WATER QUALITY IN THE MONASAVU RESERVOIR AND WEIRS AND WAILOA RIVER IN 1990

INR TECHNICAL REPORT NO. 91/3

April, 1991

INSTITUTE OF NATURAL RESOURCES

UNIVERSITY OF THE SOUTH PACIFIC

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WATER QUALITY IN THE MONASAVU RESERVOIR AND WEIRS AND WAILOA RIVER IN 1990

P. Gangaiya, A. Haynes, W. Peter and D.R. Green

Report prepared for the Fiji Electricity Authority

April, 1991

INTRODUCTION

The Monasavu hydroelectric scheme, situated on the Nadrau Plateau in central Viti Levu, Fiji was constructed in the period 1977-82. The filling of the dam began in 1982 with minimal vegetation removal. The reservoir is fed directly by the Nanuku Creek. Other small weirs divert streams to the south of Nanuku Creek into a pipeline which eventually empties into the Monasavu reservoir.

Since the filling of the Monasavu reservoir in 1982, the Institute of Natural Resources (INR) has been involved in the monitoring of water quality in the reservoir and Wailoa River for the Fiji Electricity Authority (FEA) (Gibbons and Brodie, 1985; Gangaiya, 1986; Brodie et al., 1987; Naidu, 1988 and Morrison et al., 1990). The principal aim of the study has been threefold: to study the water chemistry of the reservoir; to monitor the Wailoa River below the power station outfall and to monitor the public health status of the reservoir. In 1990, FEA requested an additional dimension in the monitoring study: to study the water quality at the weirs which contribute water to the Monasavu reservoir.

This report presents the results of the water quality monitoring in 1990, which was carried out in accordance to the proposal dated 4 May 1990 submitted by INR (Appendix 1).

The Monitoring Programme :

1. The Organisation

The monitoring of the Monasavu reservoir, weirs and Wailoa River was carried out in July and December 1990. Table 1 gives an outline of the parameters measured. Except for temperature and dissolved oxygen which were determined on-site, all other measurements were made in the INR laboratory on water samples collected in clean plastic bottles.

2. Location of Sampling Sites

2.1 Water Chemistry

The sampling sites in the Monasavu reservoir remained the same

Table 1 : Water quality monitoring programme

	No of sites monitored Water Chemistry	Monitoring sequence	Parameters measured
Monasavu Reservoir	3 stations each at 3 different depths		Temperature and dissolved oxygen profiles, clarity, pH, alkalinity, chlorophyll a, b and c, nutrients - total nitrogen, phosphorus and sulphur, ammonia, nitrate, phosphate dissolved and total iron and manganese
Wailoa River	3 stations		As above
Weirs	5 stations		As above and suspended solids, total dissolved solids
	Biological study		
Monasavu Reservoir	2 stations	July 1990	Invertebrates
Weirs	5 stations	July 1990	Algae

as in previous years (1984-1989), and are shown in Figure 1. For the Wailoa River, however, one of the four sites (located 150 m below discharge of the outflow from power station) was excluded, leaving the three sites indicated in Figure 2. The locations of the five weir sites (Wainabua, Nabilabila, Wainikasau South, Wainikasau North and Wainisavulevu) are given in Figure 3).

2.2 Invertebrate Study

The two sites visited in the Monasavu reservoir were those sampled in previous surveys. They are situated at (1) the end of the road leading to the lake (now made into a boat landing area) and (2) the dam edge. Both have relatively shallow water and a rock or gravel bottom.

The five weir sites were also inspected for algal growth.

