INSTITUTE OF APPLIED SCIENCES

THE UNIVERSITY OF THE SOUTH PACIFIC

WATER QUALITY IN THE MONASAVU RESERVOIR AND WAILOA RIVER

IAS TECHNICAL REPORT NO. 93/03

by

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1. 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) now Institute of Applied Sciences (IAS) 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; Morrison et al., 1990 and Gangaiya et al., 1991). 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 that the five weir sites be included in the study.

This report represents the results of the water quality monitoring in 1992.

2. THE MONITORING PROGRAMME

2.1 Organisation

The winter monitoring of the Monasavu reservoir, weirs and Wailoa river was carried out in July 1992. The summer monitoring was carried out in December 1992 as originally planned. Table 1 shows the water quality indicators measured at the various sites visited. The parameters stayed basically the same as in the 1991 study except at the weir sites where the number of measurements made were again reduced. The parameters chosen at the weir sites were those that would reflect the effect of logging operations in the catchment areas.

Except for temperature, dissolved oxygen and pH which were determined on-site, all other determinations were carried out in the IAS laboratory using water samples collected in clean plastic bottles. The unstable determinations such as nitrate, ammonia and phosphate were measured on the day of collection.

The monitoring team consisted of William Peter and Peni Bulivakarua together with a camera crew of two who were filming for the production of an EIA training video (SPREP).

The team noticed that the water level in the dam had not shown any physical evidence of a drop although the depths recorded at stations 2 and 3 were slightly less than the depths recorded in both July 1991 and January 1992. The mark of the "normal" water level was becoming less obvious due to a growth in vegetation obscuring the prior level.

The December monitoring team consisted of Dr Alison Haynes, Ashwin Kumar, Praveen Ravi and Peni Bulivakarua. The notable aspect of the visit was the low water level in the dam.

Table 1: Summary of Water Quality Monitoring Programme

Water Chemistry:

Location	No. of Sites Monitored	Monitoring Sequence	Parameters Measured
Monasavu Reservoir	3 stations each at different depths	July 1992 December 1992	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	As above
Weirs	5 stations	As above	Temperature and dissolved oxygen, pH, total and dissolved iron and manganese, total dissolved solids and suspended solids
Biological Study:			
Monasavu Reservoir	2 stations	December 1992	Invertebrates
Weirs	5 stations	December 1992	Algae

2.2 Location of Sampling Sites

The sampling sites for both water chemistry and the biological study remained the same as in previous years. These are shown in Figures 1, 2 and 3.

