X		
	Dryopteridaceae	Tectaria	*degeneri*	Native	X			X
	Aspidiaceae	Tectaria	*latifolia*	Native		X		
	Urticaceae	Elatostema	*macrophyllum*	Native	X	X	X	X

Appendix 4 Disturbed Forest (10X10) Measurements

Life form	Family	Genus	Species	Distribution	Plot 1	Plot 2	Plot 3	Plot 4	Total
Meso-phanerophyte	Flacourtiacea	Pangium	*edule*	Native	6				6
	Myrtaceae	Syzygium	*richii*	Native	4	1			5
	Myrtaceae	Syzygium	*clussifolium*	Native					0
	Leguminosae	Inocarpus	*fagifera*	Native	1				1
	Myristicaceae	Myristica	*fatua*	Native	1	1			2
	Urticaceae	Dendrocnide	*latifolia*	Native	14				14
	Sterculiaceae	Sterculia	*banksiana*	Endemic	2				2
	Leguminosae	Pteorocarpus	*indicus*	Native	1				1
	Sapotaceae	Burckella	*obovata*	Native	8				8
	Combretaceae	Terminalia	*sepicana*	Native		2			2
	Meliaceae	Dysoxylum	*gaudichaudianum*	Native	2	3			5
	Anacardiaceae	Semecarpus	*vitiensis*	Native	1				1
	Lecythidaceae	Baringtonia	edulis	Native	2				2
	Meliaceae	Chisocheton	*rex*	Endemic		1			1
	Agavaceae	Cordyline	*fruticosa*	Native			3		3
									53
Micro-phanerophyte	Myrsinaceae	Tapeinaspermum	*scrobiculatum*	Native	1	1			2
	Moraceae	Ficus	*wassa*	Native	3			3	6
	Moraceae	Ficus	*scabra*	Native	1				1
	Ulmaceae	Celtis	*baniculata*	Native		1			1
	Rutaceae	Murraya	*paniculata*	Native	1	2			3
	Malvaceae	Hibiscus	*tiliaceus*	Native	2	5	3		10
	Berbenaceae	Premna	*corymbosa*	Native					0
	Araliaceae	Meryta	*neo-ebudicum*	Endemic	7	3		2	12
	Rubiaceae	Psychotria	*trichostoma*	Endemic	5				5
	Agavaceae	Cordyline	*fruticosa*	Native	2	3			5
	Euphorbiaceae	Magaranga	*dioca*	Native			2	13	15
	Euphorbiaceae	Fluggea	*flexuosa*	Native				3	3
	Meliaceae	Aglaia	*elagnoides*	Native		4			4
	Euphorbiaceae	Glochidion	*ramiflorum*	Native				1	1
	Urticaceae	Pipturus	*argenteus*	Native				2	2
	Leeaceae	Leea	*indica*	Native				1	1
									71
Nano-phanerophyte	Monimiacea	Edycaria	*dorsteniodes*	Native					
	Rutaceae	Micromelum	*minutum*	Native	1				1
	Apocynaceae	Ervatamia	*obtusciuscula*	Native					0
	Alpinaceae	Costus	*sp*	Native		4			4
	Acanthaceae	Graptophyllum	*pictum*	Native		3			3
	Marantaceae	Donax	*canniformis*	Native	2				2
	Myrsinaceae	Maesa	*ambrymensis*	Endemic				4	4
	Rubiaceae	Psychotria	*aneityensis*	Endemic	2	1			3
	Acanthaceae	Hemigraphis	*reptans*	Native	1				1
	Mimosaceae	Mimosa	*pudica*	Native			4	2	6
	Solanaceae	Solanum	*torvum*	Native			3		3
	Musaceae	Musa	*nava*	Native			4		4