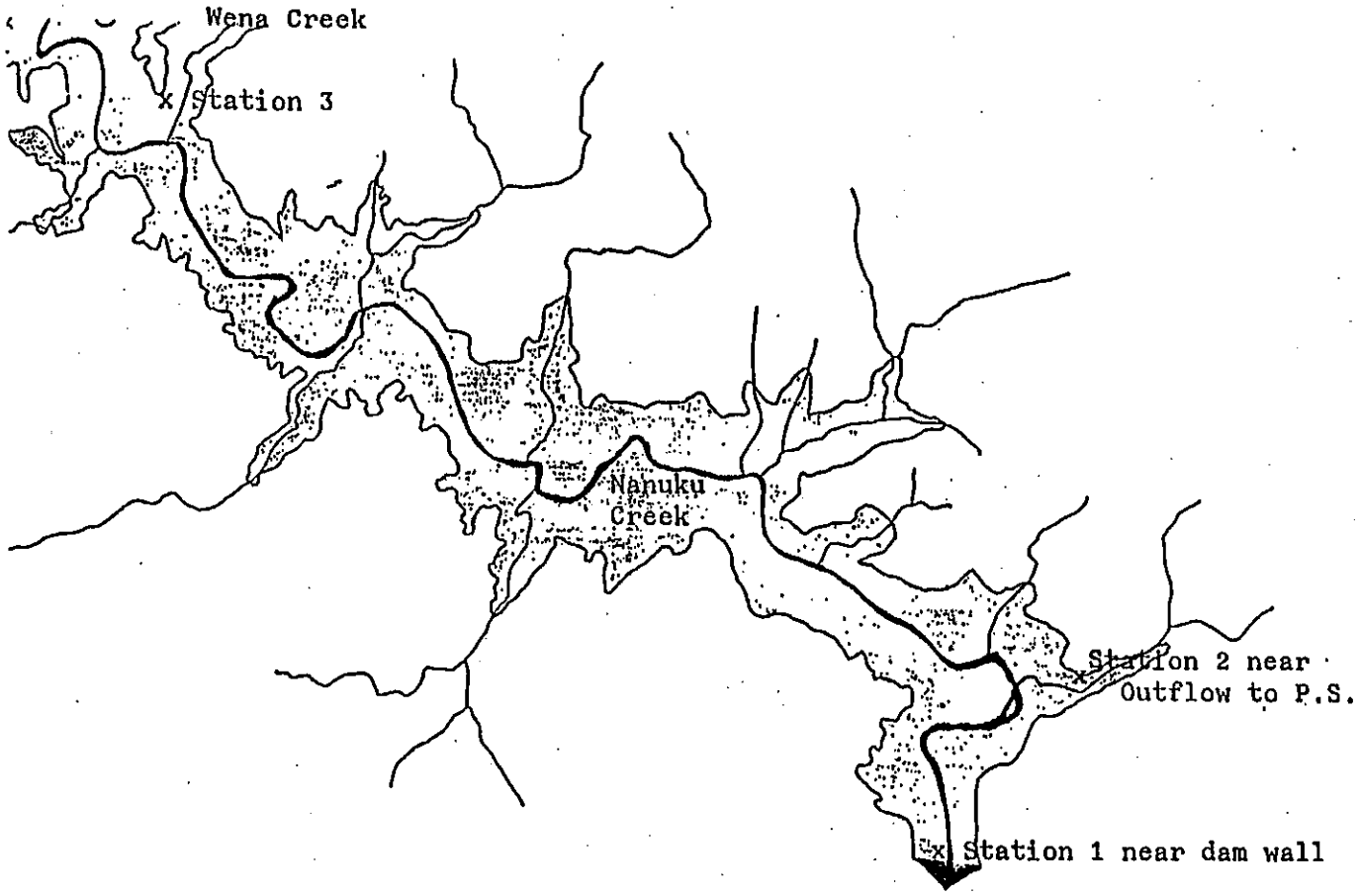

FIGURE 1 : Location of the sampling stations in the Monasavu Reservoir

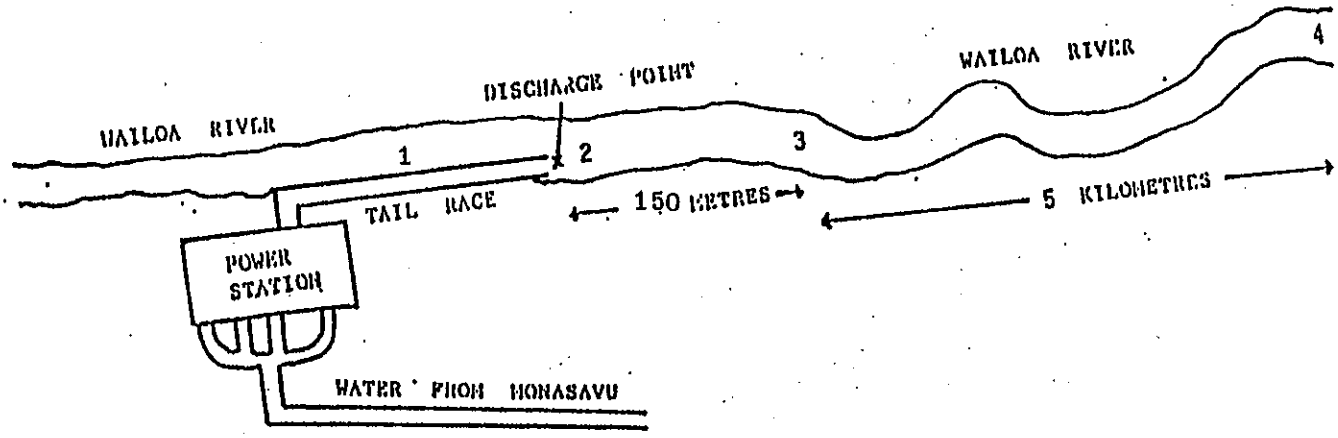

FIGURE 2 : Sampling sites along the Wailoa River

Site : 1 100 m above P.S. discharge
2 Tailrace
3 150 m below P.S. discharge
4 Wailoa at Laselevu