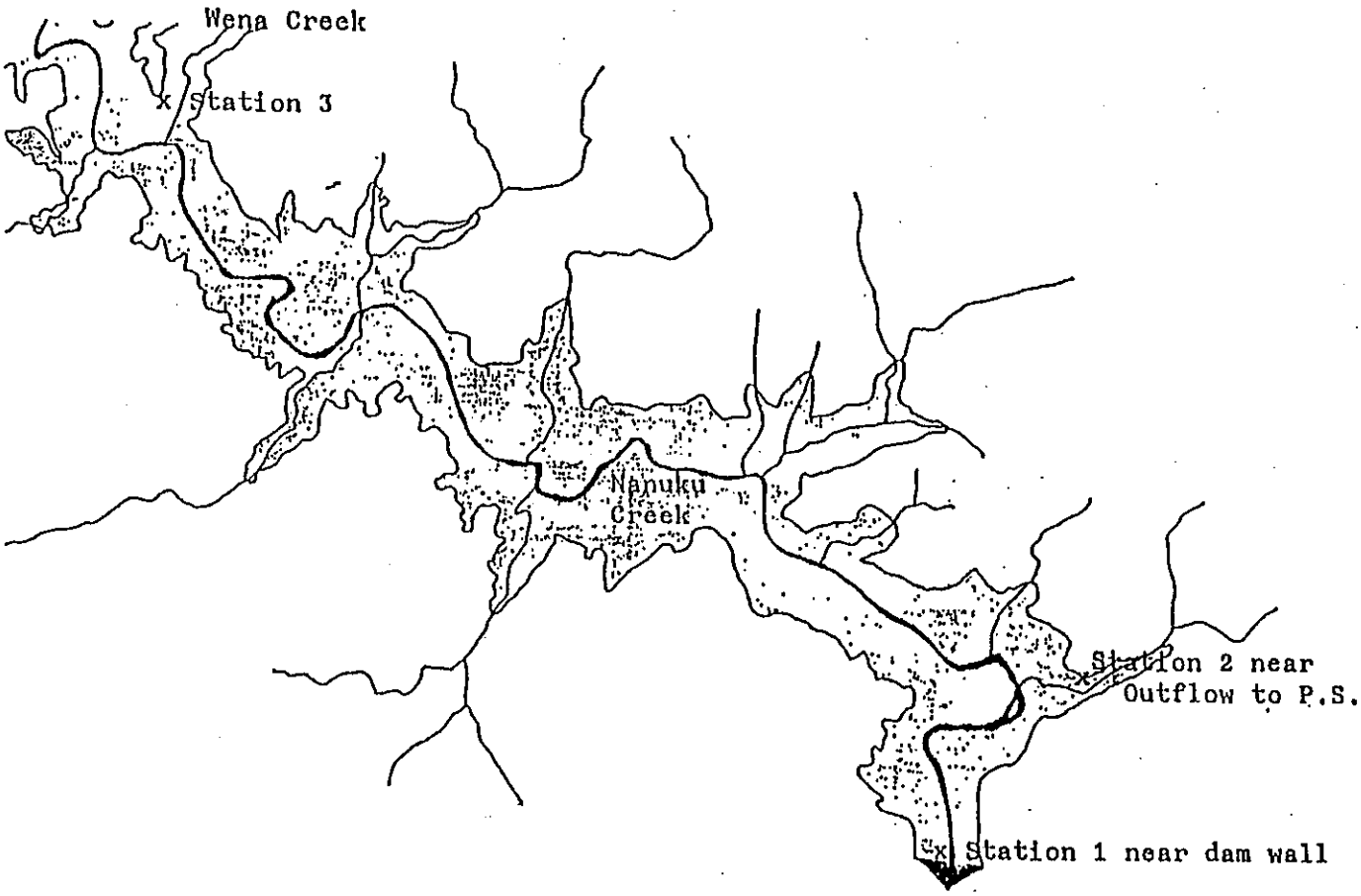


FIGURE 1 : Location of the sampling stations in the Monasavu Reservoir

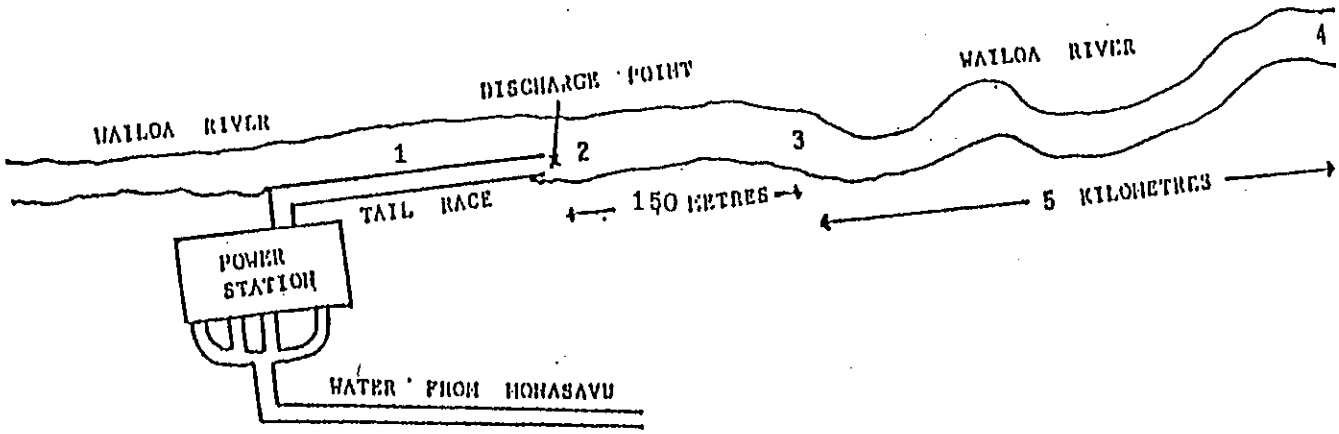


FIGURE 2 : Sampling sites along the Wailoa River

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

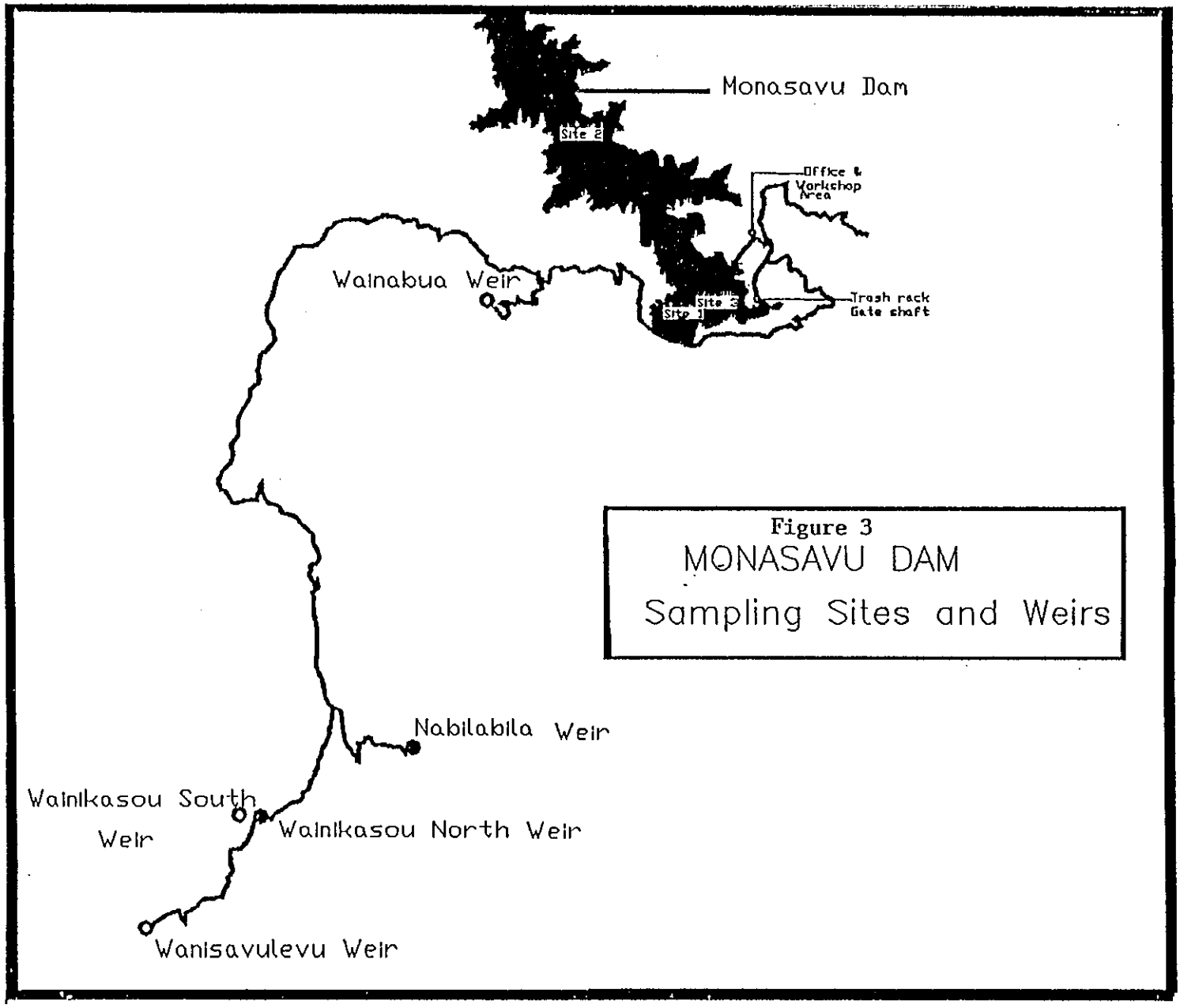


Figure 3

MONASAVU DAM

Sampling Sites and Weirs

3. WATER CHEMISTRY AT MONASAVU

3.1 Results

The dissolved oxygen and temperature profiles for each of the three stations in the reservoir are shown in Figure 4 with the data given in Appendix A. The data on water chemistry for the reservoir, weirs and Wailoa river for the winter and summer monitoring are given in Tables 2 and 3 respectively.

