INSTITUTE OF APPLIED SCIENCES

THE UNIVERSITY OF THE SOUTH PACIFIC

WATER QUALITY IN THE MONASAVU RESERVOIR AND WAILOA RIVER IN 1993

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by

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WATER QUALITY IN THE MONASAVU RESERVOIR, THE FIVE WEIR SITES AND THE WAILOA RIVER IN 1993.

1. INTRODUCTION

The Monasavu Hydroelectric scheme is situated on the Nadrau Plateau in central Viti Levu. The main Monasavu dam is located at an elevation of 670 to 750 m and is fed in the main by the Nanuku creek. In addition, water is diverted from other creeks namely the Wainisavulevu, Wainikasou north and south, Nabilabila and the Wainabua creeks in the area to the dam. Water from the dam is tunnelled down to the Power Station located at Wailoa which has a generating capacity of 80 MW.

The current monitoring programme was formally agreed upon and established in 1985 with funding provided by the Fiji Electricity Authority of Fiji (FEA) and the work to be carried out by the Institute of Natural Resources (INR) as was the name then (Brodie et al., 1987). The monitoring work continues today with funding from the FEA and the environmental assessment being carried out by staff of the Institute of Applied Sciences (IAS), formerly the INR. Initially the water quality of the dam and the Wailoa river above the Power Station and at the Tailrace (discharge site) were the main areas studied but in 1990, the FEA requested the IAS to include the five weir sites in the monitoring programme. The biological study of the main fauna of the dam, the Wailoa river and the weir sites has also been carried out in conjunction with the water chemistry assessment, but to a lesser extent (one study per year).

2. BACKGROUND

Over the years, results of water chemistry analyses have indicated a gradual improvement in the quality of the water at the reservoir, as evident from the results of nutrient levels and the metals iron and manganese. As the organic matter in the bottom of the dam gradually disappears as a result of bacterial decomposition, levels of dissolved oxygen at depth improves and the concentrations of compounds associated with anoxic conditions such as hydrogen sulphide and ammonia gradually decrease. This in fact had been predicted by previous scientific studies prior to and during the construction of the dam.

However, the seasonal trends in water temperature and dissolved oxygen variation with depth remain clear, i.e. during the winter months, the water body in the dam is relatively homothermic and as a consequence, DO levels remain fairly constant throughout the water body. In contrast, during the summer months, there is definite stratification with the surface waters being much warmer than the water at depth. This in turn creates a clear variation in DO levels in the water body, with the surface water being saturated with dissolved oxygen while the bottom waters remain anoxic. Such conditions affect the status of the metals iron and manganese as has been observed in previous monitoring visits. In winter, the levels of the metals are generally lower as they become oxidised in the surface and precipitate out as particulate matter and sink to the bottom. However, in summer the anoxic conditions at depth causes the reversal of the winter process, i.e. the iron and manganese oxides and hydroxides become reduced and get converted back to the metals thus the generally higher levels of these elements in the water column.

3. THE MONITORING PROGRAMME

3.1 Organisation

As has been the practice since 1986 (Naidu and Brodie, 1987; Naidu et al., 1989; Morrison et al.,1990; Gangaiya, 1991; Lloyd et al., 1993), the monitoring of the Monasavu dam and the Wailoa river was carried out twice yearly to cover the winter season (July) and the summer season (November - April). In 1993, the winter visit was carried out on Tuesday and Wednesday, 13th and 14th July and the summer visit was carried out on January 18th and 19th, 1994.

While the winter visit was relatively problem-free except for the pH meter malfunction, the summer visit was hampered by very heavy rainfall. In fact during the sampling visit on the 18th and 19th of January, a total of 201 mm of rain was recorded at Monasavu and the highest daily rainfall for the month of January at Monasavu (168.0 mm) was recorded on the 18th, our first sampling day (Nadi Meteorological office). The creeks including the five weir sites were flooded and the DO meter could not be used at the last station in the reservoir (station 3) after water leaked into the meter. The samples collected were all high in suspended sediment and this is reflected to a large extent in the results.

Apart from the dam and the Wailoa river, the five weir sites at Wainisavulevu, Wainikasou North and South, Nabilabila and Wainabua were also monitored as has been the case since the request was made by the FEA in 1990.

3.2 Parameters measured and Sampling Sites

The parameters assessed were the same as those assessed in previous monitoring visits.

Reservoir

At the reservoir, samples were collected and measurements made at the three stations shown in Fig.1. On-site measurements included clarity of the water, depth, water temperature and dissolved oxygen.

Clarity was measured using a white secchi disc which is lowered into the water until it just disappears from sight. The water temperature and dissolved oxygen profiles were measured at 1 m depth intervals using a YSI Model 51B Dissolved Oxygen meter. The meter was calibrated on site for altitude (dam height is 750m above sea level) and measurements were taken with altitude set at 2,500 feet.

The pH of the samples could not be measured on site because of difficulty in calibrating the meter with the prepared buffer solutions. The pH meter used was the ORION model 250A. pH of the samples were measured in the laboratory back at IAS using the same model of the pH meter and readings are given below.

Water samples from the surface, mid-depth and the bottom were collected and analysed at the IAS laboratory using standard methods (APHA, 1989) for the pH, nutrients, chlorophylls and the metals iron and manganese.

For the study of invertebrates in the lake, two sites were selected : one site at the end of the road below the FEA administration buildings and the other at the edge of the dam near the water quality station 1. As well as these, a plankton sample was collected from the dam by towing the plankton net over a distance of about 100m between stations 1 and 3.

Wailoa Power Station

At the Wailoa Power Station, the three sampling sites are shown in Fig.2 below, i.e. at the Wailoa river before the power station, below the tailrace (discharge site into the river), and at Laselevu village further downstream. The water temperature and dissolved oxygen were measured on site with a YSI Model 51B DO meter while the other parameters (pH, nutrients, chlorophylls, total and dissolved iron and manganese) were measured in the laboratory.

The aim of the monitoring at the Wailoa river is to investigate if the power station (and the hydroelectric scheme) was having an impact on the quality of the Wailoa river and the villages downstream from the power station.

The Weir sites

At the weir sites, water temperature and dissolved oxygen were also measured on site as above. The pH, total dissolved solids, total suspended solids, total and dissolved iron and manganese were analysed in the laboratory at the IAS using standard methods (APHA, 1989). The aim of the monitoring at the weir sites was to establish if the logging in the catchment area was having an impact on the quality of the water in the creeks feeding the dam.