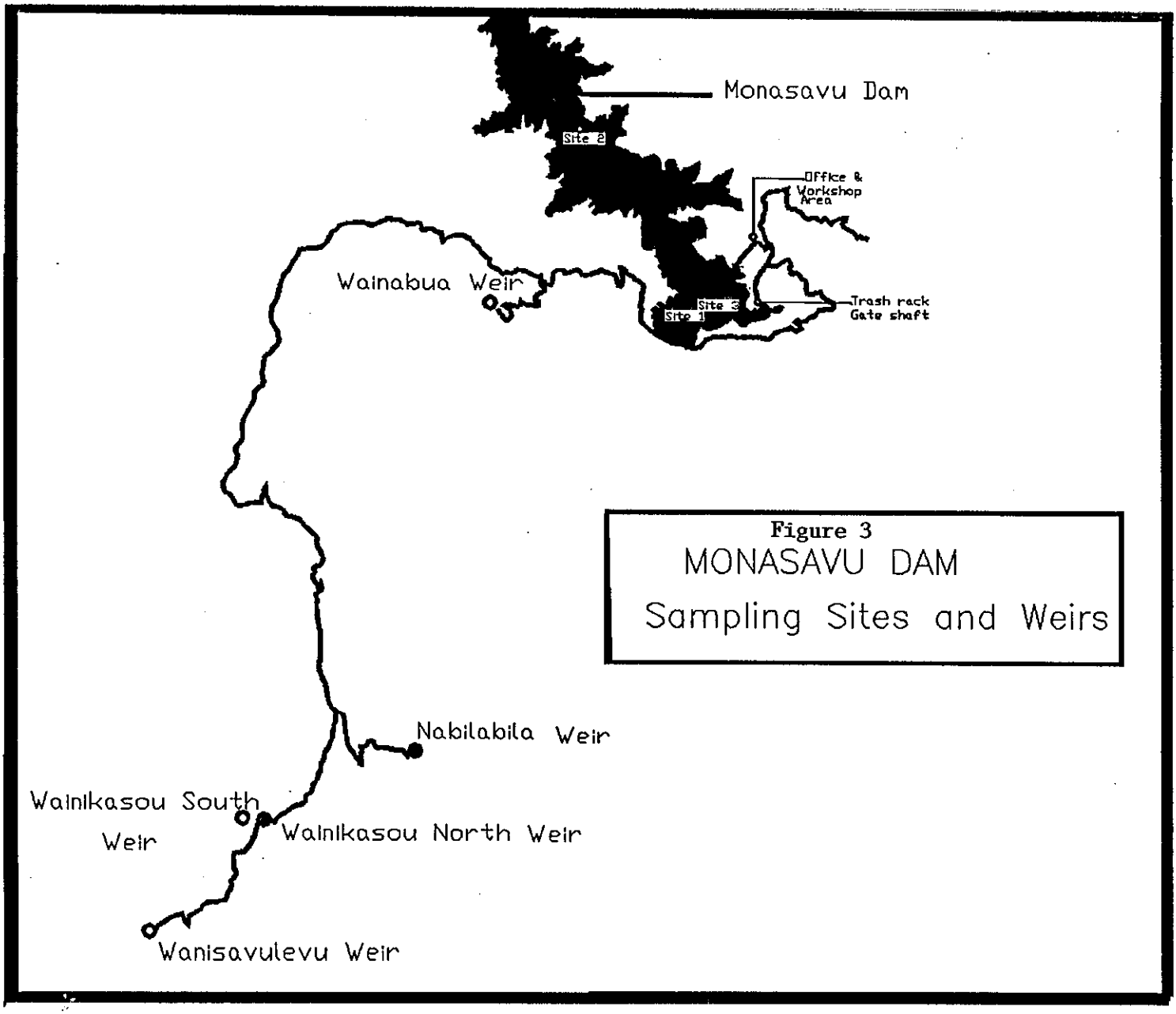

Figure 3

MONASAVU DAM

Sampling Sites and Weirs

3. Results for Water Chemistry

The dissolved oxygen and temperature profiles for each of the three sites in the Monasavu reservoir are given in Figure 4. The data on water chemistry for the reservoir, weir and Wailoa River sites for the July and December monitoring are given in Tables 2 and 3 respectively.

4. Interpretation of Results

4.1 The Monasavu Reservoir

a) Temperature and Dissolved Oxygen Profiles

Figure 4 shows that as in previous years the lake was fairly homothermal during the winter period with oxygenated water even at the bottom of the lake. In the summer, however, the bottom waters got depleted of oxygen.

Comparison of the dissolved oxygen profiles with those obtained in 1989 shows that during the winter period the amount of oxygen at a depth of 20 m was greater in 1989 than in 1990 whilst during the summer period, 1990 profiles show considerably greater amounts of oxygen at the same depth (see Table 4).

One of the reasons that may explain these results is that during the 1990 winter monitoring the water in the reservoir had not completely "turned over" and the waters at depth still had lower levels of oxygen. The considerably higher levels of oxygen at similar depth during the summer period in 1990 support the supposition of the delayed turnover, as sufficient

Table 4 : Dissolved oxygen (mg/L) at 20m at Stations 1, 2 and 3 in 1989 and 1990

		Station 1	Station 2	Station 3
	1989	6.0	7.4	7.0
Winter	1990	4.9	5.5	2.5
	1989	0.6	0.8	0.2
Summer	1990	3.9	3.6	1.0