	Piperaceae	Piper	*aduncum*	Introduce	6	5			11
									42
									166
Chamaephyte	Araceae	Epiprenum	*pinnatum*	Native		X			
	Araceae	Calamus	*vanuatuensis*	Endemic	X				
	Flagellariaceae	Flagellaria	*indica*	Native	X				
	Liliaceae	Smilax	*vetiensis*	Native	X				
	Convolvulaceae	Meremia	*peltata*	Native	X		X	X	
	Mimosaceae	Entada	*phaseoloides*	Native					
	Moraceae	Malasia	*scudens*	Native		X	X		
	Alpiniaceae	Alphinia	*oceanica*	Native	X				
	Rubiaceae	Timonius	*affinis*	Native	X				
	Verbenaceae	Lantana	*camera*	Introduce			X		
	Cucurbitaceae	Momordica	*charantia*	Native			X		
	Caesalpiniaceae	Callopogonium	*mucunoides*	Native			X		
	Compositae	Mikania	*macrantha*	Native			X	X	
	Moraceae	Malasia	*scandens*	Native		X			
	Araceae	Diefenpachia	*sp*	Native	X				
	Rhamnaceae	Ventilago	*austrocaledonicum*	Native				X	
	Mimoasaceae	Entada	*phaseloides*	Native				X	
	Convolvulaceae	Ipomea	*acuminata*	Native	X		X		
	Papilionaceae	Pueraria	*iobata*	Native		X	X		
Hemicrytophyte	Urticaceae	Elatostema	*macrophyllum*	Native	X	X			
	Aspidiaceae	Tectaria	*degeneri*	Native				X	
	Selaginellaceae	Selaginella	*durvillei*	Native			X		
	Pteridaceae	Pteris	*pacifica*	Native	X				
	Aspidiaceae	Diplazium	*sp*	Native		X			
	Melastomaceae	Medinilla	*heteromorphophylla*	Endemic		X			
	Alpiniaceae	Alpinia	*purpurata*	Native				X	
	Orchidaceae	Dendrobium	*sp (Butmas)*	Endemic				X	
	Thelypteridaceae	Sphaerostephanos	*invisus*	Native				X	
	Aspidiaceae	Diplazium	*sp*	Native	X				
	Aspidiaceae	Tectaria	*latifolia*	Native			X		
	Aspleniaceae	Asplenium	*nidus*	Native	X	X			
	Aspidiaceae	Tectaria	*latifolia*	Native				X	
	Cytheaceae	Cyathea	*lunulata*	Native			X		

Appendix 5 River Bank Vegetation Observation

River Bank Vegetation

	Family	Genus	Species	Distribution
Meso-phanerophyte	Euphorbiaceae	Macaranga	*dioica*	Native
	Annonaceae	Cananga	*odorata*	Native
	Anacardiaceae	Mangifera	*indica*	Native
	Rubiaceae	Alphitonia	*zizyphoides*	Native
	Euphorbiaceae	Fluggia	*flexuosa*	Native
Micro-phanerophyte	Euphorbiaceae	Phyllathus	*cicoides*	Native
	Moraceae	Ficus	*wassa*	Native
	Piperaceae	Piper	*aduncum*	Introduce
	Verbenaceae	Premna	*serratifolia*	Native
	Elaocarpaceae	Muntingia	*calabura*	Native
	Agavaceae	Coryline	*fruiticosa*	Endemic
	Sterculiaceae	Commersonia	*bartramia*	Native
	Araliaceae	Meryta	*neo-ebudicum*	Endemic
	Urticaceae	Pipturus	*argebteua*	Native
Nano-phanerophyte	Helyconiaceae	Helyconia	*sp*	Native
	Zingiberaceae	Alpinia	*purpurata*	Native
	Maranthaceae	Donax	*canniformis*	Native
	Asteraceae	Wendelia	*trilobata*	Native
	Rubiaceae	Mussaenda	*cylindrocarpa*	Native
	Myrsinaceae	Maesa	*ambrymensis*	Endemic
	Orchidaceae	Spathoglottis	*petri*	Native
	Graminea	Miscanthus	*sinensis*	Native
	Papilionaceae	Desmodium	*umbellatum*	Native
Chamaephyte	Verbenaceae	Lantana	*camara*	Introduce
	Convolvulaceae	Meremia	*peltata*	Introduce
	Asteraceae	Mikania	*micrantha*	Native
	Caesalpiniaceae	Caesalpinia	*major*	Native
	Papilionaceae	Derris	*elegans*	Native
Hemicrytophyte	Cyatheaceae	Cyathea	*lunulata*	Native
	Orchidaceae	Spathoglottis	*petri*	Native
	Aspleniaceae	Asplenium	*nidus*	Native
	Melastomataceae	Medinilla	*heteromorphophylla*	Native
	Dennstaedtiaceae	Dennstaedtia	*samoensis*	Native