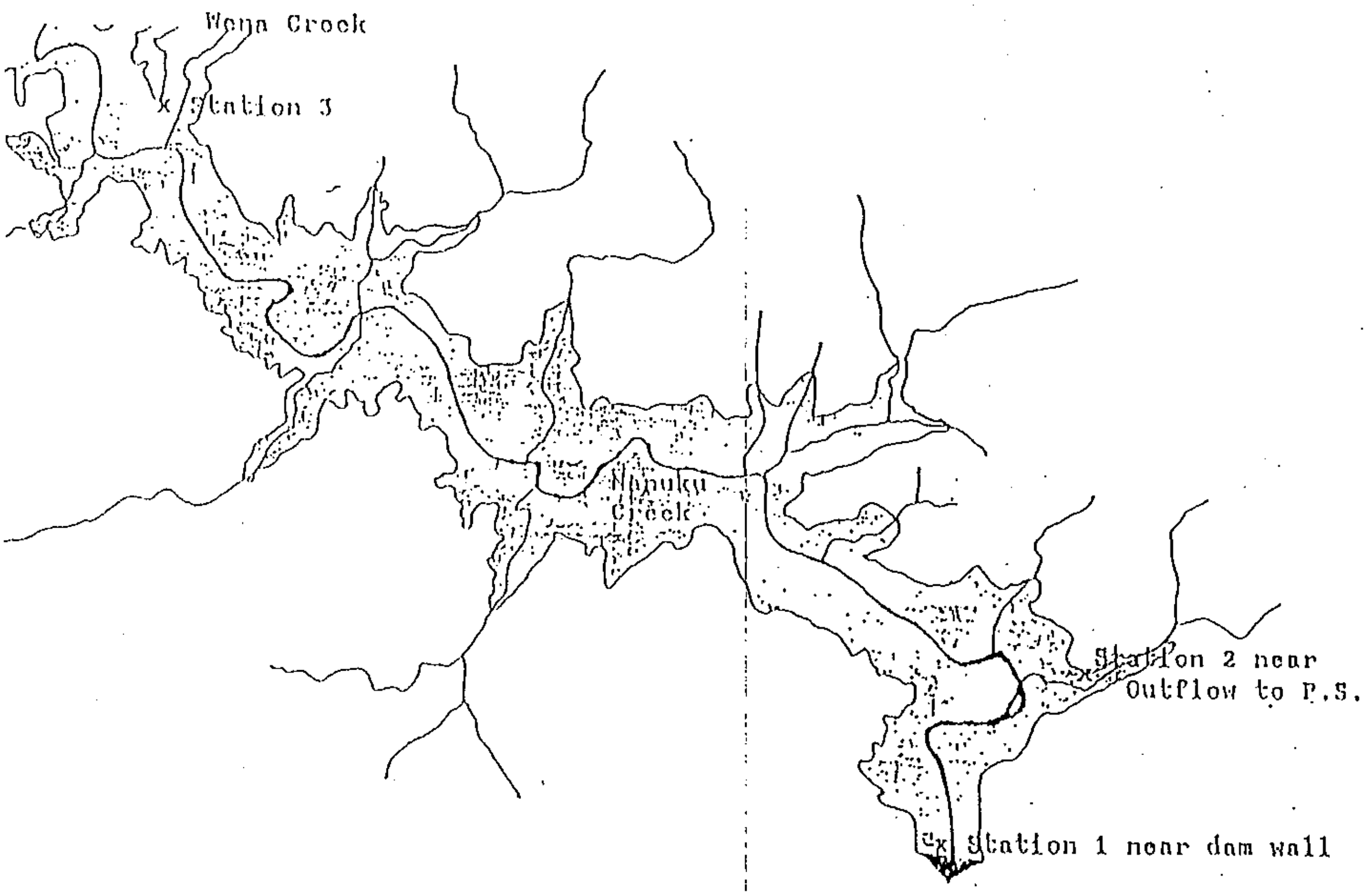


FIGURE 1 : Location of the sampling stations in the Monasavu Reservoir

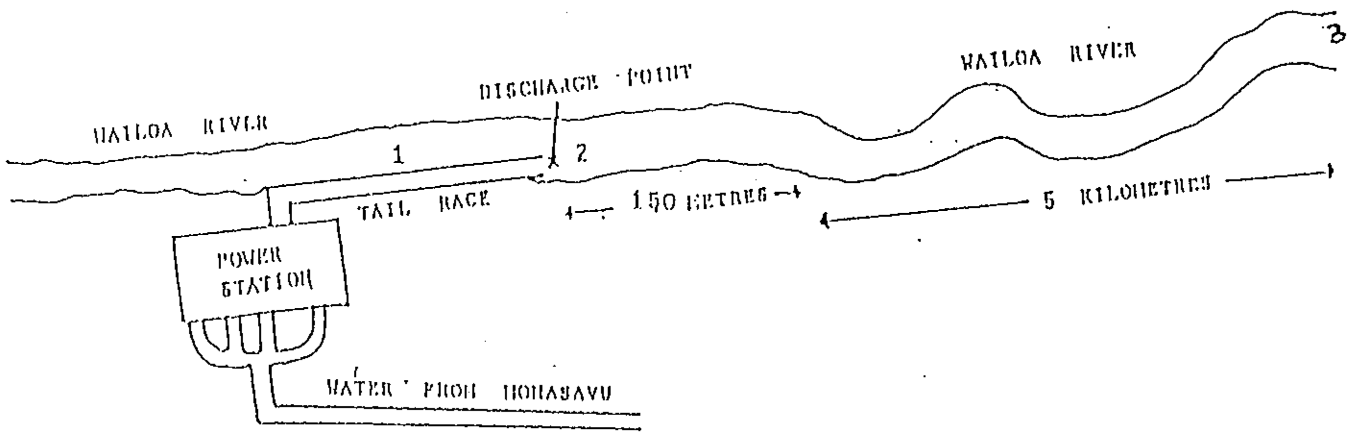


FIGURE 2 : Sampling sites along the Wailoa River

Site 1 : 100 m above Power Station discharge
Site 2 : Tailrace
Site 3 : Wailoa at Laselevu village

Table 1 : Summary of Water Quality Monitoring Programme

Location	No. of Sites Monitored	Monitoring Sequence	Parameters measured
Reservoir	3 stations each at 3 different depths	July 1993 January 1994	Temperature and dissolved oxygen profiles, clarity, pH, alkalinity, Chlorophylls (a,b,c), nutrients (nitrogen, phosphorus and sulphur), iron and manganese.
Wailoa River	3 stations	As above	As above except for the Temp./DO profiles
Weirs	5 stations	As above	Temperature, DO, pH, Total and dissolved iron and manganese, total dissolved solids and total suspended solids.
Reservoir - biological study	2 stations for invertebrates, plankton sampling over 100m in the main part of the dam.	January 1994	Invertebrates (gastropods, sponges etc.); plankton.

