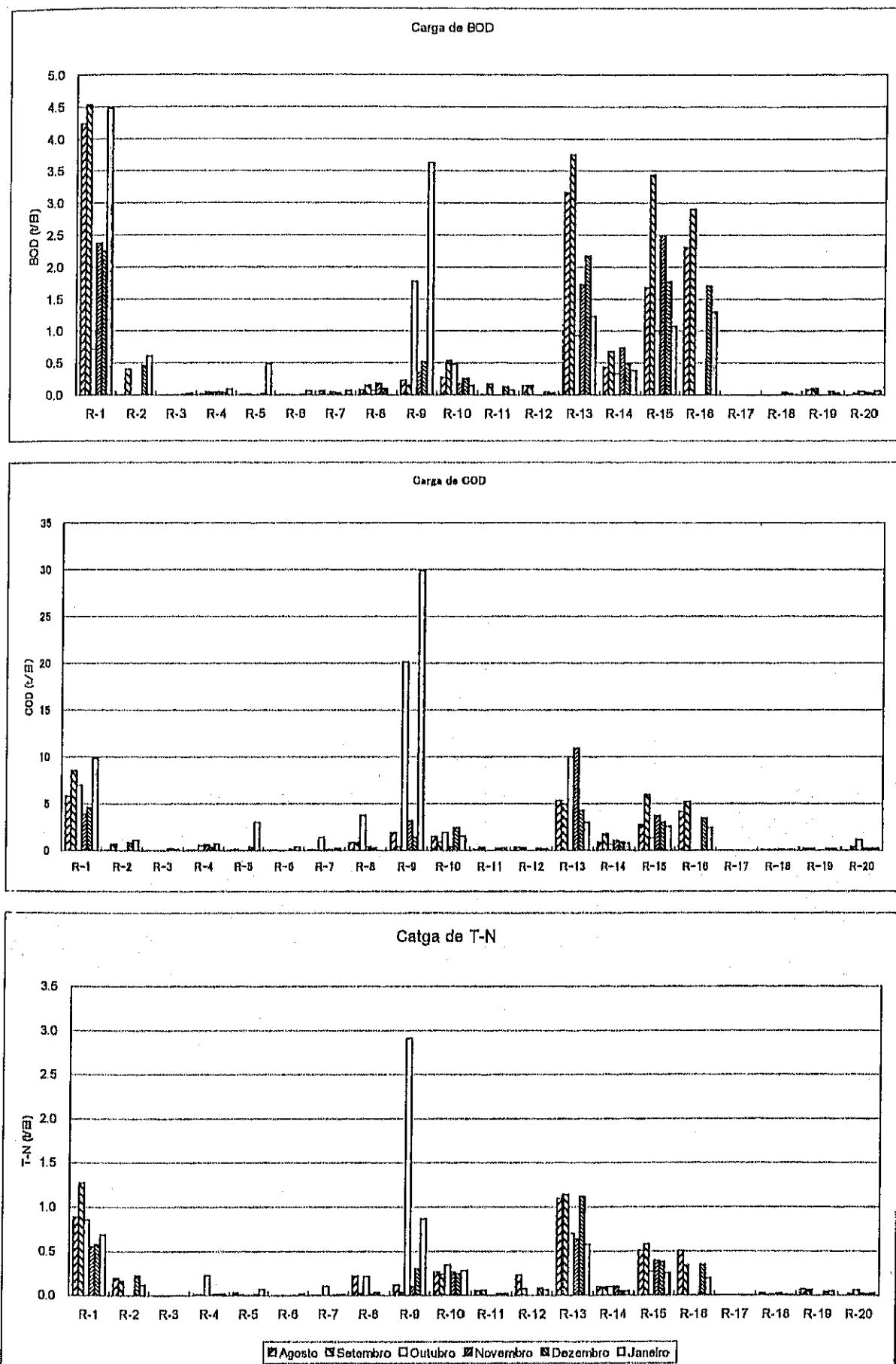
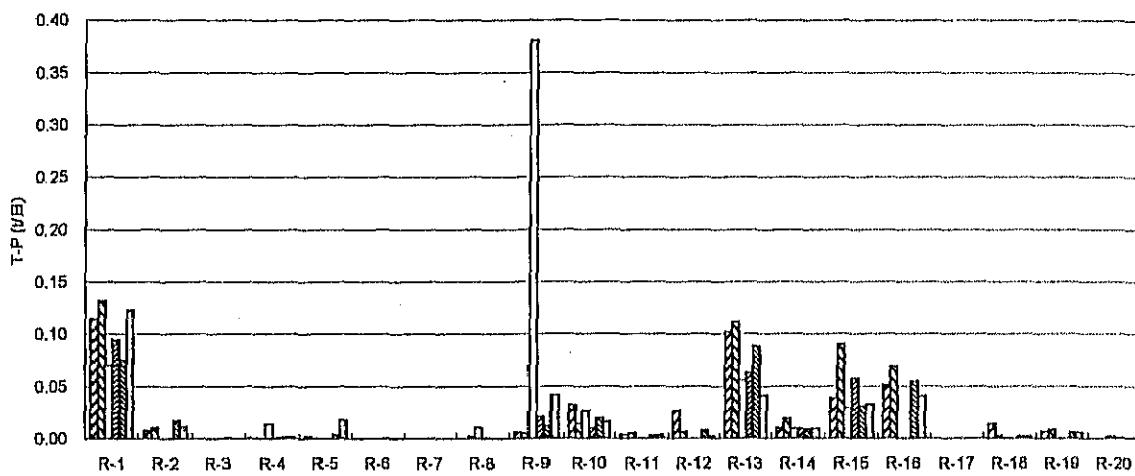


ANNEX 5.3.3

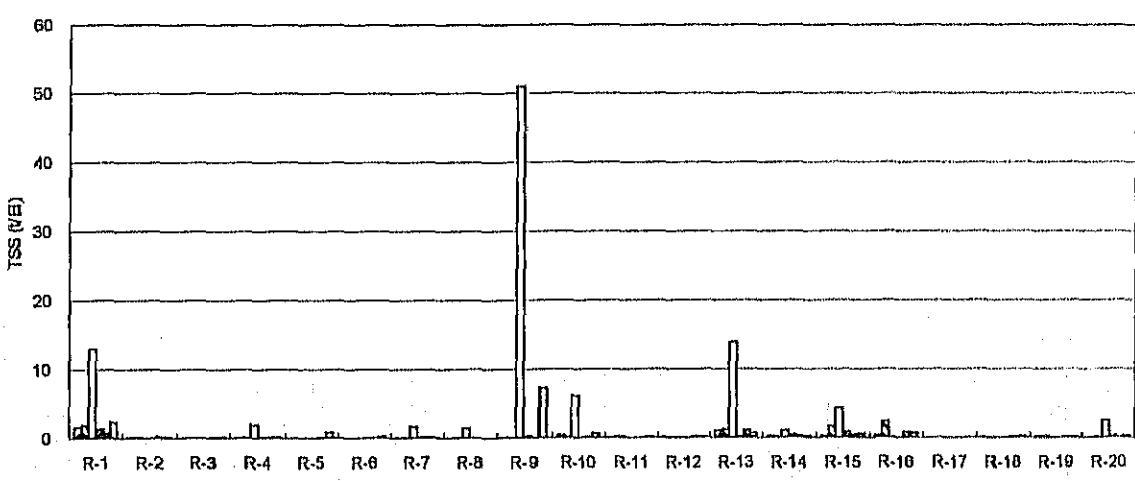
Material Anexo A5.3.3 Carga dos Tributários da Represa Billings



