South Pacific Regional Environment Programme

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A Preliminary
Environmental Impact Assessment
Report:

Epau
Micro Hydro-Electric Power Project,
Efate, Vanuatu,

by
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Environmental Impact Assessment
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Micro Hydro-Electric Power Project, Efate, Vanuatu

Prepared for the
Government of Vanuatu

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EXECUTIVE SUMMARY

The Government of Vanuatu has decided to set up a micro hydro electric-power station on the Epong river to provide up to 25KW of electric power for the village of Epao and to use this development project as a pilot plant for training purposes on hydro electric power management.

The Epao Micro Hydroelectric Power Project is expected to be completed in 1996. It will then provide for more than the total electricity needs of the village of Epao on the eastern side of Efate. This report examines the environmental impacts of the scheme and makes recommendations for their reduction. This summary highlights the main points. Detailed conclusions and recommendations are set out in section 5 of the report.

Environmental Impact Assessment needs to be completed in the early design stages of a project. In the case of the Epao project, the environmental assessment was conducted well ahead of the feasibility study and in parallel with the survey work to mark the pipeline alignment and the project layout. The village consultation process was also conducted at an appropriately early stage and should help to ensure smooth progress of the project towards completion.

It is recommended that for major developments Vanuatu continues to adopt the practises of:

- early environmental impact assessment;
- early public consultation; and
- technical review.

The Epong river running alongside the village of Epao provides the drinking-quality fresh water supply to the village. The village water supply is gravity-drawn from the river at the Epong spring through a pipeline to two reservoir tanks from which reticulated tap water is fed to each household. The hydro project proposes to channel off a third of the remaining river flow, from below the village water intake, to run the turbines and then return the same quality water volume to the river at the tailrace close to the village.

It is expected that extraction of a third of the water flow and returning it some 200-300 meters downstream will have insignificant impacts on the river living organisms. A quick survey along the stream bed reviewed very low diversity and abundance of fish life and algal growth, found mainly in small pools along the stream. There are no known endangered species around the project area.

The other main impact of the project on the river system is that there will be increased sedimentation while the construction of the project takes place. However, this should be temporary and only while the weir and intake are being built. Provided proper construction procedures are employed during the construction of the rest of the project, increased sedimentation will be minimal allowing the normal river flow to flush it downstream.

From the initial alignment survey it appeared that the proposed intake at the cave was lower than the forebay site and therefore the need to take the intake further upstream at a higher level than the forebay altitude. This has caused a need to dig a tunnel through a ridge to arrive at a suitable intake site below the village water supply intake at the spring.

It is recommended that a tunnel is drilled through to the intake rather than blasting through the ridge. Consideration should be given to drilling more than one tunnel through the ridge if a single tunnel will not provide an efficient volume flow required for the hydropower system.

The Epong River and catchment area is largely undisturbed. All village socio-economic activities tend to take place below the project area. The project is highly supported by the whole village. They have no immediate need to change their landuse pattern and therefore it is conceivable that the project area and the Epong river and catchment will remain undisturbed for a long time. It is recommended however, that the government of Vanuatu close all construction roads associated with the power scheme once construction of the project is completed.

Effective operation of the Epao scheme and protection of its surrounding environment will depend on co-operation amongst a number of groups. These include the Energy Unit, the local villagers, and the Environment Unit. It will be necessary, for example to control forestry and agricultural development on the higher slopes of the river catchment area to prevent erosion but more importantly, to prevent changes in the direction of the river flow as experienced in the 1970s due to landslides from a local logging operation upstream.

This preliminary environmental impact assessment has not identified any major impacts of the project to require further detailed investigation, except for precise hydrological studies which must be completed with the engineering feasibility study.

This EIA study has undergone an internal review in SPREP which advocated a baseline ecological study of the project area. The author of this report is of the opinion that a baseline study is not required in this case because the project offers very minimal disturbance to the Epao environment. A baseline ecological study nonetheless, will provide detailed technical information, which will satisfy academic interests, but it is additional information which is not necessary at this time and which would cost around US$10,000 to commission.

1. INTRODUCTION

1.1 The Project

The proposed Epao Micro Hydroelectric Power Scheme in East Efate involves taking water from the headwaters below the Epong Spring and passing it through a 25KW power generator to discharge back into the Epong River. The Epong River, running alongside the village of Epao, approximately 50 km from Port Vila, offers a prospect for a very small hydro-electric power development which could also be used as a pilot plant for training of locals.