3.2 Interpretation of Results

3.2.1 The Reservoir

(a) Temperature and dissolved oxygen profiles:

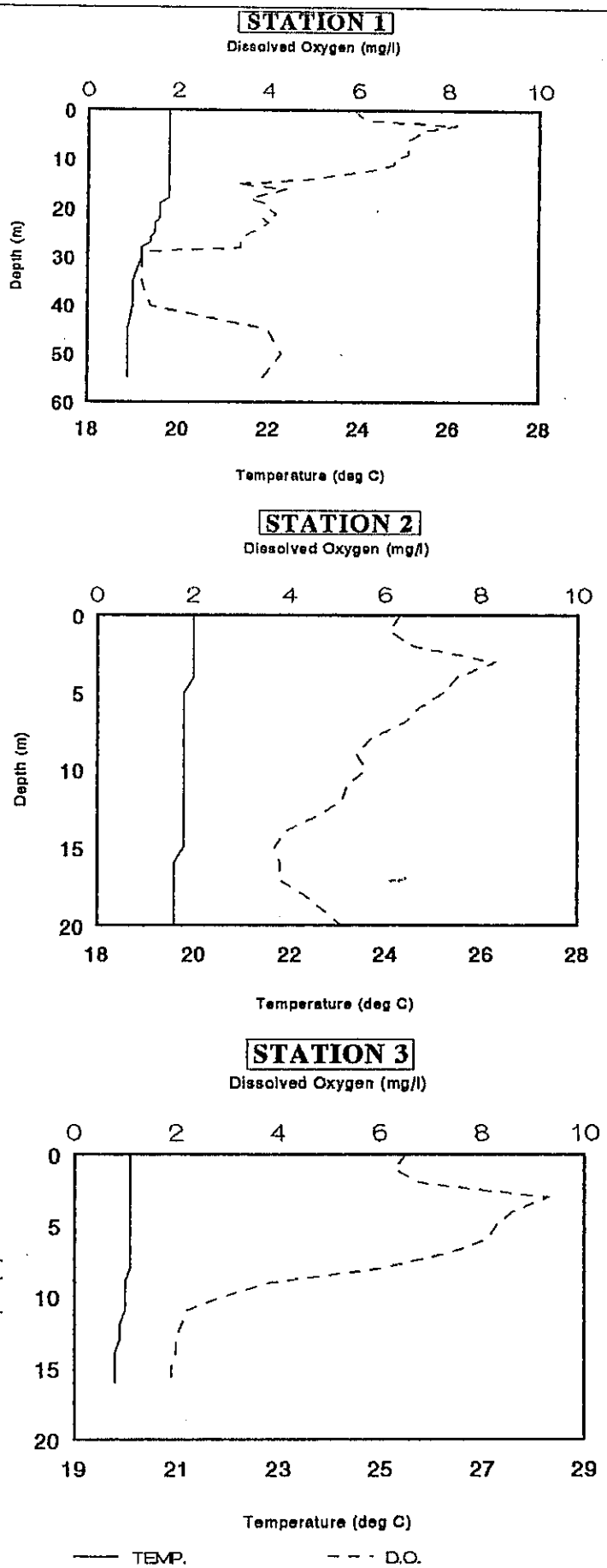
The pattern in winter in 1992 continued to be the same as in previous years with fairly homothermal conditions and relatively high levels of oxygen (>4 mg/L) at depths of 15 metres or more at all stations.

In summer however, even though the temperature profiles exhibited the same trend of a 2 to 3°C difference between surface and bottom waters, the dissolved oxygen profiles appeared different from previous years. This was particularly noticeable at stations 2 and 3 where deeper waters retained relatively high levels of dissolved oxygen (almost as much in the winter period). The reason for this could be related to the low levels of water in the reservoir, or could be due to the decreasing amount of decomposing organic matter at these depths. Future monitoring will allow us to determine whether or not a permanent change in water quality is occurring.