4. WATER CHEMISTRY AT MONASAVU

4.1 Results

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. The data on depth/temperature/dissolved oxygen for the three stations in the dam are given in Tables 4 - 8.

4.2 Interpretation of results

4.2.1 The Reservoir

(a) Temperature and dissolved oxygen profiles:

In general, the trend that has been observed during the previous monitorings is again evident in the temperature/DO profiles for the dam stations. During the winter visit, homothermal conditions prevailed with negligible temperature difference between the surface waters and the bottom of the reservoir. The temperature difference between the surface and the bottom were 1.0 °C for station 1 and 0 °C for stations 2 and 3. At the same time, the dissolved oxygen levels were relatively high (> 4 mg/L) down to depths of 18 - 19 m for all three stations (see Table 2). Only at station 3 does the DO decrease below 4 mg/L at a depth of 19 m. Since this was the first visit since cyclone Kina devastated the Fiji group including the Monasavu dam environs, it is quite possible that much organic matter (tree branches, leaves) washed down by the Nanuku creek would have accumulated on the bottom of the dam around station 3. Bacterial degradation of the organic matter at great depths with limited aeration would have created anoxic conditions and lowered levels of dissolved oxygen as seen at station 3.

TABLE 2

MONASAVU WATER SAMPLES

DATE : JULY 1993

	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)	28.4	43.0	38.3	31.2	29.1	29.1	33.4	30.5	31.2	60.4	41.2	31.2
Clarity (m)	3.0			3.5			2.0					
pH on site	6.9	6.9	6.8	6.9	6.9	6.9	6.9	6.9	6.8	8.2	7.2	7.9
Total nitrogen (mg/L)		<0.01	0.07	0.11	<0.01	<0.01	<0.01		<0.01	0.06	0.24	<0.01
Total phosphorus (ug/L)	15	15	<6.0	6.7	12	<6.0	<6.0	13	11	45	17	23
Total sulphur (mg/L)	120	0.90	1.8	33	4.5	0.80	1.7	82	1.4	1.2	8.0	0.80
Nitrate (mg/L)	0.10	0.20	0.43	0.11	0.05	0.05	0.01	0.20	0.00	0.07	0.09	0.08
Ammonia (ug/L)	80.3	31.6	236	42.6	60.8	129	122	112	51.1	70.5	30.4	37.7
Chlorophyll mg/m3 - a	5.9	0.30	20	7.2	6.2	12	9.0	9.4	0.50	0.60	5.3	2.3
- b	3.3	0.90	16	1.8	1.2	2.4	1.9	2.4	0.30	0.80	1.2	0.0
- c	0.0	0.0	0.5	0.1	0.0	0.0	0.4	0.0	0.0	0.0	0.1	0.0
Dissolved manganese (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total manganese (mg/L)	<0.2	<0.2	0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Dissolved iron (mg/L)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Total iron (mg/L)	0.4	0.3	34	0.3	0.3	2.0	<0.30	0.4	0.97	<0.3	<0.3	<0.3
Temperature (oC)	21.5	21.0	20.5	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Dissolved oxygen (mg/L)	6.6	6.4	4.6	5.8	6.0	5.0	6.6	7.1	2.0	8.0	8.0	8.0
Depth (m)	0	32	64	0	8	16	0	9	19			
Dissolved PO4 (ug/L)	14.6	14.6	14.6	29.2	29.2	18.2	94.5	36.5	21.9	139	14.6	124

TABLE 2 (Cont'd)

Sample	Total Dissolved Solids (mg/L	Dissolved		Total		Total Suspended Solids (mg/L)
		Manganese	Iron	Manganese	Iron	
Nabilabila	48	<0.2	<0.3	<0.2	<0.3	1
Wainabua	37	<0.2	<0.3	<0.2	<0.3	2
Wainisavulevu	29	<0.2	<0.3	<0.2	<0.3	1
South Wainikasau		<0.2	<0.3	<0.2	<0.3	7
North Wainikasau	59	<0.2	<0.3	<0.2	<0.3	3

TABLE 3

MONASAVU WATER SAMPLES (January 1994)

	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
Lab No.	94/211	94/212	94/213	94/214	94/215	94/216	94/217	94/218	94/219	94/203	94/204	94/205
Total alkalinity (mg/L CaCO3)	15	29	9	14	14	17	16	14	16	33	16	25
Clarity (m)	2.5			3.1			2					
pH on site	7.1	7	7	7.1	7.1	7	7.2	7	6.3	7.5	6.8	7.4
Total N (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	0.04	<0.01	0.01	0.01	0.13
Total P (ug/L)	9.1	<6	<6	7.3	<6	<6	6.2	<6	<6	14.1	<6	9.8
Total S (mg/L)	1.4	1.1	1.3	<1	<1	<1	<1	2	1.1	1.7	1.3	1.6
NO3 (NO3 ug/L)	41	108	236	<34	91	108	<34	<34	<34	590	73	103
NH3 (ug/L)	<12.2	12.6	292	<12.2	19	104	15.2	27	57.7	20.6	51	21.7
Chlorophyll mg/m3 a	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
b	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
c	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Mn (mg/L)	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Mn (mg/L)	<0.2	<0.2	0.38	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Dissolved Fe (mg/L)	<0.3	<0.3	0.5	<0.3	<0.3	0.6	<0.3	<0.3	0.5	1.4	<0.3	<0.3
Total Fe (mg/L)	0.37	<0.3	0.84	<0.3	0.34	2.1	<0.3	0.33	0.86	2.3	0.4	1
Temperature (deg C)	23	21.1	<19.5	22.9	22.1	20.9	n.d.	n.d.	n.d.	23.1	21.5	23
Dissolved O2 (mg/L)	5.4	0.4	0	7	4.7	0	n.d.	n.d.	n.d.	8.8	9	8
Depth (m)	0	29	59	0	17	34	0	11	22			
Dissolved PO4 (ug/L)	<5	<5	81.2	29	<5	<5	89.7	<5	16.2	130	<5	67.5

TABLE 3 (Cont'd)

Monasavu Water Samples (Weirs)

	Wainabua	Nabilabila	Wainisavulevu	Wainakasou Sth	Wainakasou Nth
Lab No.	94/210	94/209	94/206	94/208	94/207
Total dissolved solids (mg/L)	27	15	11	17	17
Total suspended solids (mg/L)	83	72	18	78	87
Total iron (mg/L)	6.2	4.2	1.4	5.6	9
Dissolved iron (mg/L)	4.2	1.2	0.3	1	1.7
Total manganese (mg/L)	0.3	<0.2	<0.2	<0.2	<0.2
Dissolved manganese (mg/L)	0.3	<0.2	<0.2	<0.2	<0.2
pH	7.2	7.2	6.8	7	7.2
Temperature (deg C)	20	20	20	20	20
Dissolved oxygen (mg/L)	8	7.8	7.8	8.4	8.2

TABLE 4 - WINTER RESULTS

DATA FOR MONASAVU DAM - STATION 1, JULY 1993.