1.2 EIA Brief

The South Pacific Regional Environment Programme (SPREP) responded to a request from the Government of Vanuatu for assistance in preparing an Environmental Impact Assessment (EIA) on the Epao project. SPREP agreed to assist on the terms set out by the Vanuatu Environment Unit

This document is intended as an aid to decision making on the Epao Micro Hydroelectric Power Project. It presents summary information and makes recommendations on actions which could be taken to reduce the impacts of the development project.

The document is also intended as a guide for the Environment Unit for possible future EIA use on similar micro hydro power schemes in Vanuatu.

2. DESCRIPTION OF THE PROJECT

2.1 Introduction

The proposed Epao Micro Hydroelectric Power Scheme involves diverting water flow from the Epong river at elevation of about 20m into approximately 500m of covered canal along the right-hand bank of the river and feeding a power station near Epao village. Its location is identified in Figures 1 & 3.

The small storage reservoir is in the form of a Forebay which provides an effective head of over 15 metres supplying a cross flow turbine to produce a maximum of 25KW of power with an annual output of around 0.11MWH (megawatt hours). The project is co-financed by the German Government, which is providing approximately 50,000,000 Vatu (USD500,000), and the Vanuatu Government, providing 18,000,000 Vatu (USD180,000) for land acquisition, compensation and civil works.

2.2 *Scheme Works*

(See figure 2)

- The concrete headwater weir and intake is located below the Epong spring. It will have a small settling basin. All at 15-20m high.

- From the intake a concrete canal, (typically 40cm in diameter) will then carry the water through a small ridge via a tunnel (50m long) around the side of the slopes or along the top of the ridge on the right hand side of the river bank.

- The total length of the headrace pipeline is 400-500m from the intake to the forebay above the powerstation.

- The penstock leads down the steep hill side to the powerhouse near Epao village.

- The powerhouse location will be provided with good foundation material. The power house will be built to reduce noise emissions to the village. The powerhouse will discharge water via a short enclosed tailrace into the natural stream flowing through Epao village.

- The maximum discharge of water will be up to 200 litres per second.

- The cross flow turbine will be installed to produce around 0.11MWH per year.

- Transmission lines will be constructed preferably underground as it affords less maintenance but it will be cheaper to construct overhead power lines in which case the power lines should be well secured away from falling trees and branches. The overhead wires should have safety features to prevent lightning strikes on power lines.

2.3 *Future Development*

The pipeline, penstock and powerhouse will be built to allow for future possible augmentation of the waterflow and power output.