(b) pH and alkalinity:

The pH of the water at all three stations was in the range 6 to 8, as expected for most natural waters. A decrease in pH value with depth was noted, especially in the summer period. The alkalinity

Figure 4



DISSOLVED OXYGEN/TEMPERATURE PROFILE

MONASAVU DAM – JULY 1992

MONASAVU WATER SAMPLES

DATE : JULY 1992

	Station 1 Surface	Station 1 Mid	Station 1 Bottom	Station 2 Surface	Station 2 Mid	Station 2 Bottom	Station 3 Surface	Station 3 Mid	Station 3 Bottom	Wailoa above P.S.	Wailoa Tailrace	Wailoa at Laselevu
Total alkalinity (mg/L CaCO3)	30	26	57	52	36	34	34	34	78	37	51	27
Clarity (m)	2.00			2.00			1.75					
Total nitrogen (ug/L)	0.70	0.70	1.00	0.50	0.60	0.39	0.44	3.30	0.17	0.37	0.22	0.15
Total phosphorus (ug/L)	15	21	249	12	17	23	15	20	36	35	53	28
Total sulphur (mg/L)	1.8	0.6	3.4	4.2	35.0	8.2	7.6	2.5	4.5	4.6	10.0	3.6
Nitrate (ug/L)	21	31	235	9.1	7.5	16	2.8	0.14	13	35	34	49
Ammonia (ug/L)	5	14	1140	17	n.a.	5.5	2.6	29	89	30	10	108
Chlorophyll mg/m3 - a	8.6	1.6	1.1	8.1	5.9	2.5	9.4	5.8	1.4	0.8	0.3	1.8
- b	1.6	0.3	0.2	0.7	0.2	0.1	0.6	0.5	0.4	0.03	0.05	0.06
- c	5.7	6	0	4.1	0	1.1	3.7	2.9	0.8	0.9	0.2	0.09
Dissolved manganese (mg/L)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Total manganese (mg/L)	<0.03	<0.03	0.2	<0.03	<0.03	<0.03	<0.03	0.04	0.26	0.04	<0.03	0.04
Dissolved iron (mg/L)	<0.05	0.12	0.17	0.05	<0.05	<0.05	<0.05	<0.05	0.34	<0.05	<0.05	<0.05
Total iron (mg/L)	<0.05	0.26	0.18	0.05	<0.05	<0.05	0.13	<0.05	0.41	<0.05	<0.05	<0.05
Temperature (oC)	19.8	19.2	18.9	19.8	19.8	19.6	20.1	20.1	19.8	22	20.2	21.8
Dissolved oxygen (mg/L)	5.9	3.2	3.9	6.3	5.6	5.1	6.5	6.1	1.9	6.8	7.9	7.9
Depth (m)	0	28	55	0	10	20	0	8	16			
Dissolved PO4 (ug/L)	7.6	10.0	265.0	5.3	11.0	6.7	5.0	6.1	16.0	24.0	39.0	11.0

TABLE 2

MONASAVU WATER SAMPLES DATE : DECEMBER 1992

	Station 1 Surface	Station 1 Mid	Station 1 Bottom	Station 2 Surface	Station 2 Mid	Station 2 Bottom	Station 3 Surface	Station 3 Mid	Station 3 Bottom	Wailoa above P.S.	Wailoa Tailrace	Wailoa at Laselevu
Total alkalinity (mg/L CaCO3)	26.7	27.4	34.4	26.9	26.0	26.0	29.1	29.9	32.6	49.9	26.5	39.5
Clarity (m)	1.50			1.75			1.25					
pH on site	8.94	7.31	7.03	9.05	7.34	7.21	8.55	7.25	7.08	8.00	7.35	7.95
Total nitrogen (ug/L)	<0.2	0.98	0.22	0.90	0.68	0.30	0.22	0.46	1.28	0.92	0.78	1.24
Total phosphorus (ug/L)	1990	656	802	471	2070	1420	26	22	41	58	177	47
Total sulphur (mg/L)	3.3	2.0	10.0	0.7	4.3	2.8	1.3	2.5	3.7	3.0	1.7	3.7
Nitrate (ug/L)	45.2	30.0	22.5	52.3	37.5	37.5	82.4	15.0	45.2	105.0	37.5	89.9
Ammonia (ug/L)	851	73	117	119	83	119	117	73	425	88	131	88
Chlorophyll mg/m3 - a	0.90	3.54	2.73	12.00	7.34	2.84	7.34	5.59	5.05	9.87	3.39	2.70
- b	0.98	1.38	0.92	2.46	3.82	0.81	1.83	2.32	2.30	0.96	2.14	0.86
- c	2.84	9.11	6.50	16.60	10.00	1.50	5.88	1.10	2.20	0.68	2.82	2.84
Dissolved manganese (mg/L)	<0.03	<0.03	0.60	<0.03	<0.03	<0.03	<0.03	<0.03	0.50	<0.03	<0.03	<0.03
Total manganese (mg/L)	<0.03	<0.03	0.60	<0.03	<0.03	<0.03	<0.03	<0.03	0.50	<0.03	<0.03	<0.03
Dissolved iron (mg/L)	<0.01	<0.01	5.60	<0.01	<0.01	<0.01	<0.01	<0.01	1.80	<0.01	<0.01	<0.01
Total iron (mg/L)	<0.01	0.25	5.60	0.10	0.45	0.70	0.55	0.10	1.80	0.05	0.10	0.10
Temperature (oC)	23.0	18.0	18.5	22.5	21.5	20.0	25.0	21.0	20.0	23.0	21.0	22.0
Dissolved oxygen (mg/L)	7.7	2.8	2.8	7.8	7.0	3.0	7.6	5.0	3.4	7.8	8.0	8.0
Depth (m)	0.0	20.0	39.0	0.0	9.0	18.0	0.0	6.0	11.5			
Dissolved PO4 (ug/L)	58	88	117	175	88	204	496	161	175	613	306	161