DEPTH (m)	TEMP. (°C)	D.O. (mg/L)	DEPTH (m)	TEMP. (°C)	D.O. (mg/L)
0	21.5	6.6	15	21.0	6.6
1	21.5	6.2	16	21.0	6.4
2	21.0	6.2	17	21.0	6.5
3	21.0	7.5	18	21.0	6.4
4	21.0	7.4	19	21.0	6.4
5	21.0	7.3	20	21.0	6.4
6	21.0	7.2	21	21.0	6.4
7	21.0	7.1	22	21.0	6.4
8	21.0	6.8	25	21.0	6.4
9	21.0	6.8	30	21.0	6.4
10	21.0	6.8	35	21.0	6.4
11	21.0	6.8	40	21.0	6.1
12	21.0	6.7	45	21.0	6.0
13	21.0	6.6	50	21.0	5.6
14	21.0	6.6	55	21.0	5.4
15	21.0	6.6	64	20.5	4.6

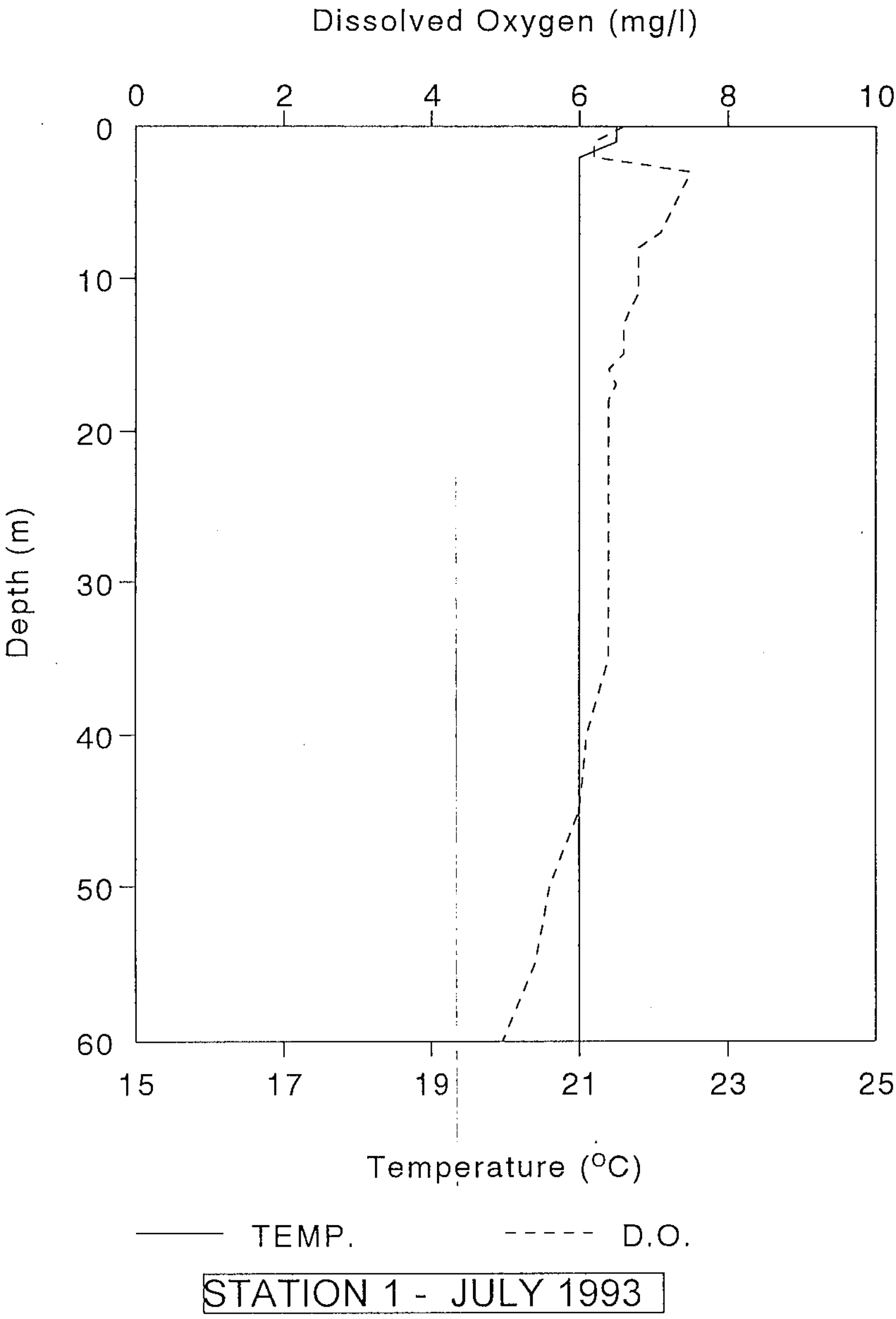

Dissolved Oxygen (mg/l)
0
2
4
6
8
10
0
10
20
30
40
50
60
Depth (m)
15
17
19
21
23
25
Temperature (°C)
TEMP.
D.O.
STATION 1 - JULY 1993

TABLE 5 - WINTER RESULTS

DATA FOR MONASAVU DAM STATION 2, JULY, 1993

DEPTH (m)	TEMPERATURE (°C)	D.O. (mg/L)
0	21.0	5.8
1	21.0	5.6
2	21.0	5.6
3	21.0	6.9
4	21.0	6.6
5	21.0	6.3
6	21.0	6.2
7	21.0	6.1
8	21.0	6.0
9	21.0	6.0
10	21.0	5.9
11	21.0	5.9
12	21.0	5.9
13	21.0	5.9
14	21.0	5.6
15	21.0	5.2
16	21.0	5.0