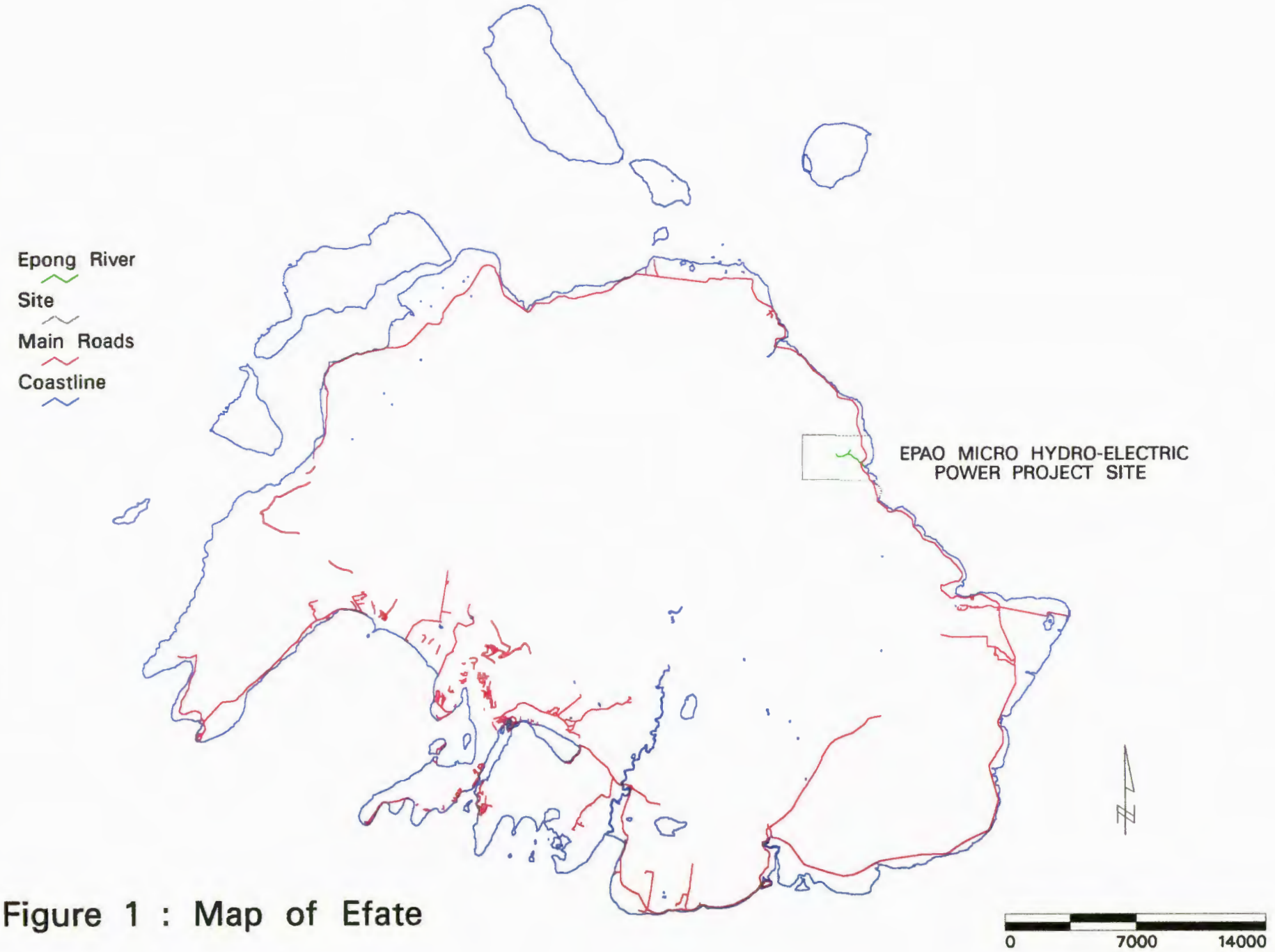

Figure 1 : Map of Efate

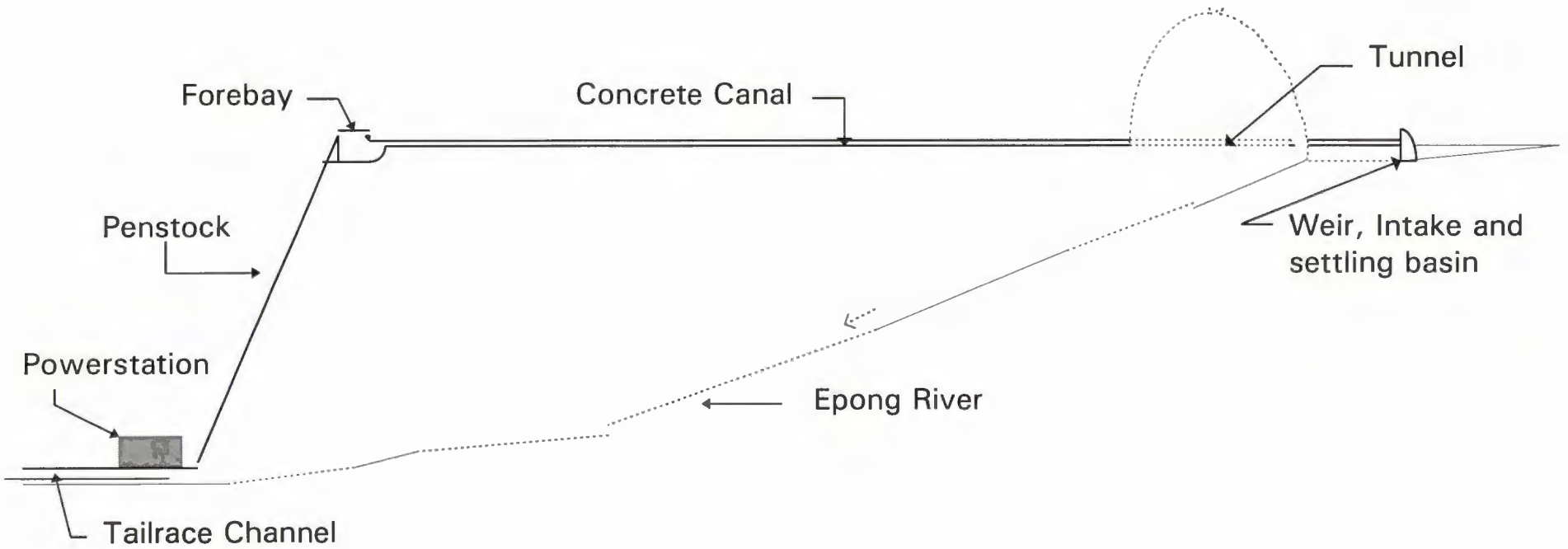

Figure 2: Sketch of Epao Hydropower Scheme

3. EXISTING ENVIRONMENTAL CONDITIONS

3.1 Physical Characteristics of the Scheme

3.1.1 Background

At the time of the environmental assessment, the topographic survey of the project area was not completed. Thus the hold-up in the completion of the feasibility study since the survey report is required to determine the suitable height for the intake location and the appropriate locations of the rest of the hydropower scheme.