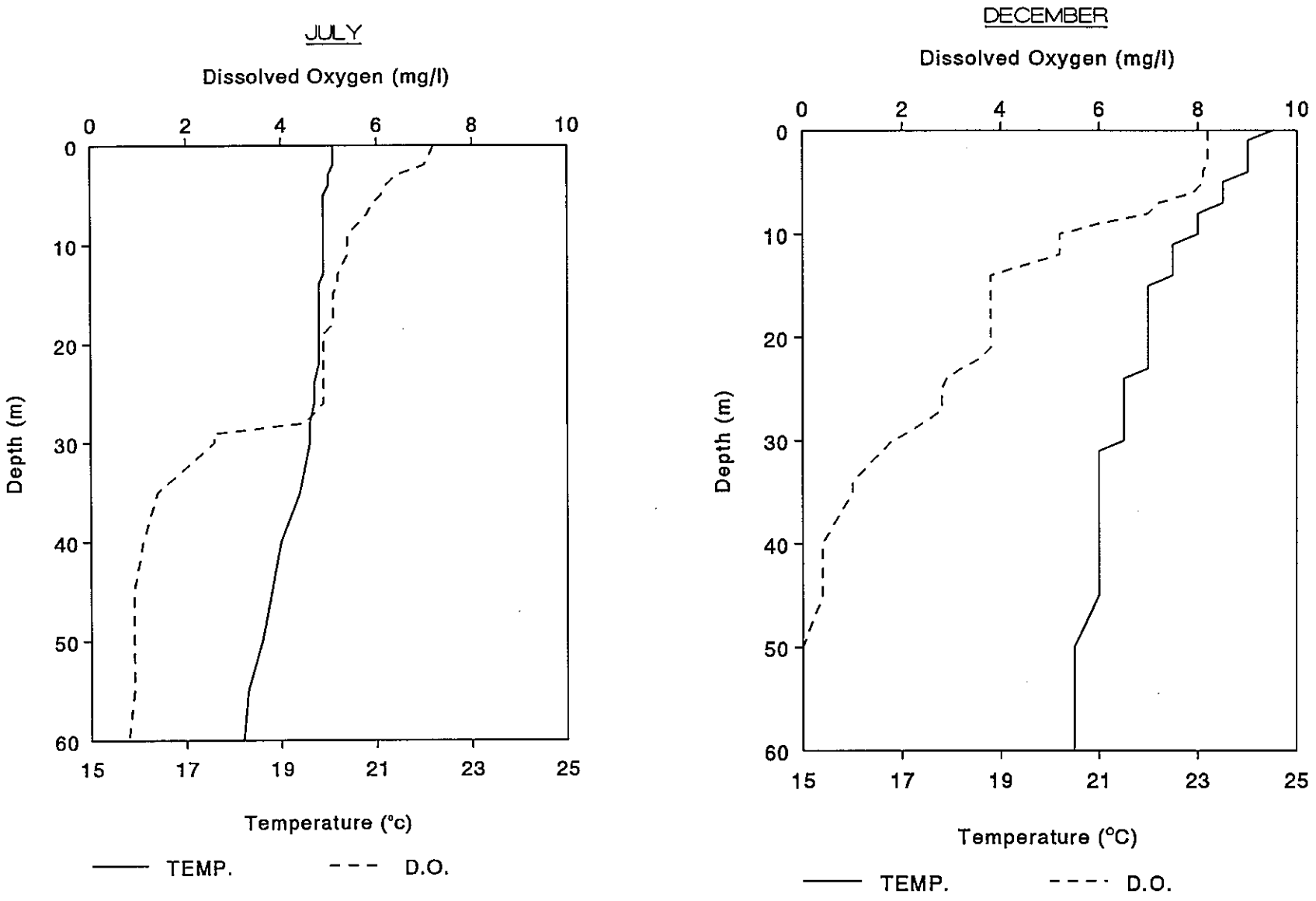

Fig.4a: **DISSOLVED OXYGEN/TEMPERATURE PROFILE**

MONASAVU DAM -STATION 1 - 1990

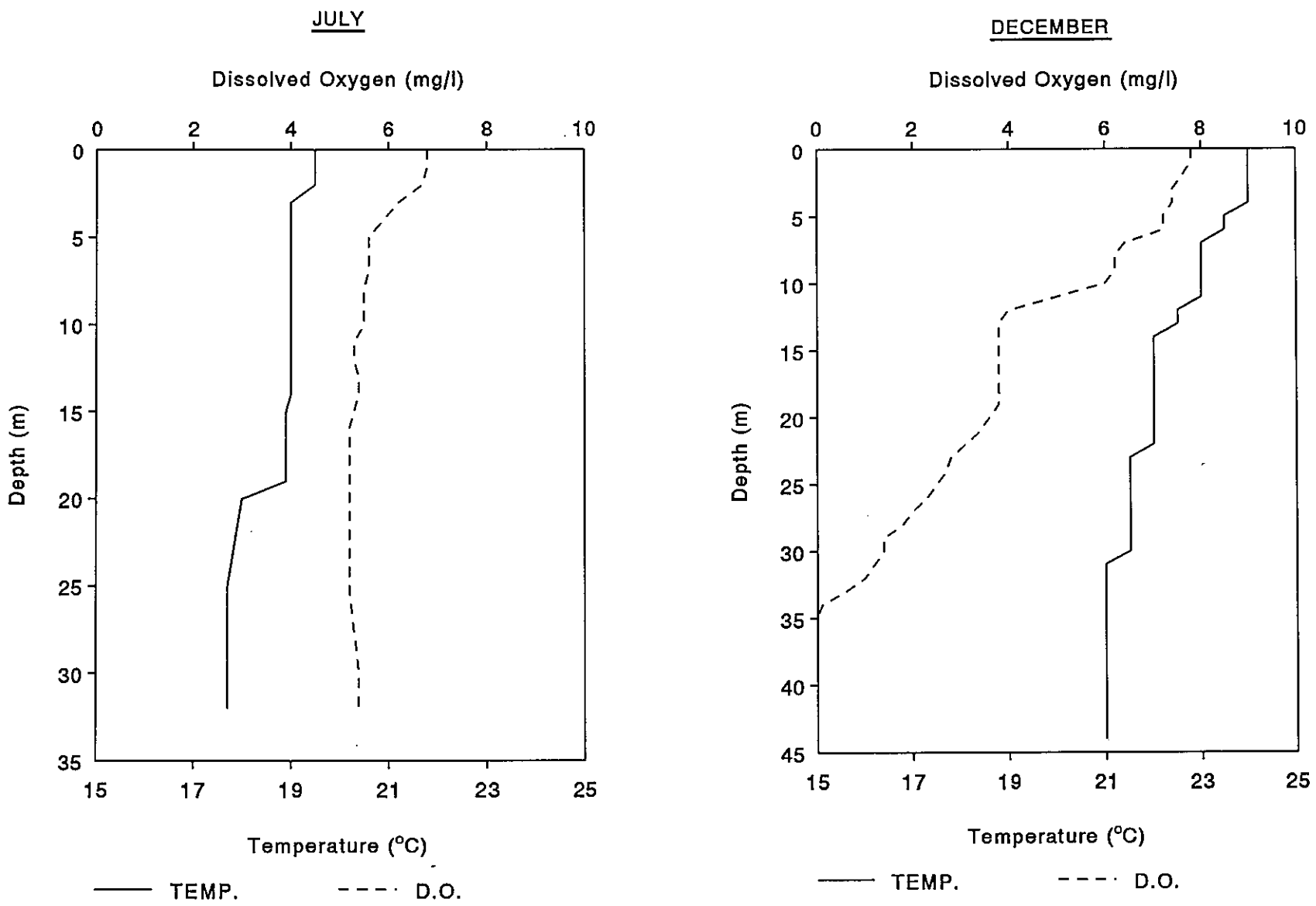

Fig.4b: **DISSOLVED OXYGEN/TEMPERATURE PROFILE**

MONASAVU DAM - STATION 2 - 1990

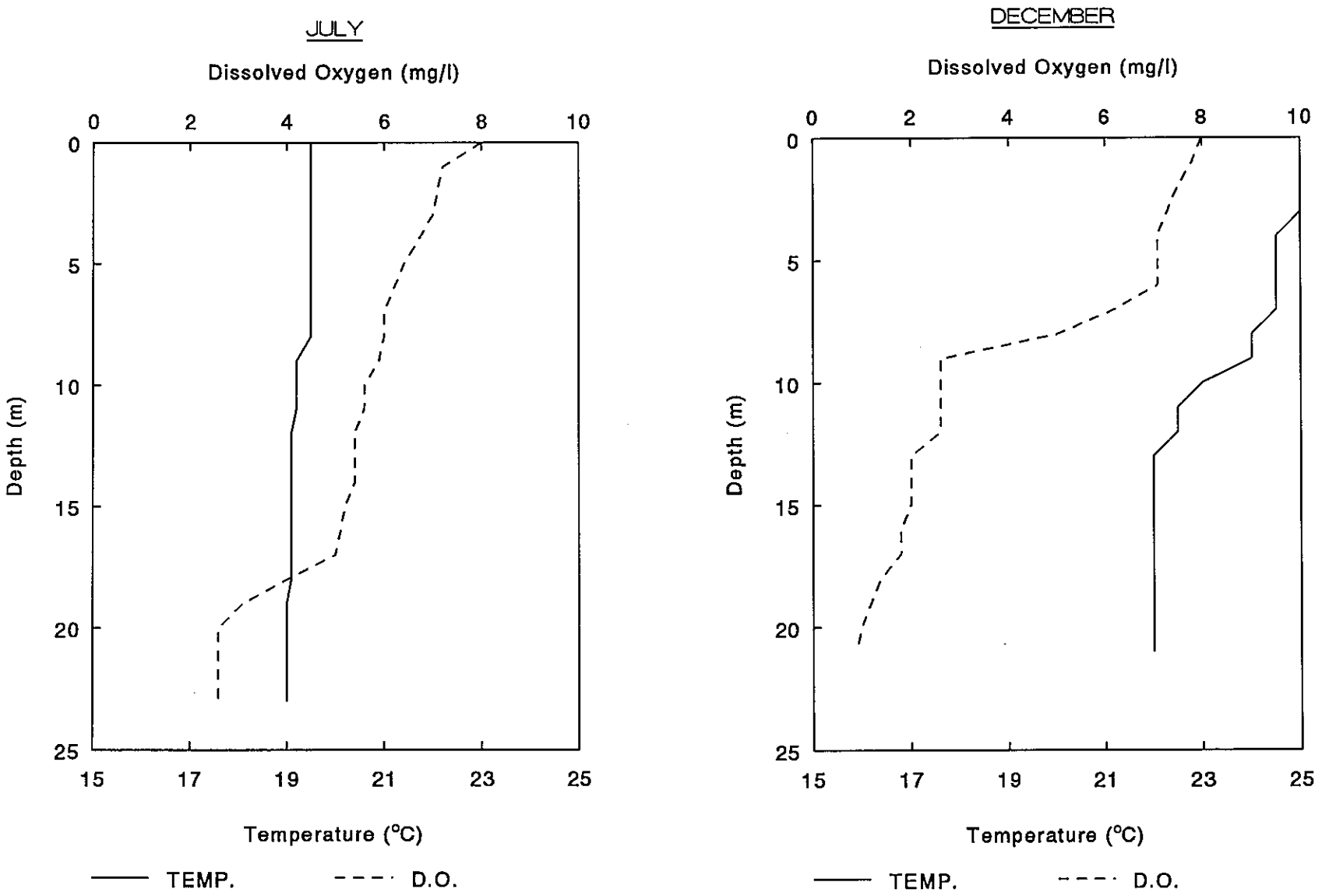

Fig.4c: **DISSOLVED OXYGEN/TEMPERATURE PROFILE**

MONASAVU DAM - STATION 3 - 1990

time was not available for the oxygen to get completely used up in decomposition processes before the next monitoring was carried out.

b) pH

The pH of the water samples at all depths was in the range 6-8, as expected for most natural waters. A decrease it pH with depth was noted.

c) Nutrients

i) Nitrogen

There was no significant pattern with depth in the concentrations of total nitrogen in the reservoir. However, greater amounts were present in the summer period (1.6-3.0 mg/L) than in the winter period (0.04-1.85 mg/L).

For nitrate, the amounts present in the summer period were generally lower than the amounts in the winter period (Table 5). This can be explained as greater utilization for photosynthetic activity during the summer period. The amounts of nitrate also increased with depth, indicating greater photosynthetic activity in the top layers.

The concentrations of ammonia generally increased with depth with greater amounts in summer than in winter; explained by the lower levels of oxygen in the summer months.

Table 5 : Nitrate and ammonia concentrations in surface and bottom waters of the Monasavu reservoir in 1990

	Nitrate (mg/L)		Ammonia (mg/L)	
	Summer	Winter	Summer	Winter
Surface	0.01-0.06	0.04-0.11	41-62	4-6.5
Bottom	0.04-0.11	0.21-0.35	79-1500	12-1000

ii) Phosphorus