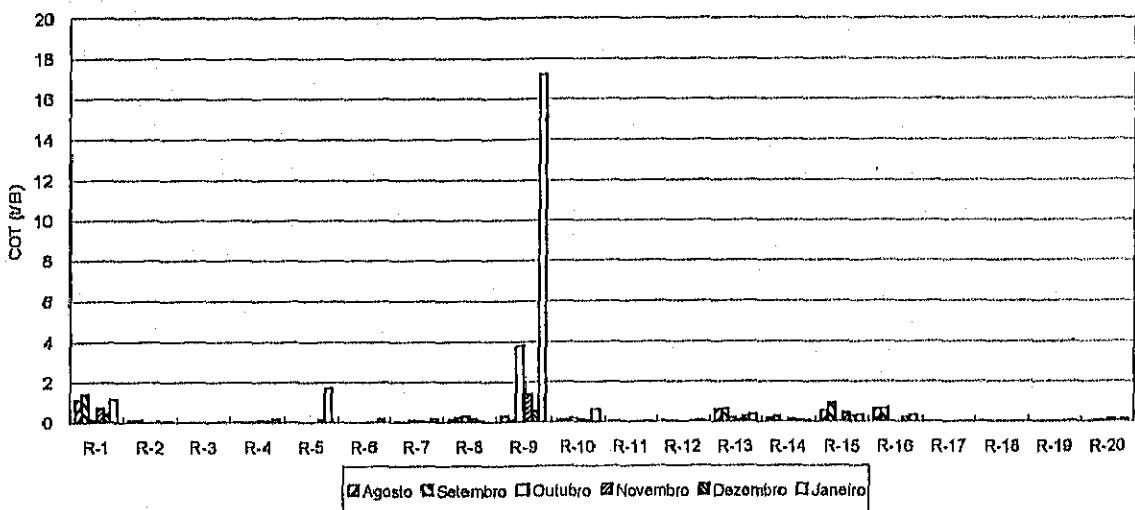
Carga de T-P



Carga de TSS



Carga de TOC



ANNEX 5.3.4

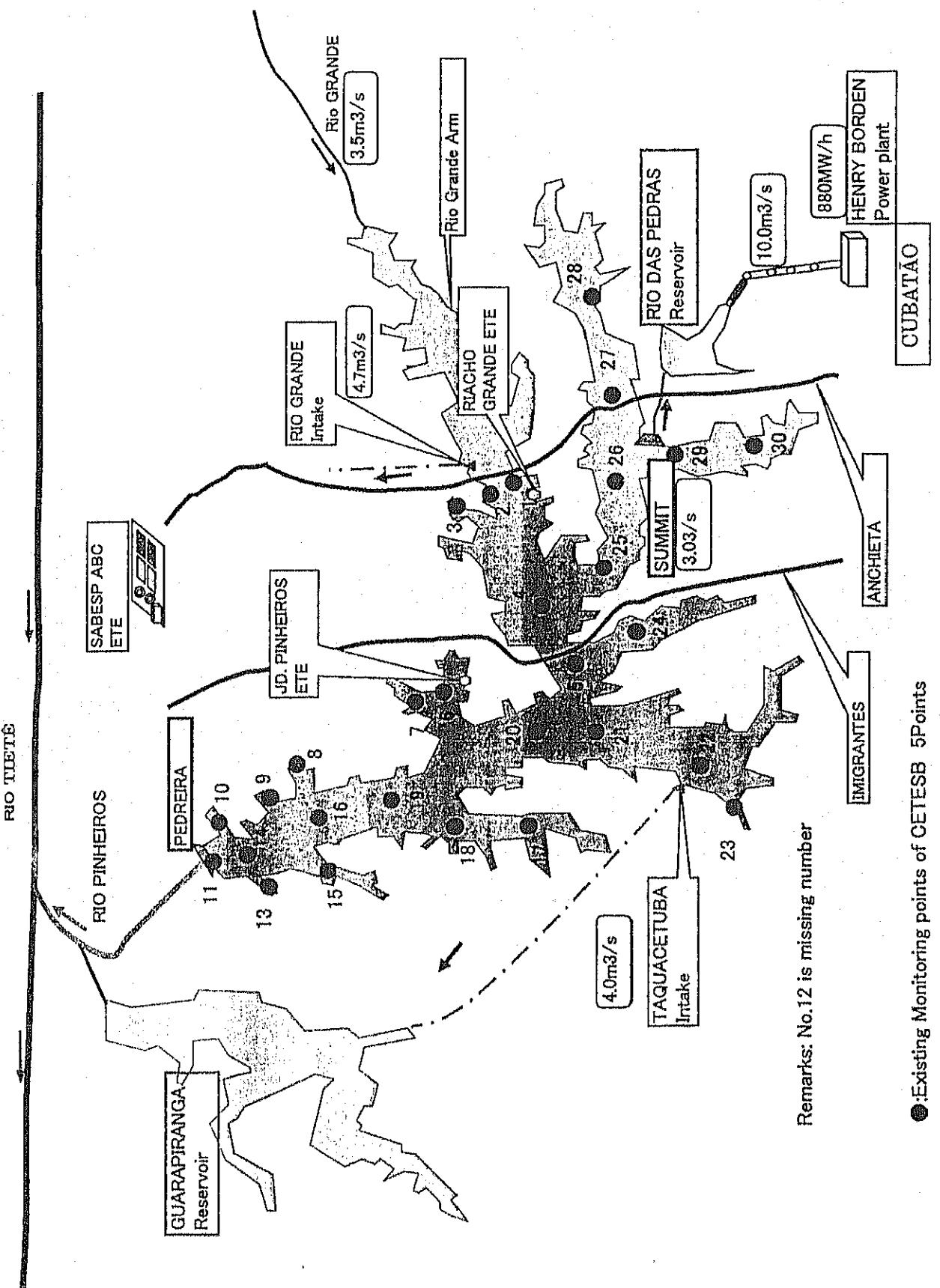
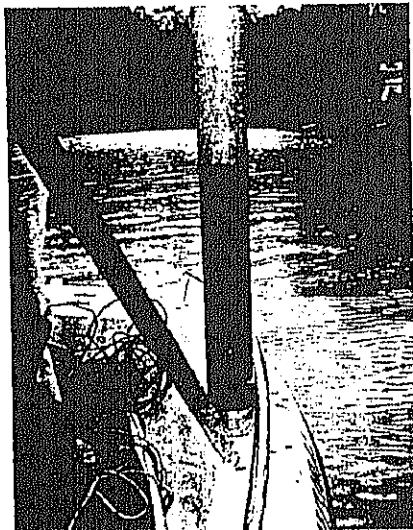


Figure –1 Location of monitoring points for water and bottom sediment

- Existing Monitoring points of CETESB 5 Points
- Additional Monitoring points of JICA STUDY TEAM 24 Points