3.1.2 Climate and Hydrology

The Epao area receives rainfall that averages approximately 2,300 mm annually. Temperatures range from a maximum 26-30 ^{0}C to a minimum between 19-23 ^{0}C. Vanuatu is prone to cyclones and Epao, like the rest of the country, gets hit with 64 knot winds or greater, once every three years while it is normal to have at least two more cyclones of lesser force, within the same three year period.

The collection of data for the hydrologic database for the project design, like the topographic data collection, has only recently commenced. It was not possible at the time therefore, to produce a comparison of the typical hydrographs representing both before and after conditions, including evaluation of adequacy of available river gauging data for typical normal, high and low year conditions.

The project's proposed flow intake of 100 litres per second, although small, representing approximately 30% of the normal river flow, will still alter the hydrological regime of the Epong river system. The feasibility study of the project should therefore provide adequate hydrological data to fully support the project.

3.1.3 Water Quality

The river water from the tributary and the Epong spring are of excellent water quality for practically all human uses. The project intake will be located below this spring which is the existing intake for the Epao village main water supply. Suspect water quality is limited to the lower parts of the river adjacent and downstream of the village due to lack of community sewerage and solid waste disposal systems before entering the sea.

3.2 *Ecology*

3.2.1 Aquatic ecology

The river supports fish life which is characterised by very low diversity and abundance. These are found mainly in several of the deeper pools of the river close to the village. Some larger fishes of the same species (unidentified) were found at the Epong spring which indicated some upstream migration of the species.

Freshwater fisheries is not actively pursued by the villagers. The only other use of the river was for swimming and laundry at the bridge site.

3.2.2 Wildlife

A couple of bird's eggs where found during the visit to the project site. The villagers do not assign much beneficial value to the bird life in this particular site. The whole project area does not seem to support much wildlife.

3.2.3 Vegetation

The dominant vegetation types in the project area which involves mainly the right hand side of the river are mid-height forests and secondary regrowth of thickets. The area is hardly used by villagers.

3.3 *Geology*

There is a general cover of limestone with alluvium, sand and or coral detritus over it. Government sources considered it unlikely that the project area, or the highland areas upstream will be disturbed for prospective mining.

3.3 1 Seismic Risk

An earthquake of a certain magnitude will be felt with intensity in different areas, depending on factors such as distance from the epicentre and local geological conditions. Maps of seismic intensity (Modified Mercalli Scale) likely to be felt in the various islands of Vanuatu have been prepared by ORSTOM in 1984. The intensity map for Efate is reproduced in Figure 3. The Vanuatu maps are based on the principle that if a certain intensity has been felt in a particular region in the past, then the same intensity may recur there in the future.