As for total nitrogen, there was no significant pattern with depth for total phosphorus and greater amounts were present in the summer period (32-230 ug/L) than in the winter period (19-96 ug/L).

Phosphate concentrations were measured in the summer monitoring only. There was no obvious pattern and the range obtained was 17-209 ug/L.

The reactive nitrogen to reactive phosphorus ratio (RN:RP) was 1.9 for the summer period (RN:RP for the same period in 1989 was 67 and for 1988 the figure was 1.2). This shows that the limiting factor for phytoplankton production is not always phosphorus as suggested in the report on the 1989 monitoring (Morrison et al., 1990).

iii) Sulphur

Total sulphur values ranged from 0.53-1.7 mg/L in the winter period and <1.7-4.0 mg/L in the summer period.

iv) Total and Dissolved Iron and Manganese

The total and dissolved ion and manganese continued to be low and were generally undetectable. Detectable amounts were present in the bottom water of Station 1 only in July and all three stations in December. The oxidation of iron and manganese followed by precipitation as particulate matter explains the low levels in surface waters.

4.2 The Weirs

The temperature of the water in the weirs in July was 4-5 degrees lower than in December and the dissolved oxygen content was higher in July at all weirs except at Wainisavulevu.

The pH and nutrient content of the weir waters were similar to the values obtained for the reservoir water and followed the same trends. The total

nitrogen and phosphorus contents were lower in July. The nitrate concentrations were lower in December and the ammonia concentrations were lower in July. The iron and manganese concentrations were generally very low. The reasons for these patterns are the same as for the reservoir waters.