Riacho Grande 2 7/11 10AM



Riacho Grande 1 7/11 10AM



Riacho Grande 3 7/11 11AM



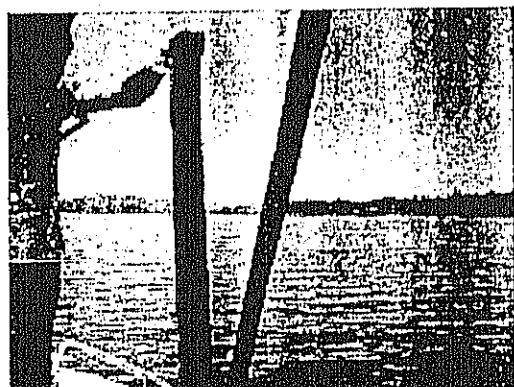
Capibari 7/11 14PM

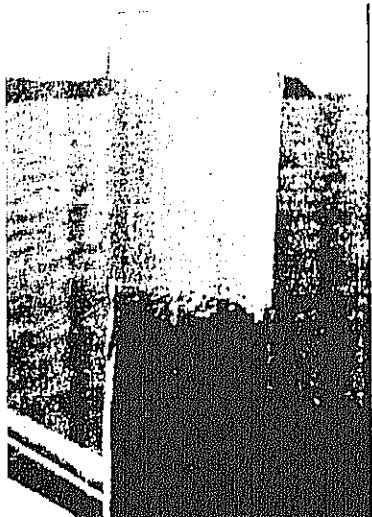


Riacho Grnd 1 7/11 10AM

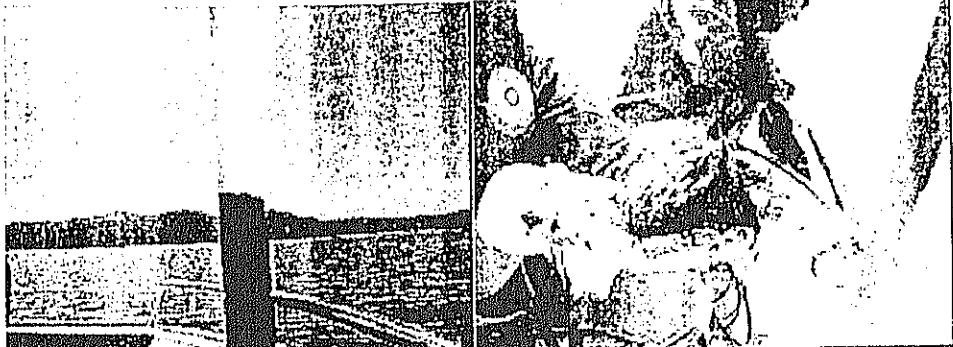


Borore 7/12 11AM





Rio Pequeno 7/12 10AM

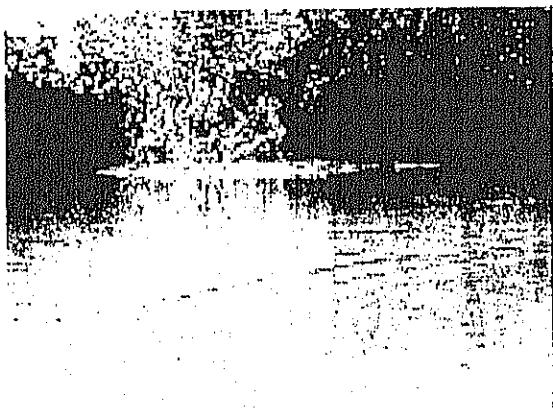


Rio Pequeno 7/12 10AM

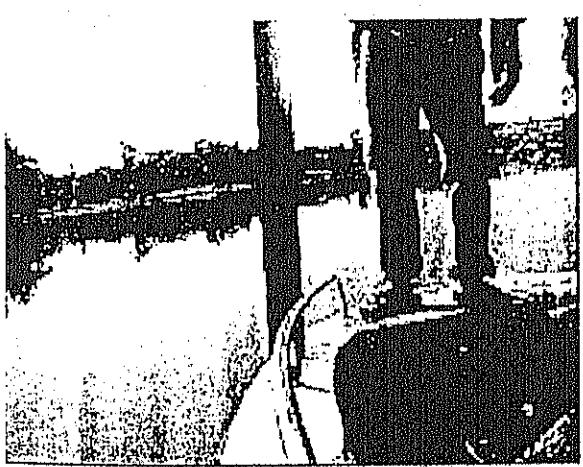
Rio Pequeno soil and roots 7/12 10AM



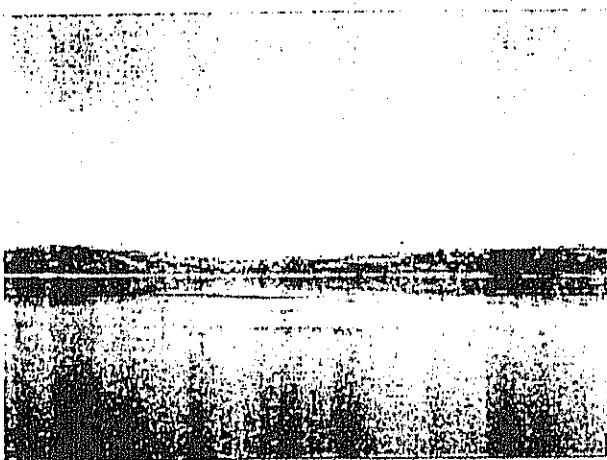
Main BL5 7/12 1PM



Taquacetuba 7/12 15PM



Grota Funda 7/13 14PM



2006/07/13 15PM Pedreira dam

Table 1 Description of result of supplemental study

Indices	Description	Status of Compliance
Sludge Volume	1 Sludge volume assumed is about 52,700 thousand m ³ including Rio Grande. The rate equals to almost 7 % of the Lake volume assuming that the water volume is 800,000 thousand m ³ . 2 Average thickness of the sediment is approximately 51 cm for the Billings, and 34cm for Rio Grande.	-
DO	1 Only 6 points out of 29 points meet class 2 regulation for DO. 2 Even in Rio Pequeno in which population is relatively small, DO is far lower than the value of regulation.	20.70%
Chi	1 Only 10 points out of 29 points meet class 2 regulation for chl. 1 Other than Mn, Any substances violating the regulation was not detected. 2 5 points out of 29 points do not meet class 2 regulation for Mn.	34.48%
Heavy Metal	1 6points out of 29 points violate class 2 regulation for NH4. 2 Violation concentrate near the Pedreira Dam.	82.76%
NH4	1 TP distribution is similar to that of surface NH4. 2 Violation concentrate near the Pedreira Dam.	79.31%
TP	1 All the point violate the regulation of coliform for class 2	-
Coliform	1 Average BOD concentration is twice as much as regulation for class 2, that is 5mg/l. 2 Influence of reverse pumping seems to be observed.	65.52%
BOD	1 Compared with BOD, COD value is about 3 times bigger, that is 28mg/l. 2 pH in 3 points is lower than that of surface, averagely -180mV.	24.13%
COD	1 EH in sediment is far lower than that of surface, averagely -180mV. 2 Water content in surface of the sediment is approximately 87%.	-
EH and pH	1 Water content in middle is lower than surface(around 65% of surface), and compressed at the bottom(around 40% of surface). 2 Huge amount of nutrient matters are deposited in the bottom.	89.66%
Water content of sediment	1 Once decomposed to NH4 or PO4 in anaerobic condition, diffusion to the water shall be made very rapidly. 2 After the first diffusion, nutrient matters will iterate the process of absorption to the sludge at the bottom and elution to the water, depending on the aqueous atmospheric condition such as DO, pH, agitation, EH, etc.	-
TOC, TP and TN in sediment	3 This huge sludge sedimentation will facilitate as a reservoir of nutrient matters for the water. Removal of sludge must be developped through all the area of the lake, in order to remove the bad influence to the water quality.- Implementation of sludge removal for limited area will not be essentially effective other than prevention of local odour emission - methan gas generation. However, complete sludge removal is extremely difficult in terms of time and budget. Assuming that sludge shall be removed at a rate of 150,000m ³ /year, it will take 115years to deal one third of total sludge -	-