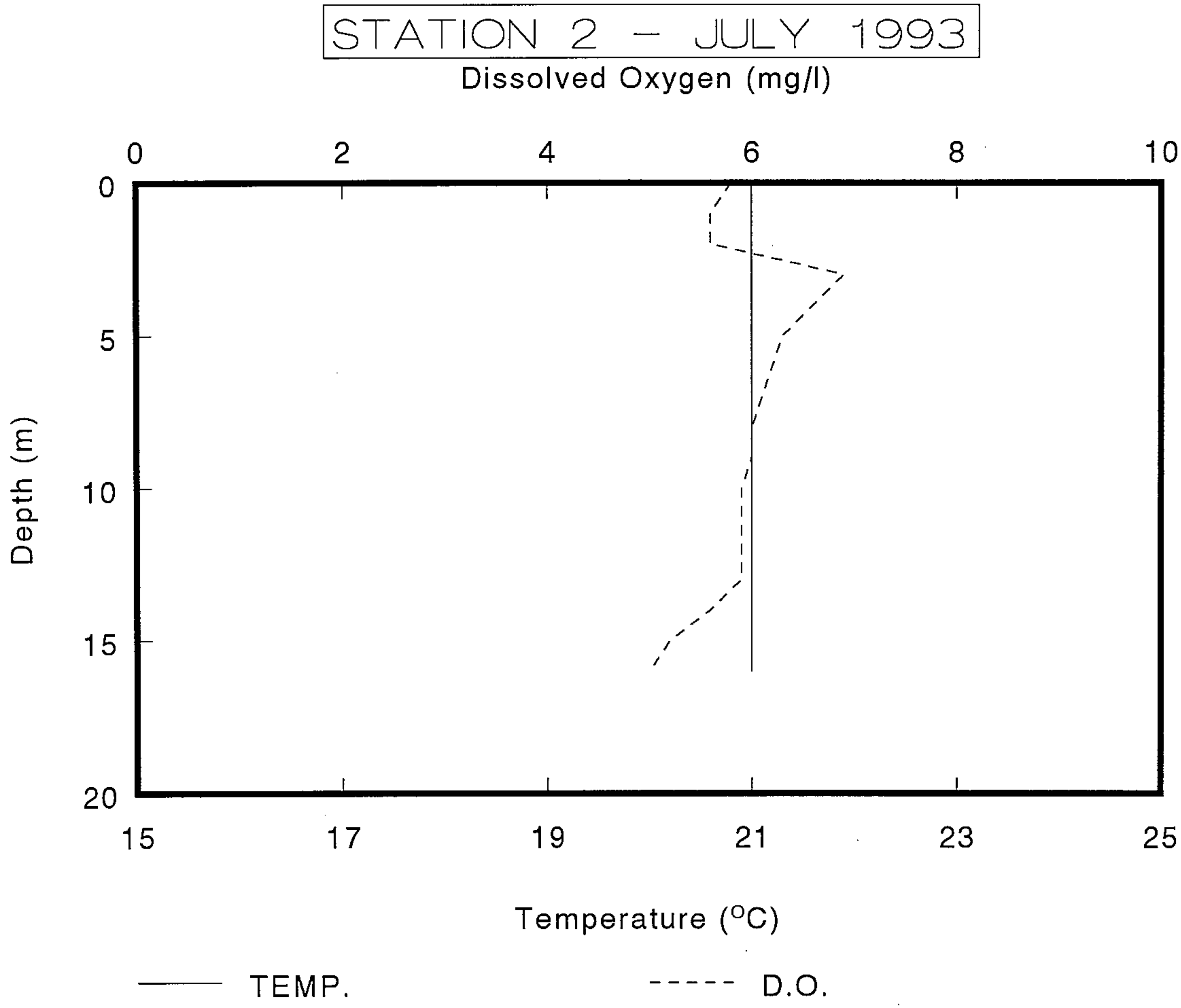

STATION 2 - JULY 1993
Dissolved Oxygen (mg/l)
0
2
4
6
8
10
Depth (m)
0
5
10
15
20
15
17
19
21
23
25
Temperature (°C)
TEMP.
D.O.

TABLE 6 - WINTER RESULTS

DATA FOR MONASAVU DAM STATION 3 - JULY, 1993

DEPTH (m)	TEMPERATURE (°C)	DISSOLVED O_2 (mg/L)
0	21.0	6.6
1	21.0	6.4
2	21.0	6.3
3	21.0	8.3
4	21.0	7.6
5	21.0	7.4
6	21.0	7.2
7	21.0	7.2
8	21.0	7.3
9	21.0	7.1
10	21.0	7.1
11	21.0	7.2
12	21.0	7.2
13	21.0	7.2
14	21.0	7.1
15	21.0	7.0
16	21.0	6.9
17	21.0	6.8
18	21.0	6.6
19	21.0	2.0