TABLE 3

was in the range 23-58 mg $CaCO_3$/L in winter and 18-35 mg $CaCO_3$/L in summer.

(c) Nutrients : Nitrogen

An increase in the concentration of total nitrogen with depth was noted at most stations in both the summer and winter periods. The amounts present in winter (.17-33 mg/L) was slightly higher than the amounts in summer (.22-1.28 mg/L).

For nitrate, the amounts present in winter were relatively low with some decrease with depth.

The concentrations of ammonia on the other hand showed some increase with depth with greater amounts in bottom waters in summer than in winter.

(ii) Nutrients : Phosphorus

Greater amounts were present in the summer (22-2070 μg/L) than in the winter months (15-249 μg/L).

Dissolved phosphate concentrations followed a similar pattern with greater amounts in summer and with an increase in concentration with depth.

(iii) Nutrients : Total Sulphur

Total sulphur values were found to be mostly less than 1.7 mg/L.

(d) Chlorophhyll

The chlorophyll content of surface water tended to be higher with generally greater amounts of chlorophyll a in summer than in winter with greater amounts of chlorophyll b and c in winter than in summer.

(e) Total and dissolved Iron and Manganese

The total and dissolved iron and manganese continued to be lower in winter than in summer with a notable increase in concentrations with depth, especially in summer. In the surface, the iron and manganese are oxidised and precipitated as particulate matter which then sinks to the bottom. This process and the reduction under relatively anoxic conditions at depth explain the patterns observed.

3.2.2 The Weirs

The temperature and dissolved oxygen content of the water in the weirs remained relatively unchanged over the winter and summer periods.

The pH value of the water was in the range 6 to 8 and generally higher in the winter than in summer. The total and dissolved iron and manganese were generally undetectable or very low.

As in 1991, the total suspended solids were almost negligible and the total dissolved solids were low (4-88 mg/L), as expected for fresh water. The logging operations, if there are any in the catchment areas of the weirs, are having very little effect on the water quality.

3.2.3 The Wailoa River

The water exiting the power station at the tailrace was rapidly oxygenated and is not noticeably different from the water in the river above the power station. Levels of nutrients and seasonal variations were as for the weir and reservoir waters.

4. BIOLOGICAL SURVEY

The seventh Invertebrate Survey of Lake Monasavu was carried out on 1 December 1992.

The water level in the lake was again very low. It was nearly 30m below the level of July, 1985-1990.

The two sites visited were those sampled in previous surveys. They were situated at -

1) the end of the road (now much extended)
2) the dam edge

The stones and rocks at both sites had a thick covering of mud which would inhibit benthic invertebrate life because it covers their food source i.e. epilithic algae.

However a few live gastropods of the species Melanoides tuberculata were found near the end of the road. Many empty shells of M. tuberculata were found at both sites. They extended 10-12m above the present water.

Plankton

1) Copepods (Crustacea) were very abundant
2) mite (1)
3) Also present were blackflies , spiders and caddisflies that had fallen in the water.