The total suspended solids were almost negligible in both July and December and the total dissolved solids were low (13-65 mg/L), as expected for fresh water.

4.3 The Wailoa River

The water exiting the power station was rapidly oxygenated but the amounts of dissolved iron and manganese were still higher than the amounts in the Wailoa River above the power station. however, by the time the water reachesed Laselevu, the amounts were reduced to background values. Levels of nutrients and seasonal variations were as for the weir and reservoir waters.

5. Biological Study

As well as the gastropod *Melanoides tuberculata* which was present in the lake in 1988 and 1989, two other gastropods *Melanoides lutosa* and *Physastra nasuta* were found in small numbers. *Physastra nasuta* was last present in the lake in 1987.

Of the ten specimens of *M. tuberculata* dissected, the mantle of one 20 mm high specimen contained a nematode worm which was probably commensal rather than parasitic.

The invertebrates found were :

Gastropoda : *Melanoides tuberculata*
Melanoides lutosa
Physastra nasuta

Hirudinea : (leeches)	*Vivabdella* sp.
Planaria : (flatworms)	a small pink flatworm
Porifera : (sponges)	green sponge on rocks
Trichoptera :	caddisfly larvae
PLANKTON :	Copepods (Crustacea) were very abundant, fern sporangia, plant seeds and blackfly that had fallen into the water.

Wainisavulevu, Wainikasou South and Wainikasou North Weirs contained large amounts of the large green alga, *Chara excelsa*. This weed obstructs the outfalls of these weirs after heavy rain.

This plant was mentioned in the Report on Wainisavulevu Creek 1979 as *Nitella* sp. and was found in quieter sections fo the streams e.g. at Wallutu camp, just above Vuwa falls and just above Nabilabia - Wainisavulevu confluence.