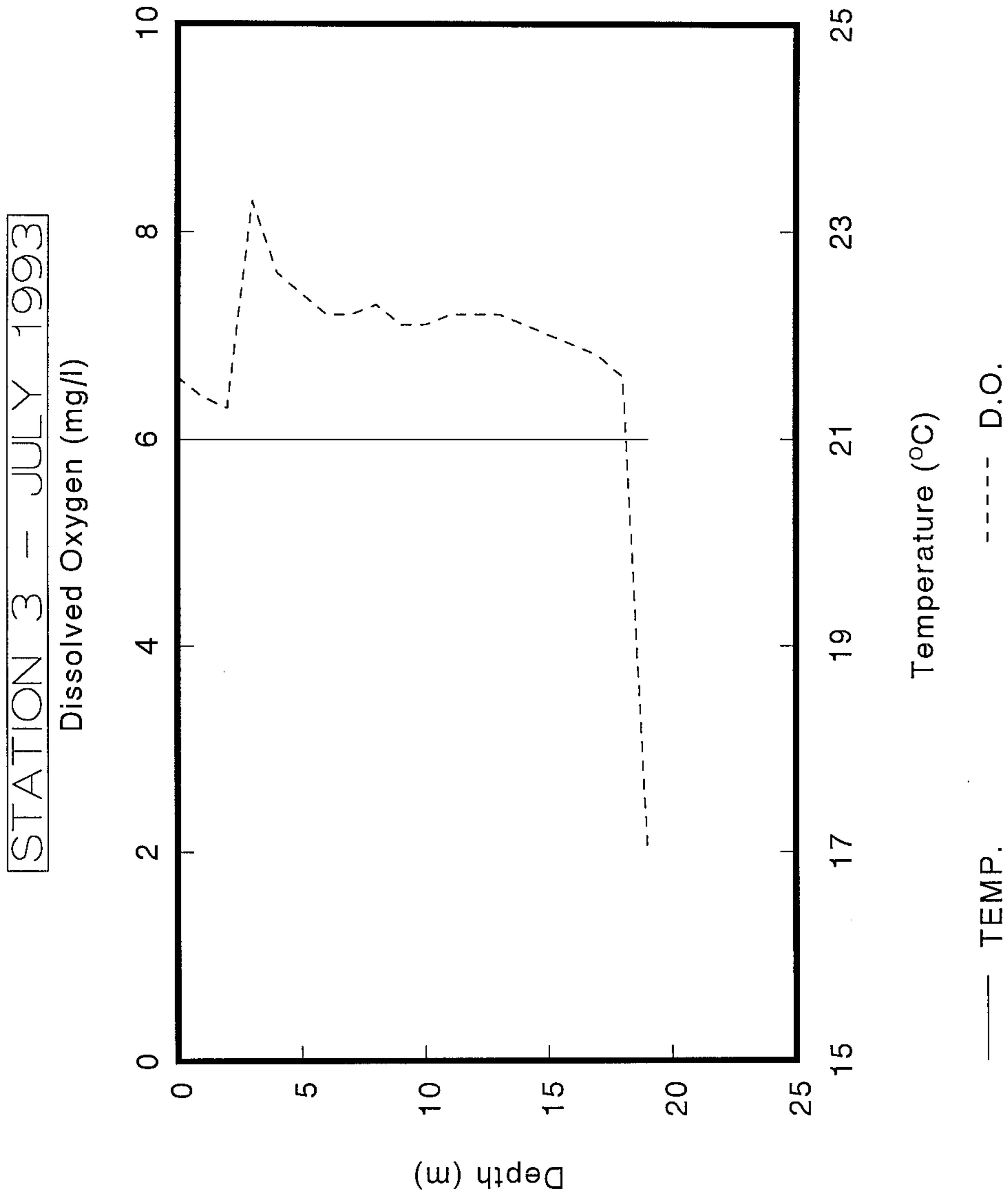
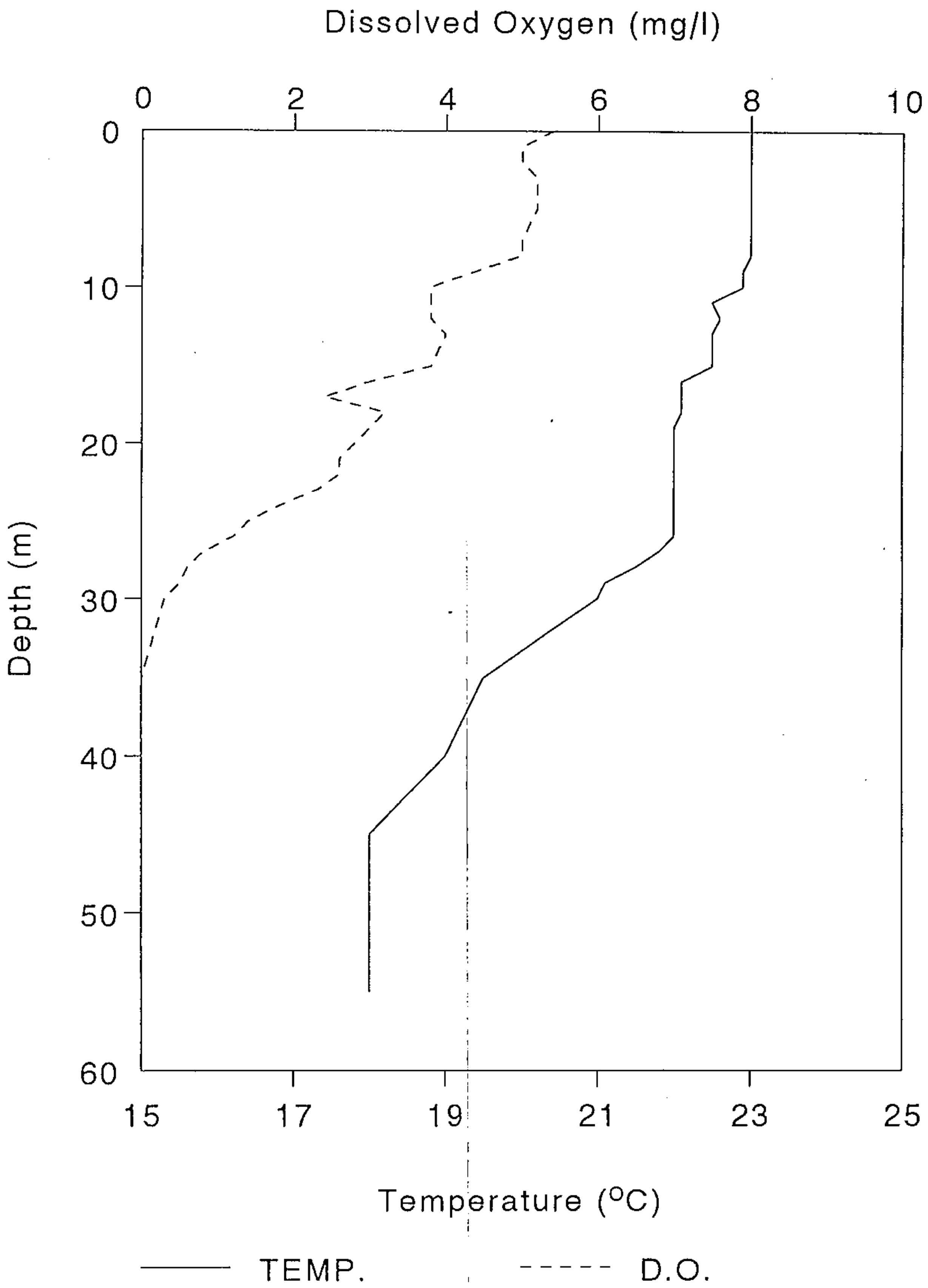

STATION 3 — JULY 1993
Dissolved Oxygen (mg/l)
0
2
4
6
8
10
Depth (m)
0
5
10
15
20
25
15
17
19
21
23
25
Temperature (°C)
TEMP.
D.O.

TABLE - 7 - SUMMER RESULTS

DATA FOR MONASAVU DAM STATION 1 - JANUARY, 1994

DEPTH (m)	TEMP. (°C)	DISS. O_2 (mg/L)	DEPTH (m)	TEMP. (°C)	DISS. O_2 (mg/L)
0	23.0	5.4	16	22.1	3.0
1	23.0	5.0	17	22.1	2.4
2	23.0	5.0	18	22.1	3.2
3	23.0	5.2	19	22.0	3.0
4	23.0	5.2	20	22.0	2.8
5	23.0	5.2	21	22.0	2.6
6	23.0	5.1	22	22.0	2.6
7	23.0	5.0	23	22.0	2.3
8	23.0	5.0	24	22.0	1.8
9	22.9	4.4	25	22.0	1.4
10	22.0	3.8	26	22.0	1.2
11	22.5	3.8	27	21.8	0.8
12	22.6	3.8	28	21.5	0.6
13	22.5	4.0	29	21.1	0.4
14	22.5	3.9	30	21.0	0.3
15	22.5	3.8	35	19.5	<0