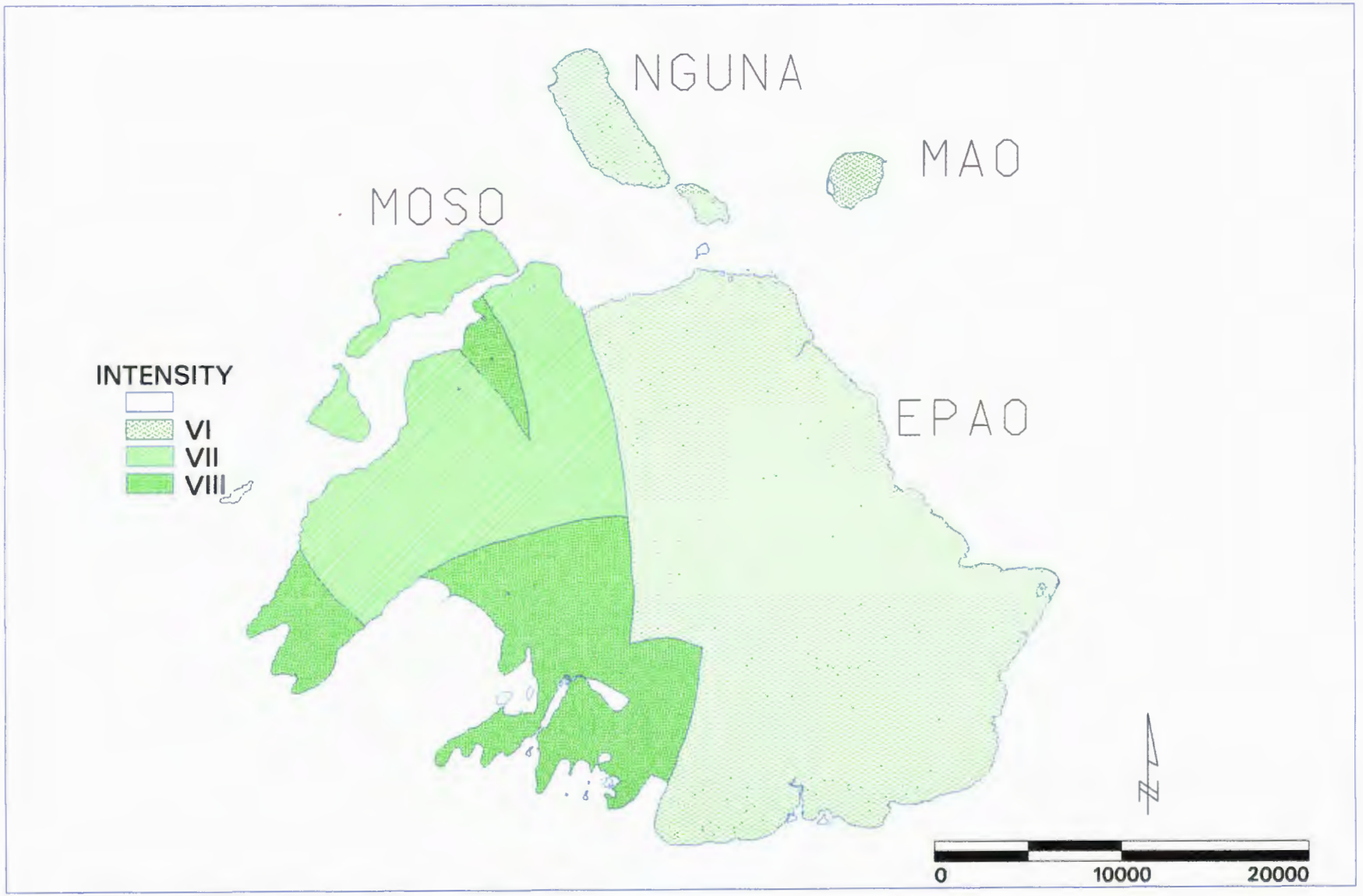

Figure 3 : Seismic intensity map of Efate

In terms of damage to engineering structures the following scale may be used:

MM Intensity	Damage
VI	very little, if any structural damage
VII	a small amount of damage to unreinforced masonry
VIII	substantial damage to unreinforced masonry, some damage to normal reinforced concrete. Houses shifted on foundations
IX	severe damage to most structures. Cracks in ground and landslides
X	most masonry and frame structures destroyed. Serious damage to dams and embankments, large landslides.

Based on the information above (see also Figure 3) it can be seen that for the Epao Micro Hydropower Project area, earthquake intensities of about MM VI can be expected within the economic design life of the project, although intensities in Port Vila over the same period could be up to MM VIII.

3.4 Socio-economics

3.3.1 Demography

See Annex 1 for details of Epao Village Survey.

The Epong river and the Epao Village are within the province of Shefa. The present population is around 247. The population density is about one person per hectare, compared to a national population density of 1.90 in 1989. The population live on the lowlands near the coast with all 46 households engaged in agricultural production mainly for commercial uses (60%) but also for subsistence living (40%).

3.3.2 Village water supply and sanitation

The Epong river supplies all water requirements for the village. The village water supply intake is located at the Epong spring where water is piped down to two holding tanks (approx 2000 litres each) on a low spur above the village. Every household has its own piped water main from which other taps are connected.

Sanitation is reasonably good due to the high quality water supply, except for the lack of a proper sewerage system. The nearby bushes are used for sanitary purposes and for the time being, this has not posed any major health problems because of the large area of bush currently utilised for such purposes by a relatively small number of residents. For long term planning for the village, it is recommended that a proper sewerage system is installed to maintain the positive gains already made in sanitation and public health in Epao village.

4. ENVIRONMENTAL EFFECTS OF THE SCHEME

4.1 Introduction

Evaluation of hydropower development, albeit at prefeasibility stage, should include a brief appraisal of significant effects on the physical, ecological and social environment.

The feasibility study for the scheme was not completed at the time of the environmental assessment. Thus, the locations and design of the scheme were the closest approximation the engineers were able to make on the best information available at the time. This report therefore looked at the overall project site and makes a comprehensive assessment of the possible immediate and secondary effects of the scheme.

4.2 River Flow

The proposed Epao scheme would effectively take out a third of the normal volume flow for 500metres of the river above the village. There is fish life and presumed upstream migrations/spawning patterns could be disturbed by formation of a weir. This could to some extent be overcome by taking up only a small side of the river for a weir, thus leaving a "fish pass" for the young ones to migrate upstream. Fish capture and transport over the obstruction should be arranged if necessary.