CONCLUSIONS

The chemical, physical and biological assessments of the reservoir indicate that it is in what appears to be a stable cycle of temperature stratification and oxygen depletion at depth in the summer and reduced stratification with re-oxygenation of the water in the winter months. Oxygen levels were somewhat higher in the December monitoring than in the previous summer monitoring, but this may be a function of the variation in timing of the sampling (December versus February) rather than any real improvement in water quality. The other parameters monitored show no obvious abnormalities, so the reservoir appears to be in a stable, and perhaps an improving condition with regard to water quality.

The weirs showed good water quality, although Wainisavulevu, Wainikasou, and Wainikasou North weirs contained lots of the large green algae *Chara excelsa*, which, we were told, sometimes obstructs the weir outfalls after heavy rains.

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Morrison, R.J., Haynes, A., Peter, W. and Green, D.R. 1990. Water quality in the Monasavu reservoir and Wailoa river in 1989. INR Technical Report No. 90/2, 14p.

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APPENDIX 1

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INSTITUTE OF NATURAL RESOURCES

Our Ref :

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Date : 4th May, 1990

P.O. Box 1168, Suva, Fiji.
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313900 Ext. 343, 374, 348, 339, 251
Telex : FJ2712 (Wateres)
: FJ2276
Fax : ~~XXXXX~~ 300373
Cable : INR, University, Suva.

The General Manager
Fiji Electricity Authority
Private Mail Bag
LAUTOKA

Attention : Mr Hing Sue

Dear Sir

Further to your discussions with Professor Morrison and Dr Green, please find attached our proposal for the monitoring of the Monasavu Dam and environs for this year.

We hope this is to your approval.

Yours sincerely

C R Lloyd
DIRECTOR

PROPOSAL FOR MONITORING OF MONASAVU DAM AND ENVIRONS - 1990

1. SITES :

The following sites will continue to be monitored :

i) Station 1 - reservoir (surface, mid, bottom)

ii) Station 2 - reservoir (surface, mid, bottom)

iii) Station 3 - reservoir (surface, mid, bottom)

iv) Above Wailoa Power Station

v) Tail Race - Wailoa Power Station

vi) Laselevu Village

In addition there will be four (4) sites at upstream weirs sampled this year. This would give a total of ten (10) sites and sixteen (16) samples on each visit.

2. FREQUENCY OF SAMPLING :

Two visits are planned. One in June/July (mid-winter) and another in December (mid-summer).

3. PARAMETERS TO BE MEASURED/ANALYSED

For each of the sites mentioned in 1 above, the following parameters will be measured/analysed :

pH, dissolved oxygen, temperature, dissolved and total iron, dissolved and total manganese, total phosphorus, total sulphur, total nitrogen, nitrate, ammonia, dissolved phosphate, alkalinity and chlorophyll a, b and c.

At stations 1, 2 and 3 (reservoir) a dissolved oxygen/temperature profile will be measured together with clarity.

Additional analysis for suspended solids and total dissolved solids will be done on the four weir samples.

An invertebrate study will be carried out in the June/July visit.

(Note : A full analysis of the weir sites will be carried out this year only to generate baseline data. For subsequent years, only selected parameters will be measured - the costs will therefore be lower in the future).

4. MANPOWER

i) Sampling :

Two (2) days per sampling visit for one laboratory assistant, one laboratory technician and one senior technician

ii) Invertebrate Study :

One (1) day for one sampling visit for one fellow.

iii) Report Preparation :

Two (2) days for one senior fellow.

iv) Laboratory Analysis :

Costs covered by analysis charges.

5. REPORT :

Data obtained from the June/July monitoring will be sent one month after the monitoring. A final report will be produced two months after the December monitoring.

6. COSTING :

i) Measurements/Analysis :

- pH/dissolved oxygen/temperature/clarity	$ 15.00
- dissolved and total iron	$ 12.00
- dissolved and total manganese	$ 12.00
- total phosphorus	$ 12.00
- total sulphur	$ 12.00
- total nitrogen	$ 25.00
- nitrate	$ 10.00
- ammonia	$ 10.00
- dissolved phosphate	$ 10.00
- alkalinity	$ 10.00
- chlorophyll a, b and c	$ 35.00
TOTAL COST PER SITE	$ 163.00

oCost of analyses for sixteen (16) samples per visit for 2 sampling visits = 16 X $163 X 2 = $5,216.00

- suspended solids	$ 10.00
- total dissolved solids	$ 10.00

oCost of additional analyses for four (4) weir sites per visit for two sampling visits = 4 x $20 x 2 = $ 160.00

*TOTAL FOR ANALYSES $5,376.00

ii) Sampling :

o laboratory assistant - 2 days per visit for 2 sampling visits = 2 x $120 x 2 = $480.00

o laboratory technician - 2 days per visit for 2 sampling visits = 2 x 190 x 2 = $760.00

o senior technician - 2 days per visit for 2 sampling visits = 2 x $300 x 2 = $1,200.00

*TOTAL FOR SAMPLING $2,440.00

iii) Invertebrate Study :

o fellow - 1 day for 1 sampling visit

= 1 x $375

*TOTAL FOR INVERTEBRATE STUDY $ 375.00

iv) Report Preparation :

o senior fellow = 2 days = 2 x $560

*TOTAL FOR REPORT PREPARATION $1,120.00

v) Transport :

o use of INR car for 2 days per visit for 2 sampling visits

*TOTAL FOR TRANSPORT $ 500.00

(Note : FEA will provide transport from the Reservoir to the weir sites)

vi) Meals :

Meals for two lunches, one dinner and one breakfast for four people in June and three people in December

*TOTAL FOR MEALS	$	80.00

vii) Accommodation :

To be provided by F.E.A.