Weirs

The water was low in all weirs and the large green alga *Chara excelsa* was only present in Wainikasou South and Wainikasou North weirs. It formed a short mat on bottom of each.

Wailoa River at Laselevu Village

A notable development in the river at this site was the appearance of an abundant population of the endemic gastropod Fijidoma maculata. Other invertebrates were also more abundant than they have ever been since 1985.

5. REFERENCES

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APPENDIX A

DATA FOR MONASAVU DAM - STATION 1
JULY - 1992

DEPTH (m)	TEMP. (°C)	D.O. (mg/l)	DEPTH (m)	TEMP. (°C)	D.O. (mg/l)
0	19.8	5.9	18	19.8	3.6
1	19.8	6.0	19	19.6	4.0
2	19.8	6.3	20	19.6	4.0
3	19.8	8.2	21	19.6	4.2
4	19.8	7.4	22	19.6	3.9
5	19.8	7.3	23	19.5	4.0
6	19.8	7.1	24	19.5	3.8
7	19.8	7.1	25	19.5	3.6
8	19.8	7.1	26	19.4	3.4
9	19.8	7.1	27	19.4	3.4
10	19.8	6.8	28	19.2	3.2
11	19.8	6.8	29	19.2	1.3
12	19.8	6.4	30	19.2	1.2
13	19.8	5.6	35	19.0	1.2
14	19.8	5.0	40	19.0	1.4
15	19.8	3.3	45	18.9	4.0
16	19.8	4.4	50	18.9	4.2
17	19.8	4.0	55	18.9	3.9

* pH - SURFACE - 5.8
  MID - 6.3
  BOTTOM - 5.4

* CLARITY - 2m

* DEPTH - 55m

DATA FOR MONASAVU DAM - STATION 2
JULY - 1992

DEPTH (m)	TEMPERATURE (°C)	DISSOLVED OXYGEN (mg/l)
0	19.8	6.3
1	20.0	6.1
2	20.0	6.6
3	20.0	8.3
4	20.0	7.5
5	19.8	7.2
6	19.8	6.7
7	19.8	6.4
8	19.8	5.7
9	19.8	5.4
10	19.8	5.6
11	19.8	5.2
12	19.8	5.1
13	19.8	4.6
14	19.8	3.9
15	19.8	3.7
16	19.6	3.8
17	19.6	3.8
18	19.6	4.2
19	19.6	4.7
20	19.6	5.1

* pH SURFACE - 5.9
  MID - 6.0
  BOTTOM - 6.1

* CLARITY - 2m

* DEPTH - 20m

DATA FOR MONASAVU DAM - STATION 3
JULY - 1992

DEPTH (m)	TEMPERATURE (°C)	DISSOLVED OXYGEN (mg/l)
0	20.1	6.5
1	20.1	6.3
2	20.1	6.8
3	20.1	9.3
4	20.1	8.6
5	20.1	8.3
6	20.1	8.1
7	20.1	7.3
8	20.1	6.1
9	20.0	3.9
10	20.0	2.9
11	20	2.2
12	19.9	2.1
13	19.9	2.0
14	19.8	2.0
15	19.8	1.9
16	19.8	1.9

* pH - SURFACE - 7.6
  MID - 6.6
  BOTTOM - 6.2

* CLARITY - 1.75m

* DEPTH - 16m

DATA FOR OTHER SITES AT MONASAVU
JULY - 1992

SITE	pH	TEMPERATURE (°C)	DISSOLVED OXYGEN (mg/l)
WAINISAVULEVU	5.5	19.5	8.0
WAINIKASOU SOUTH	6.5	18.2	8.8
WAINIKASOU NORTH	5.5	19.0	8.4
NABILABILA	5.9	18.5	8.9
WAINABUA	6.6	18.5	8.3
ABOVE POWER STATION	6.4	22.0	6.8
POWER STATION TAILRACE	5.2	20.2	7.9
LASELEVU	5.2	21.8	7.9

PROPOSAL FOR MONITORING OF MONASAVU

DAM AND ENVIRONS - 1993

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

Weira :

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

2. FREQUENCY OF SAMPLING :

Two visits were 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 that 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/emperature/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 day = 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 TRANSPOR $ 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