Water quality will be affected temporarily as the weir and settling basin is constructed. The settling basin must be able to be flushed or cleaned out periodically. The laying of the concrete canal, including the tunnelling through the ridge, and the building of the powerhouse will create disturbance to the landform and vegetation along the right hand side of the river above the village. Some soil erosion and sedimentation of the river during the construction phase therefore, will take place, but the village main water supply will not be affected.

Hydrologic analysis must be provided by the engineering feasibility study to show seasonal river flow needed for extracting sustained maximum power for the scheme from the river. The sustainability of the scheme depends largely on the required river flow being available all year round.

4.3 Construction

4.3.1 Tunnels

The only possible immediate environment impact of the tunnelling to carry the pipeline is that caused by the disposal of the tunnelling material. It is highly recommended that blasting is not used at all, instead drilling should be employed. The tunnel will be about 50m long

by 50cm wide thus the excavated material could amount to around 10 cubic metres - a small volume of material which could be disposed in the following manner:

(a) topsoil and highly weathered material from the tunnel should be dumped in spoil disposal area;

(b) weathered rock could be used for roading purposes; and

(c) good quality rock could be used as aggregate in concrete production.

4.3.2 Supply Canal

The route of the covered concrete canal follows the side of the ridge on the right hand side of the river. If survey heights permit, the canal should be laid along the top of the ridge line which would provide a more stable base for the canal.

The canal is typically 50cm high by 50cm wide and the contractors should limit the working zone to a 2m width over this some 500m route. Two work stations will be used; one near the tunnel area, the other near the powerstation. An access road will be necessary to the work station near the powerhouse but the existing road along the spur is adequate for access to the second work station.

The work stations should have a designated spoil disposal area each which together with access roads and all areas of bare spoil should be revegetated to prevent erosion. This should be specified in the civil contract.

In view of the high annual rainfall and the potential for high daily rainfall, this vegetation work should proceed as early as possible as the canal installation takes place.

4.3.3 Powerhouse

4.3.3.1 Noise Emission

The powerhouse will be constructed on a site approximately 50m above the Epao village. Noise arising from the generator would not be a problem. It is understood that "appropriate noise protection measures will be taken".

Since the powerhouse will be constructed at the boundary of an adjacent household, it is recommended that noise at the face of the powerhouse does not exceed 60dBA. This is an uncommonly accepted standard in New Zealand for industrial concerns adjacent to residential property. For continuous noise, production of 45dBA is the accepted standard at the boundary for noise produced at night.

There is insufficient information available to say definitely whether this standard would be met at the nearest household.

4.3.3.2 *Tailrace*

The tailrace canal carrying the spent water from the powerhouse will discharge directly into the river close above the Epao village. The single tailrace cannal of approximately 5m-10m length should have a grating at the outlet to prevent children entering the tailrace outlet.

4.3.3.3 *Outfall to Stream*

The discharge of up to 200 litres per second into the river will mean that the river will return to its normal flow just above the village area. It is acknowledged that leading the tailrace into the river will affect to a certain degree the village life (safety, bathing and washing habits). The river is used for washing clothes and children playing in the area

4.4 *Secondary Effects*

4.4.1 Power Transmission

The preference is for the transmission lines to be placed underground to the village because it affords more security to the scheme and aesthetically it is a better option than overhead power lines. Erecting overhead power lines however, is less expensive and therefore this alternative may be more acceptable.

Since Epao, as most of Vanuatu, receives two or more cyclones per annum, it is recommended that if overhead transmission lines are installed that they be erected securely and placed away from tall trees and falling branches to reduce chances of disturbance to the village power lines. Clearing of existing trees along the transmission lines should be kept to an absolute minimum, particularly from the powerhouse to the nearest household.

Thunder and lightning are common during rain storms. Transmission lines should therefore, have lightning protectors installed. There is concern by the villagers that without the lightning protectors, the electricity cables themselves might provide the transmission routes for flash lightning fires to the households.

4.4.2 Transportation of Materials

Construction of the Epao micro hydropower scheme is expected to take less than a year. Heavy trucks will be hauling all the components from Port Vila to the two work stations at the project site. This should not cause significant disruption to the villages along the dirt road from Port Vila as long as the trucks keep their speed down through the villages.

4.5 *Social Effects*

Construction of the hydropower scheme will have an obvious effect on local villagers. They will provide the labour for construction and clearing of the site. There will be a significant injection of cash in the local community, although it might not fall equally to all households.

In the longer term the power scheme will bring direct benefits to the local community providing electricity for the whole village. Some people will be directly employed for maintenance of the scheme. It would be desirable for as many of these workers as possible to be drawn from the Epao village itself with appropriate training provided.