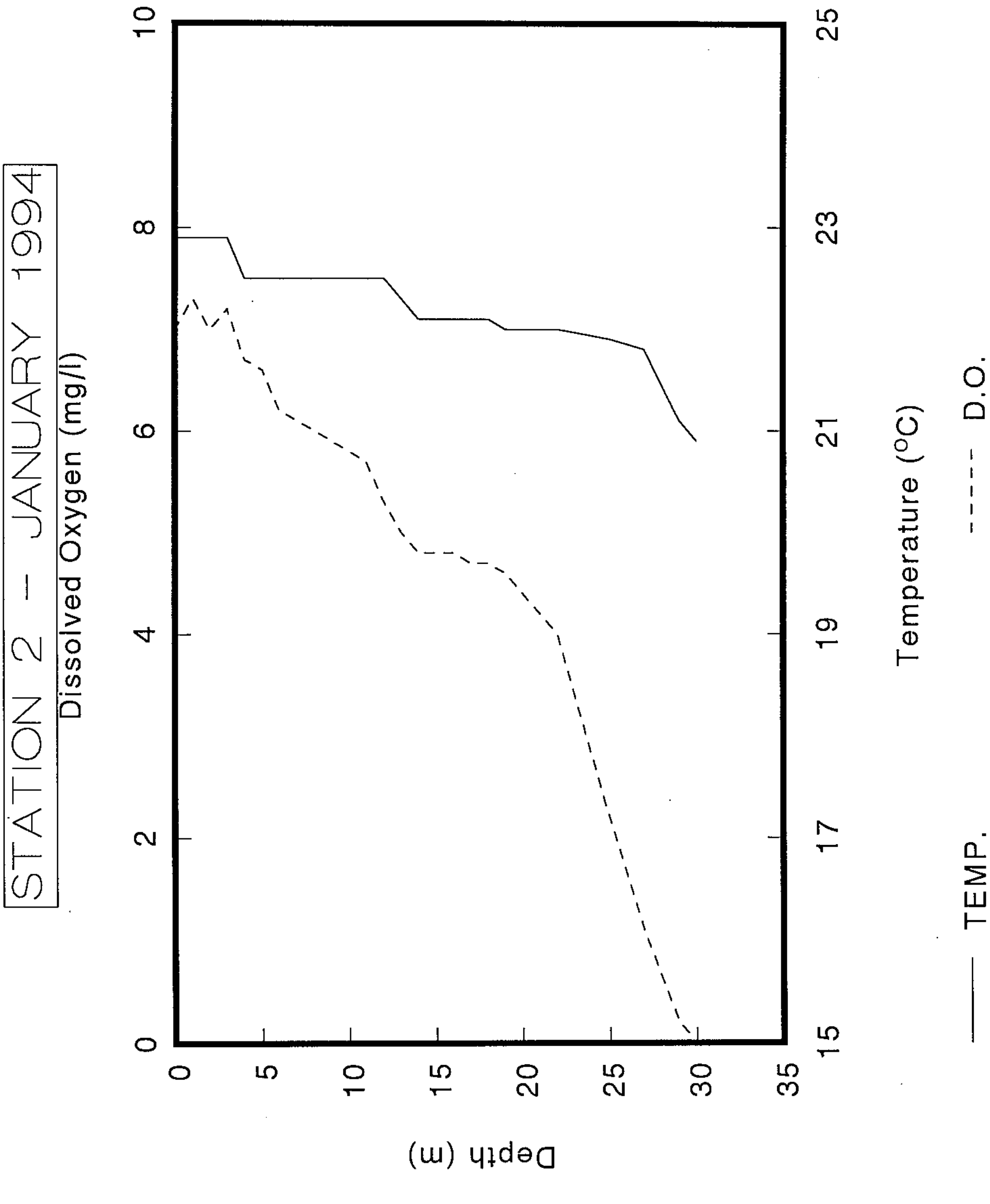


STATION 1 - JANUARY 1994

TABLE 8 - SUMMER RESULTS

DATA FOR MONASAVU DAM STATION 2 - JANUARY, 1994

DEPTH (m)	TEMP. (°C)	DISS.O_2 (mg/L)	DEPTH (m)	TEMP. (°C)	DISS.O_2 (mg/L)
0	22.9	7.0	13	22.3	5.0
1	22.9	7.3	14	22.1	4.8
2	22.9	7.0	15	22.1	4.8
3	22.9	7.2	16	22.1	4.8
4	22.5	6.7	17	22.1	4.7
5	22.5	6.6	18	22.1	4.7
6	22.5	6.2	19	22.0	4.6
7	22.5	6.1	20	22.0	4.4
8	22.5	6.0	22	22.0	4.0
9	22.5	5.9	25	21.9	2.2
10	22.5	5.8	27	21.8	1.1
11	22.5	5.7	29	21.1	0.2
12	22.5	5.3	30	20.9	<0



STATION 2 - JANUARY 1994
Dissolved Oxygen (mg/l)
0
2
4
6
8
10
Depth (m)
0
5
10
15
20
25
30
35
15
17
19
21
23
25
Temperature (°C)
TEMP.
D.O.

During the summer visit in January 1994, there was definite temperature gradient in the water, and dissolved oxygen levels decreased steadily with depth at both stations 1 and 2 in the reservoir. No measurement of temperature and DO could be done at station 3 due to meter malfunction. At station 1, the temperature difference between the surface and the bottom was 3.5 °C while at station 2 it was 2 °C. The change in DO levels with depth were more obvious. At station 1, DO levels of < 4 mg/L occurred from a depth of 10 m onwards while at station 2, conditions were slightly better with DO of < 4 mg/L occurring from around 22 m onwards. It appears that the presence of the aerator near the tunnel outlet near station 2 was helping increase the DO levels than would otherwise have occurred.

(b) pH

The pH values for all the sites during the winter sampling was in the range 6.8 - 8.2 and during the summer visit, the range was 6.8 - 7.5. All these values are in the expected range for dams (Wetzel, 1975) and also for recreational waters for Fiji which is 5.0 - 9.0 (NEMP 6, 1992).

(c) Total Alkalinity

The alkalinity was in the range 28.4-43.0 mg/L $CaCO_3$ during the winter period and this was similar to values obtained in the past (Gangaiya, 1991; Lloyd et al., 1992). The summer values varied from a low 9 to 29 mg/L $CaCO_3$. There has not been any major difference in the total alkalinity values over the years, indicating that the water quality in the reservoir has remained fairly stable for a number of years now.

(d) Nutrients

Total nitrogen values for both the winter and summer visits have been much lower than in previous years. The range of values in winter was <0.01 to 0.11 mg/L and the summer values varied from <0.01 to 0.07 mg/L. There was no obvious pattern in the values and the summer values would have been greatly influenced by the flood conditions.
The concentrations of nitrates in the winter visit varied from 0 to 0.43 mg/L and in summer, values ranged from <34 to 236 ug/L. The general pattern noted at most stations was an increase in nitrate levels with depth.

The concentrations of ammonia in winter ranged from 31.6 to 236 ug/L and in summer from <12.2 to 292 ug/L. As has been the trend in previous monitorings, the concentrations of ammonia increased with depth, the highest value being recorded for the deepest site (station 1 - bottom) in summer.