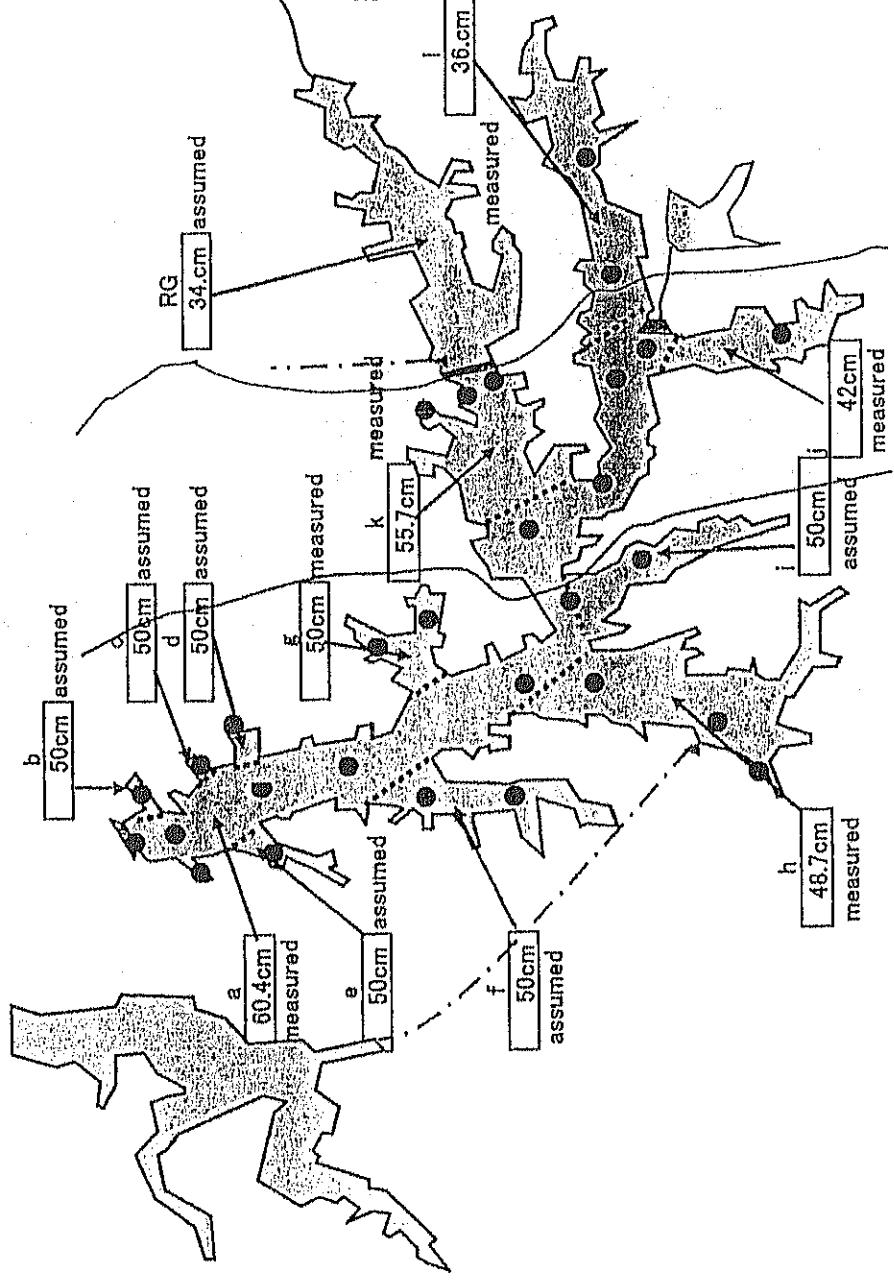


Table 2 Sludge Volume as of Aug. 2006

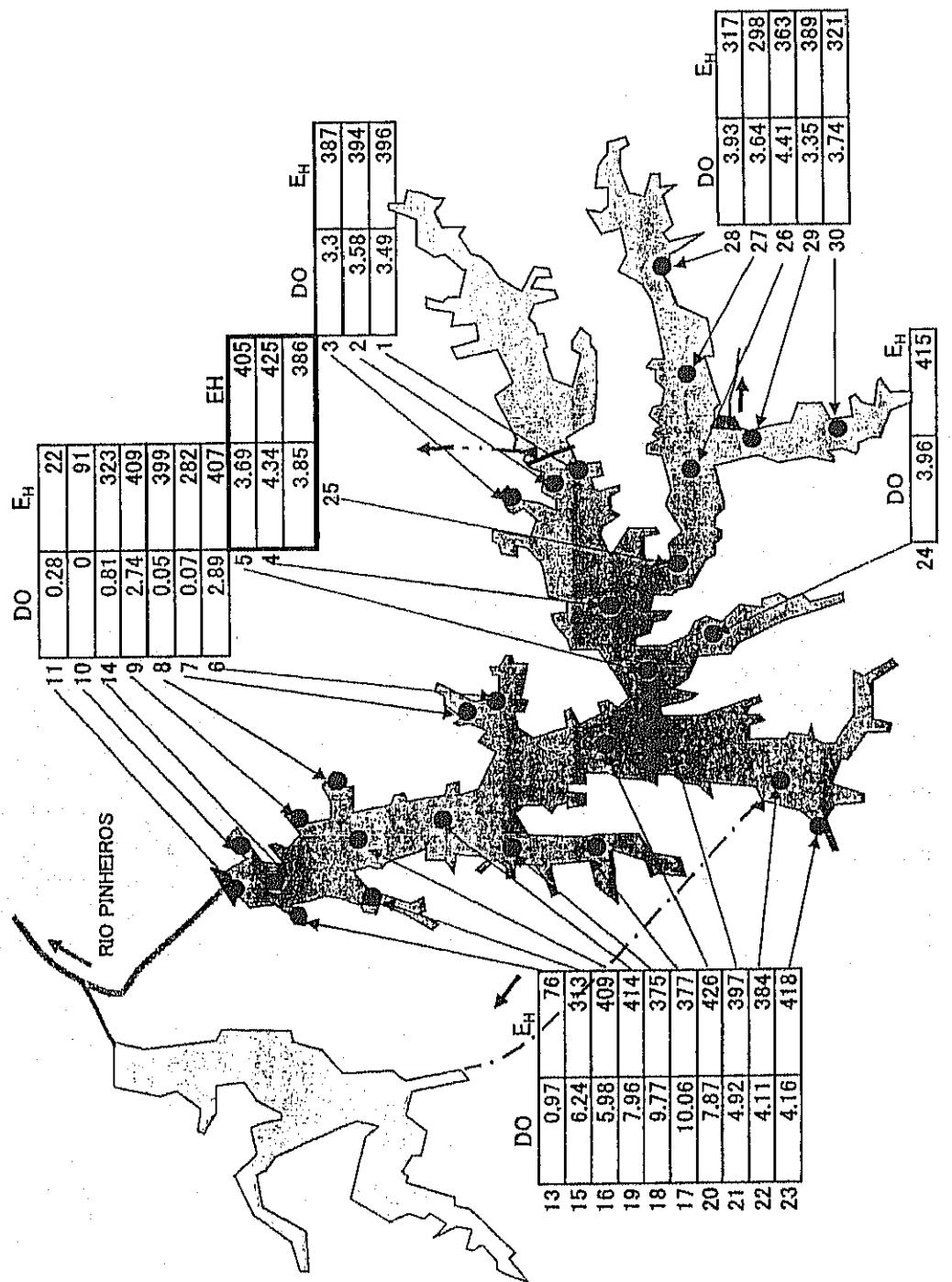
Area	Area ha	Sludge cm	Sludge volume m ³
a	3256.9	60.4	19,671,676
b	58.5	50	292,500
c	55.9	50	279,500
d	122.9	50	614,500
e	164.3	50	821,500
f	509.2	50	2,546,000
g	300.7	50	1,503,500
h	1,732	48.7	8,434,840
i	304.4	50	1,522,000
j	1,027.50	42	4,315,500
k	578.2	55.7	3,220,574
l	1,236.7	36	4,452,120
Sub Total	9,347.2		47,674,210
RG	1,467.0	34	4,587,800
Total	10,814.2		52,662,010