The power generated by the hydro scheme will have significant benefits at the national level. It will provide a reliable electricity supply to the village at minimum costs. The hydropower scheme will provide a training facility for energy officers and others in micro hydropower scheme management. Government is utilising the available renewable natural resource to help reduce dependence on imported diesel.

5. CONCLUSIONS AND RECOMMENDATIONS

The Epao micro hydropower scheme represents a typical project where a renewable natural energy resource, in this case the presence of running water, is utilised to generate electricity to the village community of Epao. Use of the Epong river, by diverting a third of its normal flow, will not cause significant environmental losses in this case. The construction of the scheme however, will produce some impacts which can be mitigated by incorporating environmental planning as recommended in this report.

(1) Hydrologic studies must be completed to fully support the seasonal river flow required for extracting sustained maximum power for the scheme.

(2) Building of the intake in the river will block upstream migration of fish.

(a) **Recommendation:** That sufficient "fish passage" room is given when constructing the weir and settling pond.

(b) **Recommendation:** That the intake weir and settling pond have the capacity to accommodate storm flows and a flushing mechanism that reduces frequent servicing.

(3) The tunnelling poses a slight problem because of the lack of a 50cm width drilling machine in the country. Blasting has therefore been considered.

(a) **Recommendation:** That, instead of blasting, two or more tunnels are drilled, side by side, using the available but small drilling machine.

(b) **Recommendation:** That the excavated material is disposed of in the designated spoil disposal area.

(4) Construction will lead to exposed soil and spoil along the 500metre length of the project site.

(a) **Recommendation:** That two workstations are maintained with designated spoil disposal areas.

(b) **Recommendation:** That during clearance of the site, trees are avoided and the working zone along the canal route is limited to the trench size that will hold the canal.

(c) **Recommendation:** That revegetation of all exposed areas is undertaken as soon as the canal installation takes place.

(d) **Recommendation:** That all access roads to and including the workstations are closed and revegetated as soon as the construction of the scheme is completed.

(e) **Recommendation:** That recommendations (4) (a) - (d) form part of the contract for the construction of the project..

(5) The secondary effects of the project are also important considerations that have to be taken into account in any environmental assessment. It is recommended that the Environment Unit monitors the progress of the construction of the project and recommends apropriate actions as and when new environmental considitions arise.

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Annex 1-1

VILLAGE QUESTIONNAIRE

QUESTIONNAIRE FOR FIELD SURVEY

Province	: SHEFA
Island	: EFATE
Village	: EPAU
Subvillage	:

Data in this section refer to the village or to the particular part of the village where the microhydroplant is projected. Information is based on a survey made by the field economist and an interview held with the village chief and other community members .

A. VILLAGE CHARACTERISTICS

1 a. Number of houses

	Units	%
permanent	108	100
semi permanent	0	0
under construction	0	0
Total	108	100

1 b. Number of households

Units	46

2. Grouping of houses

a. Total number of clusters: 4

b. Number of households in:

		Cluster type
cluster 1	4	C
cluster 2	25	C
cluster 3	12	A
cluster4	5	C
outside any cluster	0	
	46	

A = alongside the road, distances between houses below 50m
B = alongside the road,distances between houses above 50m
C = houses grouped in a circular way
D = other

3. Distance from the projected hydropower plant

cluster 1	50 meters
cluster 2	300 meters
cluster 3	600 meters
cluster 4	1200 meters

4. Distance of village from UNELCO network (applicable only in Efate and Santo)

Distance from UNELCO transmission line: 60 km

5. Distance from main road

a. Road distance: 0 km

b. Quality of road

tarmac		gravel	X	earth	

6. Distance from district capital

Annex 1-2

a. Road distance: 68 km

b.transport services

public bus	
private service	X
no transport available	

c. Mode of transport

bus	X	boat	

B. POPULATION

1. Number of inhabitants today

Age	Total
<10 years	35
11-20 years	25
21-60 years	180
>60 years	7
Total	247

age distribution to be based on estimate

2. Population growth

	inhabitants
Total population 1994	247
Total population 1989	204
Total population 1985	?
Total population 1980	?