Total phosphorus values were generally low with no obvious pattern in the concentrations. The range in summer was <6 to 9.1 ug/L and in winter, the range was <6 to 15 ug/L.

There was also no obvious pattern in the distribution of dissolved phosphates at all sites during both the summer and winter visits. The range of PO_4 in winter was 14.6 - 94.5 ug/L and in summer was <5 - 89.7 ug/L.

The concentrations of total sulphur were generally low in summer (all <2 mg/L). The variation in winter was greater with values ranging from 0.80 to 120 mg/L. Again no obvious pattern could be found for the distribution of total sulphur.

(e) Chlorophyll

In summer all chlorophylls *a*, *b* and *c* were low throughout the water column. During the winter visit, chlorophylls *a* and *b* were present in varying amounts and chlorophyll *c* was very low.

(f) Total and dissolved iron and manganese

For total iron, the concentrations during both winter and summer sampling were low. In winter, the only significantly high value was 34 mg/L recorded at the bottom waters of station 1 (deepest part of the dam), where anoxic condition would have reduced the iron oxides and hydroxides and releasing the element back in the water column. In summer the range was <0.3 mg/L to 2.1 mg/L with no real variation with depth.

The concentration of dissolved iron were also generally low during both the winter and summer visits. In winter, all values were <0.3 mg/L. In summer, the bottom waters showed some presence of the element while the surface and mid-depth waters all had <0.3 mg/L.

Total manganese concentrations were low (<0.2 mg/L) throughout the water column during winter and summer, with the exception of the deepest part of the dam at the bottom of station 1 which showed some presence of the element.

The same trend found for total manganese was also found for dissolved manganese with all values being below <0.2 mg/L.

The low concentrations of the total and dissolved iron and manganese in the dam in general, with the exception of the deeper waters has been the trend for the last ten years since 1985 (Gangaiya, 1986; Naidu & Brodie, 1987; Naidu et al., 1989; Morrison et al., 1990; Gangaiya, 1991; Lloyd et al., 1993).

4.2.2 The Weirs

The visit in July, 1993 was the first after the devastation of cyclone Kina. There was still much gravel, sediment and refuse in the creeks, particularly at the Wainikasou south weir site making the creeks rather shallow. However, this did not affect the quality of the water in general. At the Wainabua weir site, the road was inaccessible due to a lands slip and road construction was already underway.

The visit in January coincided with one of the wettest periods in the year and all the creeks were flooded and the weirs were submerged (see photos appended).

The pH, temperature and dissolved oxygen concentrations were all within acceptable ranges for freshwater creeks during the winter and summer visits.

The total dissolved solids concentrations were in the range 29-59 mg/L in winter and 11-27 mg/L in summer. These values are similar to results from previous monitorings.

The total suspended solids concentrations were low as usual during the July sampling (1-7 mg/L) but as a result of the heavy rain and flood in the creeks, the TSS were rather high in January with the range from 18-87 mg/L. Four of the five weir sites recorded between 72 and 87 mg/L TSS. The low total suspended solids concentrations indicated that water quality in the creeks was not being adversely affected by the logging in the area but, two visits in a year are not sufficient to draw any realistic conclusions in this regard.

The concentrations of total and dissolved iron were all low. In winter all values were below 0.3 mg/L and in summer total iron varied from 1.4 to 9.0 mg/L while dissolved iron varied from 0.3 to 4.2 mg/L.

The concentrations of total and dissolved manganese were also low with virtually all values being below the detection limit of 0.2 mg/L. The only exception was at Wainabua in summer when total and dissolved manganese were a low 0.3 mg/L.

4.2.3 The Wailoa River

The three sites along the Wailoa River (Fig.2) are compared to see if the Power station was having an impact on the quality of the water. Also by comparing status of iron and manganese at the bottom of station 2 in the dam and the tailrace below the Power station, the possibility of deposition of these metals on the machinery in the power station can be indirectly addressed.

As far as pH, temperature and dissolved oxygen are concerned, there were no significant difference in the values for the three sites along the Wailoa River during both the winter and the summer visits. The values of pH, temperature and DO were similar for station 2 bottom and at the tailrace during the winter visit but in the summer visit, the DO levels were much different, i.e. while it is very low at the bottom of station 2, it is very high at the tailrace which means that the water is quickly oxygenated at the power station.

The nutrient levels are generally similar for the three sites along Wailoa River and the dam sites. As has been the trend so far, the level of ammonia is greatly reduced from when the water leaves the dam (bottom station 2) until it is discharged at the tailrace and this is a consequence of the oxygenation process of the water in the power station. The same process however creates problems as far as the iron and manganese levels are concerned.

There is no cause for concern as far as manganese levels are concerned. All values of total and dissolved manganese in the dam and along the Wailoa River were below detection limit (<0.2 mg/L) except for the bottom of station 1 in winter.

The dissolved iron levels were all low (<0.3 mg/L) in winter but in summer, the bottom waters of the dam had higher levels compared to the surface as a result of anoxic conditions favouring the reduced forms of the metals. The concentration of dissolved iron was less at the tailrace compared to bottom of station 2. The oxygenation of the water in the power station would cause the oxidation of the iron to the insoluble oxides and hydroxides and these could be a cause for concern for the FEA machinery at the power station.The same trend was observed for total iron in summer as well as in winter.

5. BIOLOGICAL SURVEY - Report on the Invertebrates in Lake Monasavu, January 1994, By Dr. Alison Haynes.

An invertebrate survey of Lake Monasavu was carried out on 19 January 1994. Heavy rain fell during the survey and the streams entering the lake were in flood.

In the two sites studied in the lake, the only two invertebrates present were the water snail Melanoides tuberculata and the freshwater sponge Spongilla sp. This brown sponge was abundant on the rock surfaces and its round cream gemmules (reproductive structures) were very obvious.

Plankton

Copepods (crustacea) were very abundant. Cladocera (crustacea), a few, were observed for the first time in the lake. There were many small yellow algal colonies.

6. CONCLUSIONS

The results of the water quality analyses in 1993 showed that the general trends observed in previous monitorings have persisted i.e. the water body being relatively homothermic in winter and stratified in summer and as a consequence of this seasonal variation, the levels of dissolved oxygen with depth show marked changes in summer and not so much in winter. The DO levels in turn affect the status of ammonia, dissolved and total iron and manganese. However, there has been marked reduction in levels of these elements over the years.

The results of the summer visit on January 18th and 19th may have been affected by the very heavy rainfall and flood, thus the high total suspended solid concentrations in the creeks.

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APPENDIX A - PHOTOGRAPHS OF FLOODED WEIR SITES - January 18 1994