Average thickness in BI 0.510 m
 Average thickness in RC 0.340 m
 Average thickness total 0.487 m

●:Existing Monitoring points of CETESB 5 Points

◎:Additional Monitoring points of JICA STUDY TEAM 24 Points
 Rio Grande Arm is assumed using the data of Reference 1)

Figure -2 Distribution of sludge thickness in the Billings Lake as of Aug. 2006



Average DO	3.94 mg/l	STD DEVIATION	2.64 mg/l
22	75.86 %		

●:point conforming class 2 regulation

●:point breaking class 2 regulation

Figure -3 Surface DO and E_H

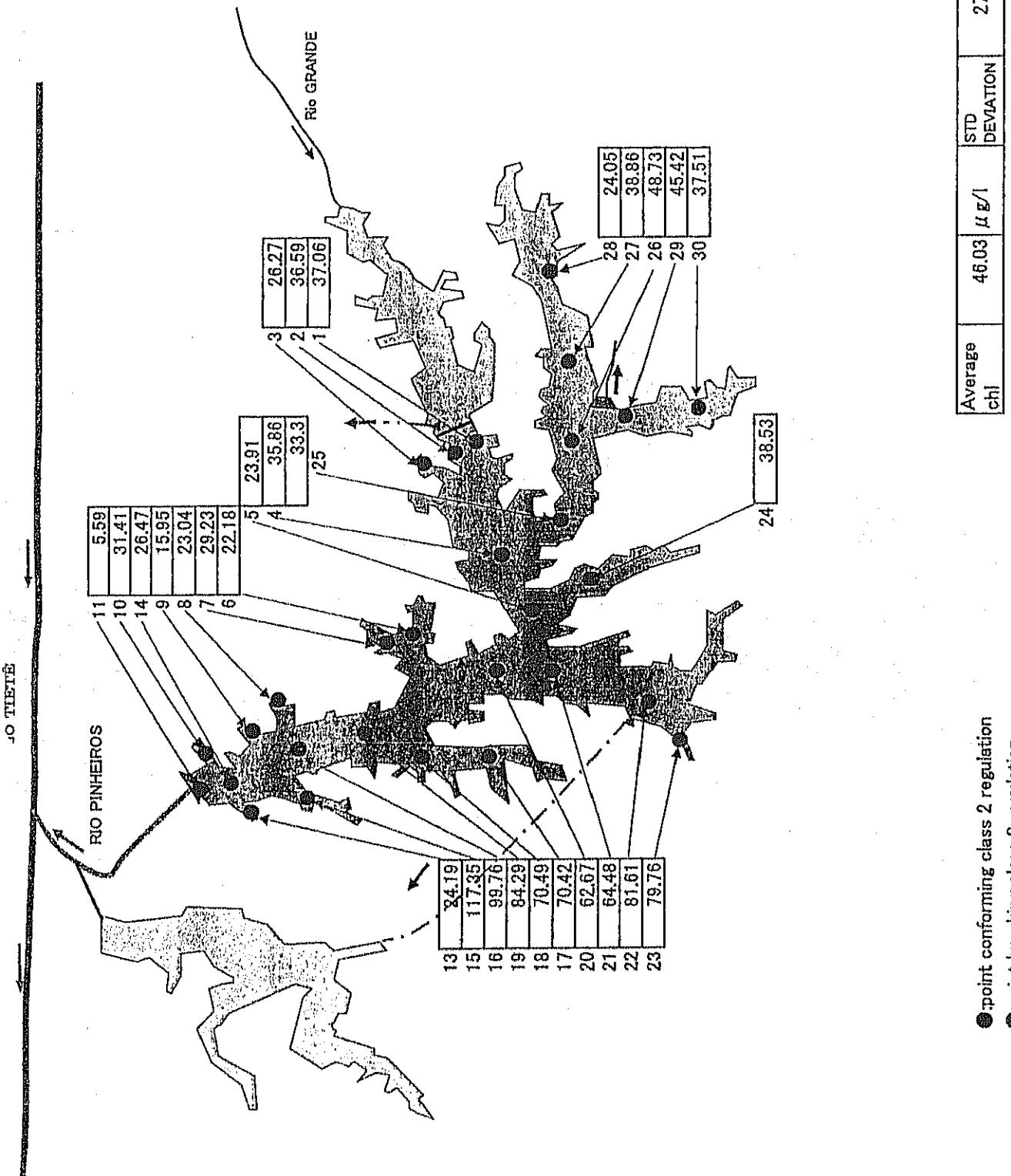
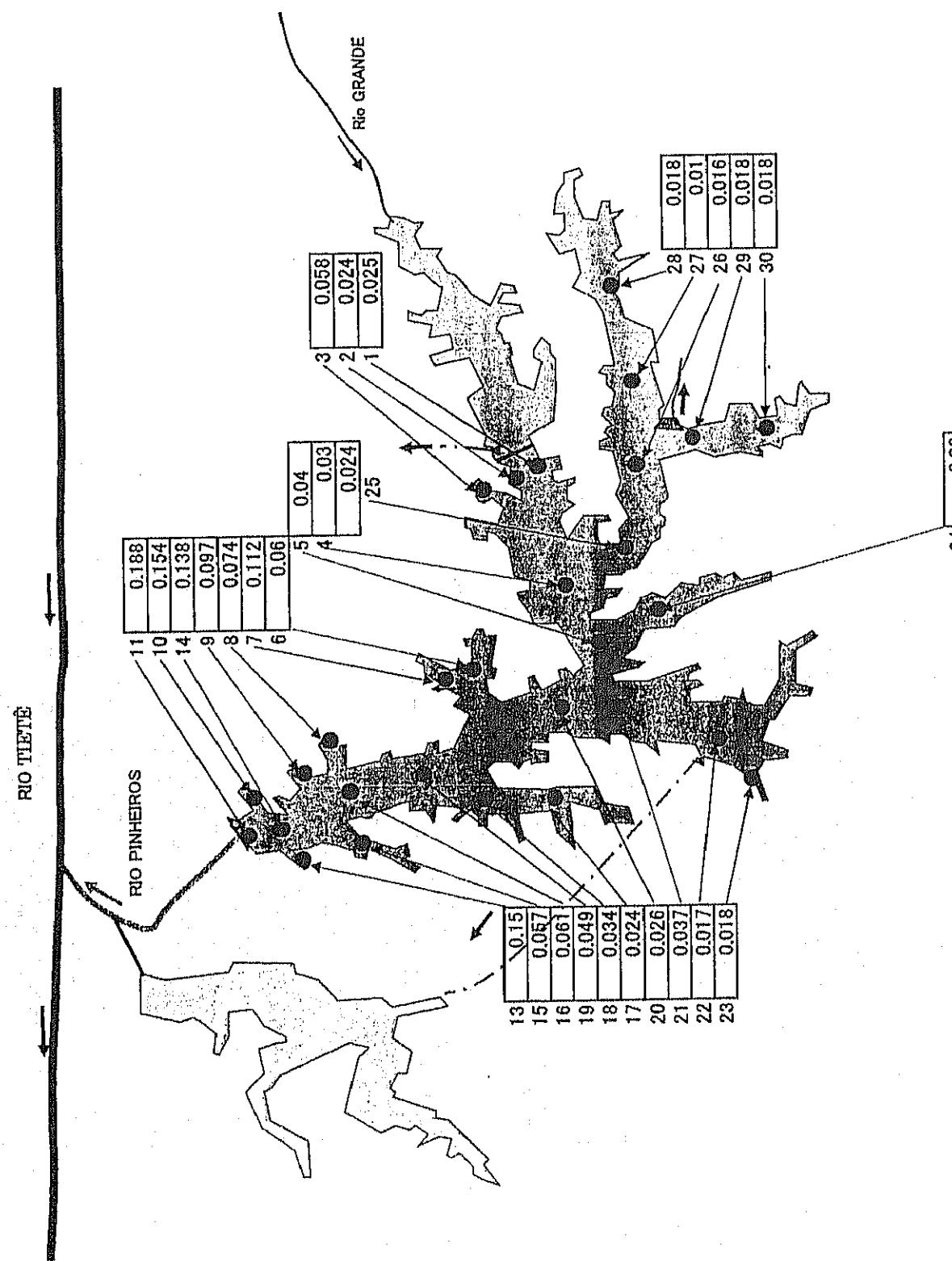
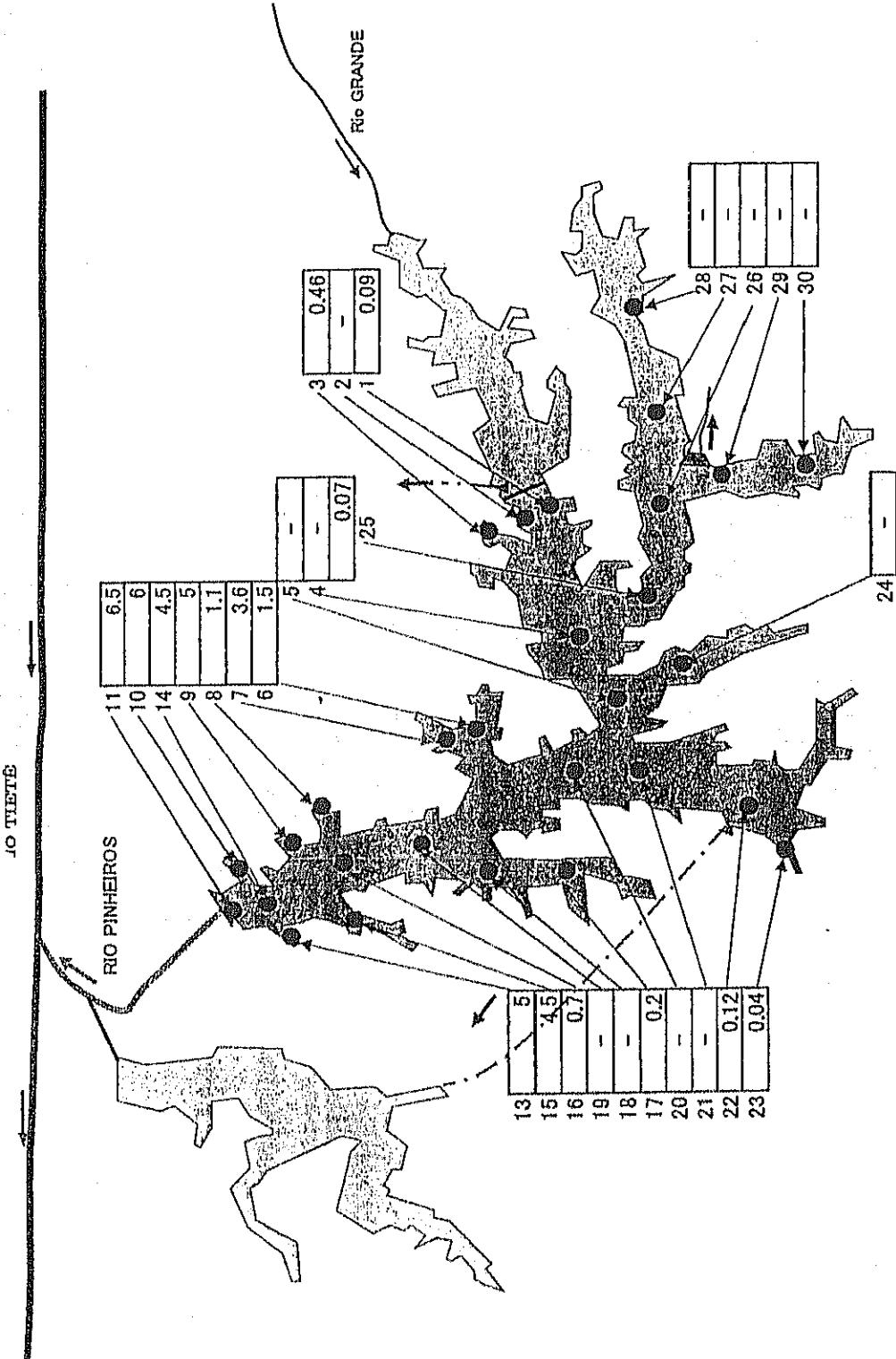