3. Number of households

Number of households	46
Number of family heads	51

4. Education of the head of family

	No.	%	
No school at all	1	2	
Primary school, not finished	10	20	
Primary school, finished	32	63	
Secondary school, not finished	2	4	
Secondary school, finished	4	8	
College, university	2	4	one only during holidays in village
Other (training)	0	0	
Total	51	100	

5. Employment situation of the head of family

	No.	%
Government employee	3	6
Trader, business man	5	10
Farmer	40	78
Unregular employee	3	6
Other	0	0
Total	51	100

C. VILLAGE INFRASTRUCTURE

1. Public Infrastructure

	No	
Primary school	1	
Secondary school	0	
Other type of school	1	kindergarten
Government office	0	
Aid post	1	in women's club
Community hall	2	
Post office	0	
market with building	0	
water supply (by power)	0	
Church	1	
telecommunication office	0	
Police station	0	
Other	0	

2. Private/community infrastructure

	No.		
Grocery shops	3	size of shop	small
restaurant/nakamal	1		
Handicraft centre	0		
Workshop	0	Type of workshop	
Other	0		

D. VILLAGE PRODUCTION

1. Agricultural production

a. number of households engaged in agricultural production: 46

b. Average size of agricultural land per household (hectare): 1

Share of	%
Subsistance agriculture	40
Commercial crops	60

2. Plantations

a. Fruit trees

Number of households engaged in plantation of fruit trees: 46

Average number of fruit trees per household: 70

Major type of fruit trees (mark two):		
	Papaya	
	Banana	X
	Orange	
	Coconut	X
	Avoca	
	Other	

b. Commercial plants

Number of households engaged in plantation of commercial plants: 46

Average number of commercial plants per household: above 100

Major type of plants (mark two)	
Yam	
Manioc	X
Cacao	
Sugar cane	
Kava	
Taro	
Other	

3a. Animals (total number in the village)

	No.
Cows	150
Goats	50
Pigs	50
Chicken	300
Ducks	2

3b. number of families who own animals

No.
46
11
20
46
1

4. Machinery (number and total capacity)

	No.	Cap	
Diesal/gasol. generators	2		both owned by shopowner and under repair
Tractors	1		
Trucks and pick-ups	3		
Motor boat	0		
Other	0		

5. Non-agriculture production/services

small handicraft centre for tourists in shop outside the village:
an entrance fee for a closeby cave is charged from tourists.

E. VILLAGE WEALTH INDICATORS

(Total number of units in the village)

	No.	
Ordinary kerosene lamps	100	
Coleman pressurized lamps	25	
Radio sets /cassette rec.	65	
Television sets	1	
Refrigerators	1	in shop outside village
Motor bicycles	0	
Motor Cars	0	
Other	0	

Distance to nearest kerosene supply station: 0km

F. HOUSEHOLD INCOME

1. Average monthly income per household (estimate of vilage chief) — 10, 000 Vatu

2. Cost of living per household per month — 5,000 Vatu

G. ELECTRIFICATION

1. Existing installations or plans to provide electricity

	existing number	planned number	capacity (in W)
stand alone PV	1	0	80
centralized PV	0	0	
gasoline generator	1	0	
diesel generator	1	0	
other	0	0	

H. WILLINGNESS TO CONNECT

1. Number of households willing to have electricity
(estimate of village chief) — 43 households

2. Average power demand desired by each household
(estimate of village chief)

200w /household

appliances to be used
lighting
radio/tape recorder
video?

3. Affordable connection fee for the village
(estimate of village chief)

10,000 -15,000 Vt/household

4. Affordable monthly tariff for the village
(estimate of village chief)

500 -1,000 Vt/month

5. Preferred periods of electricity service
(estimate of village chief)

	yes /no
24 hours per day	X
from 17h to 24h	X
from 17h to 6h	X

6. Number of villagers willing to contribute labour for construction works

all

7. Village interest in the management of the plant

Annex 1-6

no responsibilty for management	
only operations, maintenance and repair	
full operational and financial responsibility	X

I. PRESENT USE OF ENERGY FOR LIGHTING AND ELECTRICAL APPLIANCES

1. Appliances used for lighting

	no. of household.	no of hours per day	
ordinary kerosene lamp	46	12	
pressurized lamp	21	only feasts	
torch light	46	0.25	outside
open fire	0		

2. Consumption of energy for lighting

	litre/day	
ordinary kerosene lamp	0.2	for 12 hours
pressurized lamp	1	for 12 hours

duration of use of set of battery for torch light	3 -4 weeks
size of torch light (number of batteries)	3-4

3. Consumption of energy for other appliances

duration of use of set of battery for radio	100 hours	(4 batt.)
duration of use of set of battery for tape rec.	12-15 hours	(8 batt.)

consumption of kerosene for refrigerator	n.a	litre/week

consumption of diesal for water supply	n.a	litre/week
period of operation of water supply per week	n.a	hours
capacity of water pump	n.a	kw

4. Price of energy

price of kerosene	70	Vt per litre
price of diesel	72	Vt per litre
price of dry cell battery	60 -80	Vt per batt.