*TOTAL COST FOR TWO SAMPLING VISITS	$9,891.00

7. PAYMENT

The total for the invertebrate study and fifty percent (50%) of all other costs will be invoiced with the July data. The balance will be invoiced when the final report is sent.

PROPOSAL FOR MONITORING OF MONASAVU

DAM AND ENVIRONS - 1991

1. SITES :

The following sites will continue to be monitored:

Monasavu Reservoir :

i) Station 1 - reservoir (surface, mid, bottom)
ii) Station 2 - reservoir (surface, mid, bottom)
iii) Station 3 - reservoir (surface, mid, bottom)

Wailoa River :

iv) Above Wailoa Power Station
v) Tail Race - Wailoa Power Station
vi) Laselevu Village

Weirs :

vii) Wainabua
viii) Nabilabila
ix) Wainikasou - South and North
x) Wainisavulevu

2. FREQUENCY OF SAMPLING :

Two visits are planned. One in June/July (mid-winter) and another in December (mid-summer).

3. PARAMETERS TO BE MEASURED/ANALYSED :

For all the sites in the Monasavu reservoir and Wailoa river mentioned in 1 above, the following parameters will be measured/analysed:

> pH, dissolved oxygen, temperature, dissolved and total iron, dissolved and total manganese, total phosphorus, total sulphur, total nitrogen, nitrate, ammonia, dissolved phosphate, alkalinity and chlorophyll a, b and c.

At stations 1, 2 and 3 (reservoir) a dissolved oxygen/temperature profile will be measured together with clarity.

For the weir sites the following parameters will be analysed:

pH, dissolved oxygen, temperature, clarity, dissolved and total iron, dissolved and total manganese, suspended solids and total dissolved solids

An invertebrate study will be carried out in the June/July visit.

4. MANPOWER :

i) Sampling :

Two (2) days per sampling visit for one laboratory assistant, one laboratory technician and one senior technician.

ii) Invertebrate Study :

One (1) day for one sampling visit for one fellow.

iii) Report Preparation :

Two (2) days for one senior fellow.

iv) Laboratory Analysis :

Costs covered by analysis charges.

5. REPORT :

Data obtained from the June/July monitoring will be sent one month after the monitoring. A final report will be produced two months after the December monitoring.

6. COSTING :

i) Measurements/Analysis :

Monasavu reservoir and Wailoa river (12 sites).

- pH/dissolved oxygen/temperature/clarity	$ 15.00
- dissolved and total iron	$ 12.00
- dissolved and total manganese	$ 12.00
- total phosphorus	$ 12.00
- total sulphur	$ 12.00
- total nitrogen	$ 25.00

- nitrate	$ 10.00
- ammonia	$ 10.00
- dissolved phosphate	$ 10.00
- alkalinity	$ 10.00
- chlorophyll a, b and c	$ 35.00
TOTAL COST PER SITE	$163.00

°Cost of analyses for twelve (12) samples per visit for 2 sampling visits = 12 x $163 x 2 $3912.00

Weirs.

- pH/dissolved oxygen/temperature/clarity	$ 15.00
- dissolved and total iron	$ 12.00
- dissolved and total manganese	$ 12.00
- suspended solids	$ 10.00
- total dissolved solids	$ 10.00
TOTAL COST PER SITE	$ 59.00

°Cost of additional analyses for five (5) weir samples per visit for two sampling visits
= 5 x $59 x 2 $590.00

*TOTAL FOR ANALYSES $4,502.00

ii) Sampling :

- o laboratory assistant - 2 days per visit for 2 sampling visits = 2 x $120 x 2 $480.00
- o laboratory technician - 2 days per visit for 2 sampling visits = 2 x 190 x 2 $760.00
- o senior technician - 2 days per visit for 2 sampling visits = 2 x $300 x 2 $1,200.00

*TOTAL FOR SAMPLING $2,440.00

iii) ***Invertebrate Study :***

o fellow - 1 day for 1 sampling visit
= 1 x $375 $ 375.00

iv) ***Report Preparation :***

o senior fellow - 2 days = 2 x $560

*TOTAL FOR REPORT PREPARATION $1,120.00

v) ***Transport :***

o use of INR car for 2 days per visit for 2 sampling visits

*TOTAL FOR TRANSPORT $ 500.00

(Note : FEA will provide transport from the Reservoir to the weir sites)

vi) ***Meals :***

Meals for two lunches, one dinner and one breakfast for four people in June and three people in December

*TOTAL FOR MEALS $ 80.00

vii) ***Accommodation :***

To be provided by FEA

*TOTAL COST FOR TWO SAMPLING VISITS $9,017.00
= = = = =

7. **PAYMENT** :

The total for the invertebrate study and fifty percent (50%) of all other costs will be invoiced with the July data. The balance will be invoiced when the final report is sent.