Figure -4 Chl Distribution



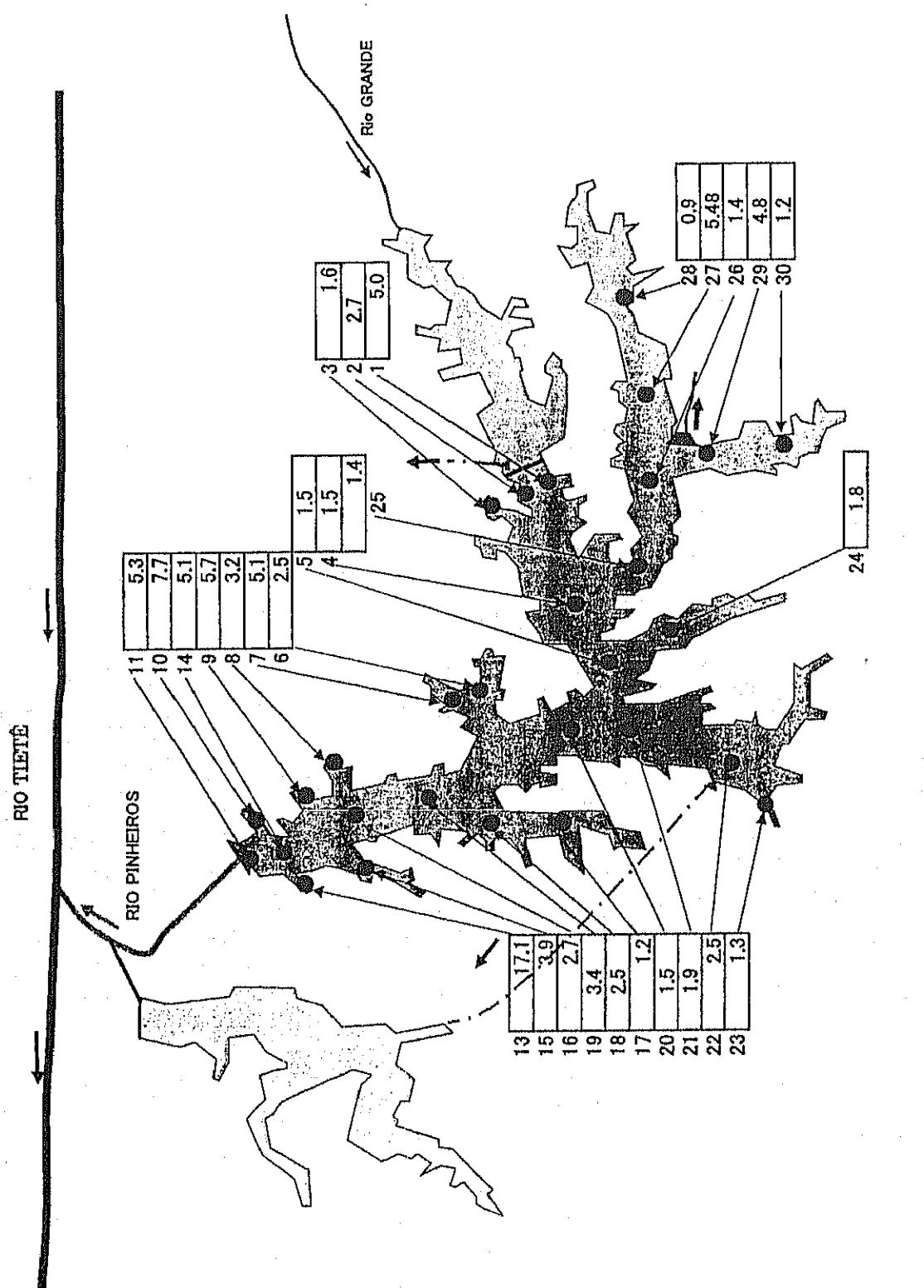
Average Mn	0.06 mg/l	STD DEVIATION	0.05 mg/l
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Figure -5 Mn distribution



Average NH ₄	2.46 mg/l	STD DEVIATION	2.44 mg/l
-	-	-	-

Figure -6 NH₄ distribution



Average total N	3.51 mg/l	STD DEVIATION	3.16 mg/l
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Figure -6-2 Total N distribution

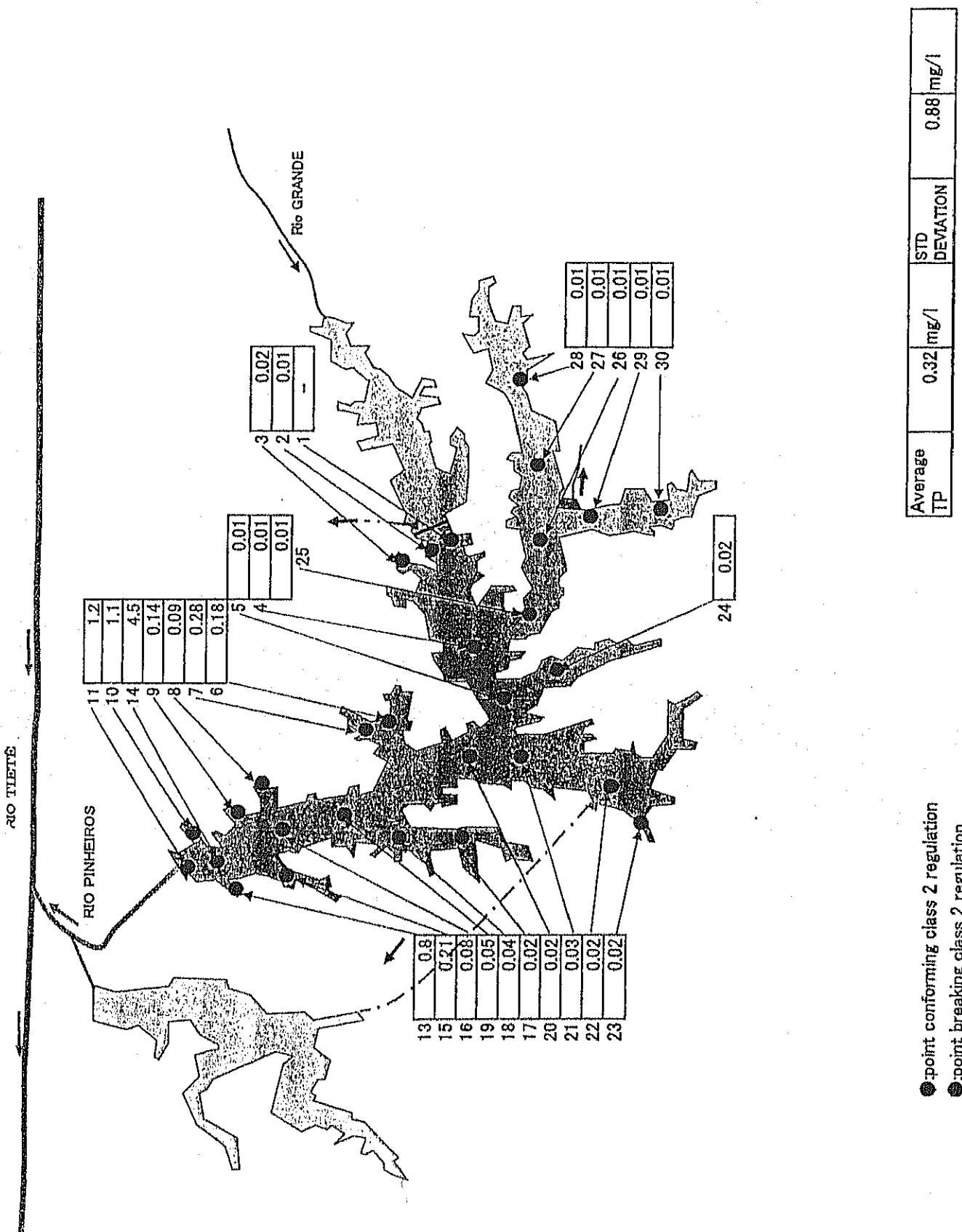
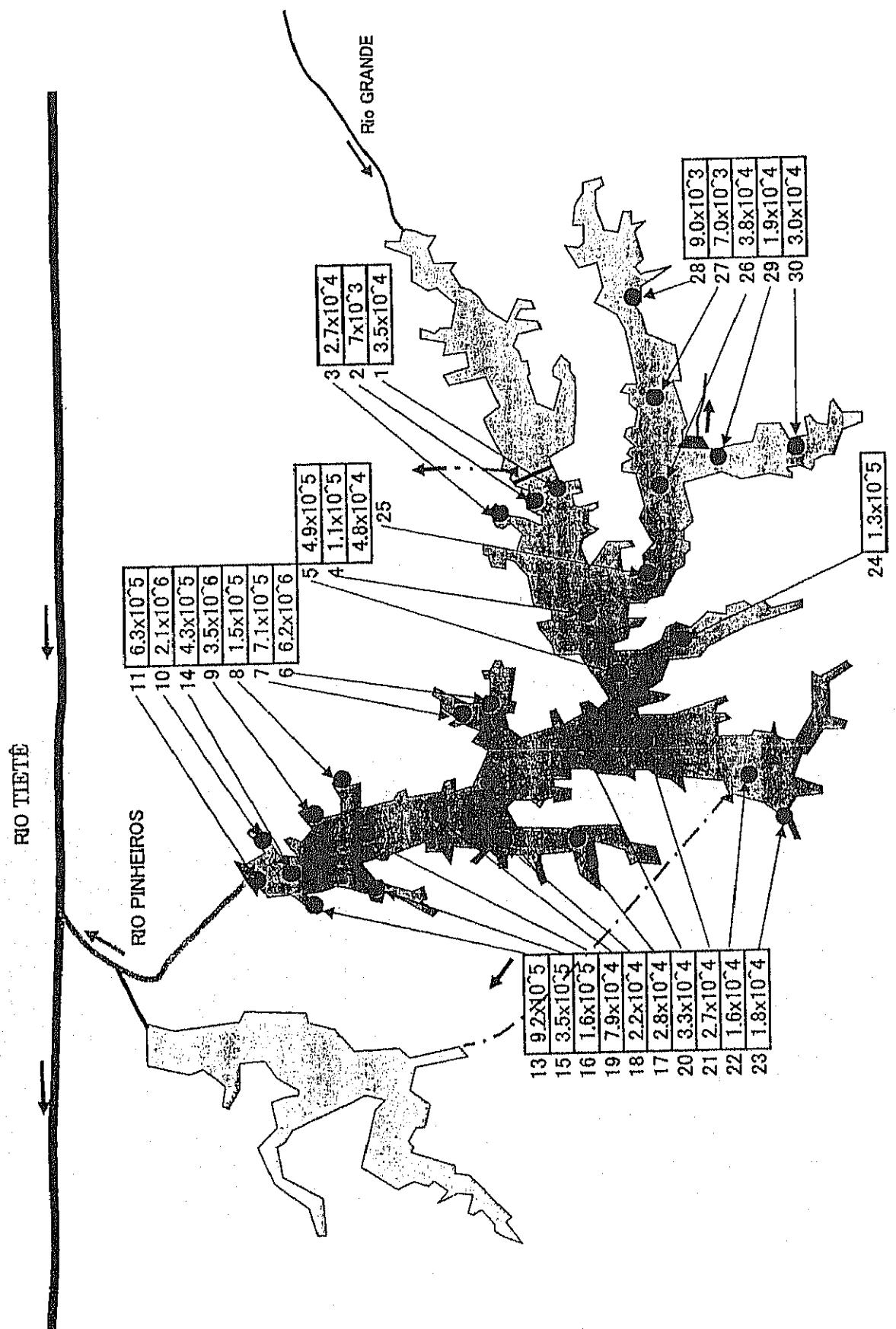