Appendix 6 Man-made Cliff Vegetation Observation

Man-made cliff

	Family	Genus	Species	Distribution
Meso-phanerophyte	Euphorbiaceae	Macaranga	*dioica*	Native
	Euphorbiaceae	Glochidion	*ramiflorum*	Native
	Leguminosae	Pteorocarpus	*indidus*	Native
	Anacardiaceae	Mangifera	*indica*	Native
	Sapotaceae	Burckella	*obovata*	Native
	Rubiaceae	Alphitonia	*zizyphoides*	Native
Micro-phanerophyte	Euphorbiaceae	Phyllathus	*cicoides*	Native
	Moraceae	Ficus	*adenospermum*	Native
	Moraceae	Ficus	*wassa*	Native
	Moraceae	Ficus	*scabra*	Native
	Myrsinaceae	Maesa	*abrymensis*	Endemic
	Urticaceae	Pipturus	*agenteus*	Native
	Piperaceae	Piper	*aduntum*	Native
	Euphorbiaceae	Claoxylon	*gillisonii*	Native
	Leeaceae	Leea	*indica*	Native
	Malvaceae	Hibiscus	*tiliacese*	Native
	Verbenaceae	Premna	*serratifolia*	Native
	Elaocarpaceae	Muntingia	*calabura*	Native
	Myrtaceae	Psidium	*guajava*	Native
	Euphorbiaceae	Cordieaum	*variegatum*	Native
	Euphorbiaceae	Acalypha	*caturus*	Native
	Agavaceae	Coryline	*fruiticosa*	Native
	Sterculiaceae	Comensonia	*batramia*	Native
	Rubiaceae	Guettarda	*sp*	Native
Nano-phanerophyte	Helyconiaceae	Helyconia	*sp*	Native
	Zingiberaceae	Alpinia	*purpurata*	Native
	Maranthaceae	Donax	*canniformis*	Native
	Araceae	Alocasia	*microrrhiza*	Native
	Asteraceae	Wendelia	*trilobata*	Native
	Graminea	Miscanthus	*sinensis*	Native
Chamaephyte	Palmae	Calamus	*vanuatuensis*	Endemic
	Verbenaceae	Lantana	*camara*	Introduce
	Convolvulaceae	Meremia	*peltata*	Introduce
	Asteraceae	Mikania	*micrantha*	Native
	Asclepiadaceae	Hoya	*australis*	Introduce
	Convolvulaceae	Ipomea	*sp*	Native
	Moraceae	Ficus	*tintoria*	Native
	Piperaceae	Piper	*wishmannii*	Native
	Leguminosae	Mimosa	*budica*	Native
	Caesalpiniaceae	Caesalpinia	*major*	Native

	Leguminosae	Derris	*elegans*	Native
Hemicrytophyte	Thelypteridaceae	Christella	*dentata*	Native
	Dennstaedtiaceae	Tectaria	*crenata*	Native
	Athyriaceae	Diplazium	*sp*	Native
	Cyatheaceae	Cyathea	*lunulata*	Native
	Orchidaceae	Spathoglottis	*sp*	Native
	Aspleniaceae	Asplenium	*nidus*	Native
	Hymenophyllaceae	Trichomanace	*humile*	Native
	Melastomataceae	Medinilla	*heteromorphophylla*	Native
	Sellaginellaceae	Selaginella	*durvillei*	Native
	Dennstaedtiaceae	Dennstaedtia	*samoensis*	Native
	Lycopodiaceae	Lycopodium	*sp*	Native
	Dryopteridaceae	Pronephrium	*sp*	Native

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