Figure -7 TP distribution



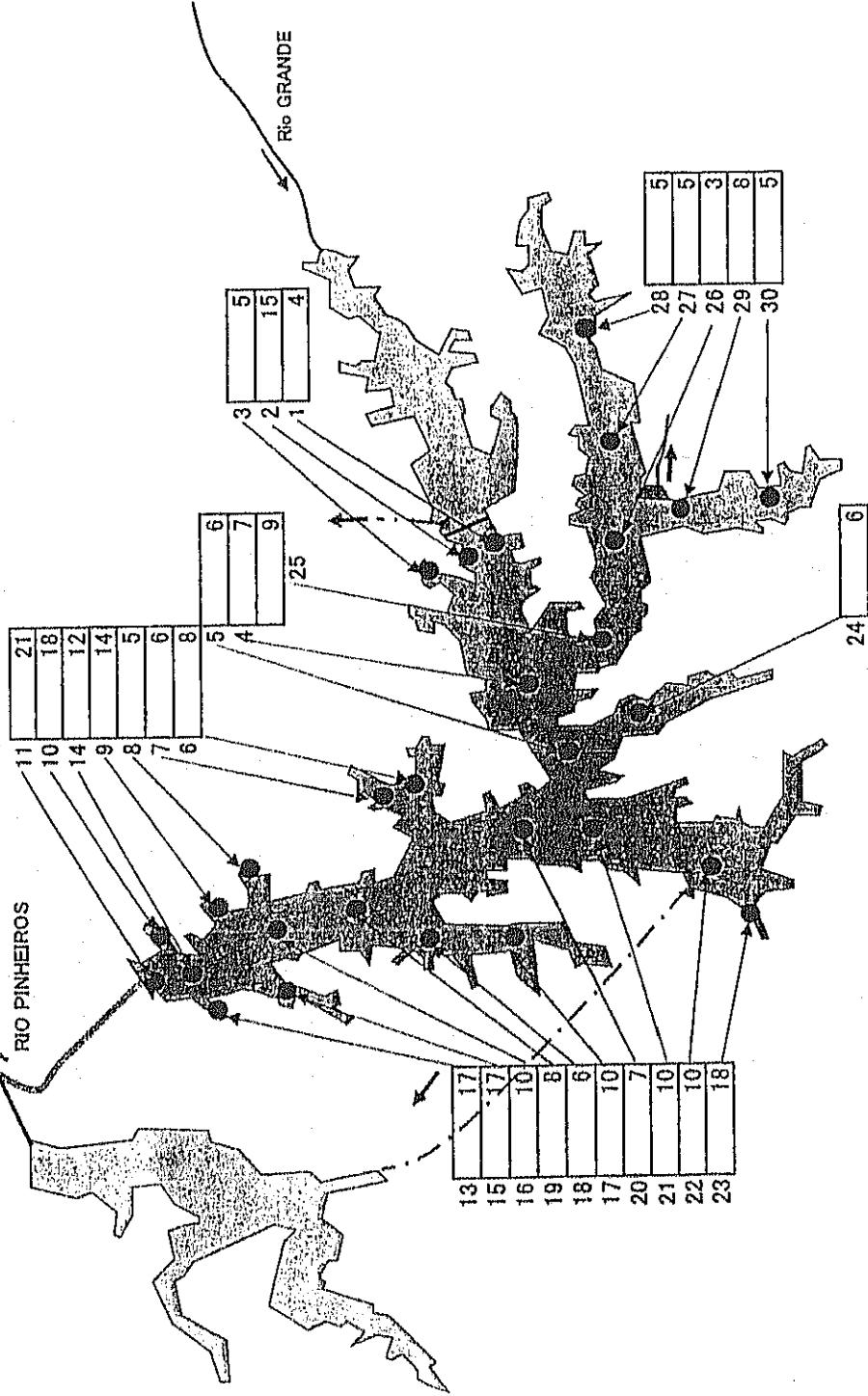
Remarks : All the points violate the regulation for Total coliform

- point E.coli lower than
- point E.coli bigger than

20 points
9 points

Figure -8 T₁ coli distribution

RIO TIETE



Average BOD	9.48 mg/l	STD DEVIATION	4.96 mg/l
7	24.14 %	22	75.86 %

- point conforming class 2 regulation
- point breaking class 2 regulation

Figure -9 BOD distribution

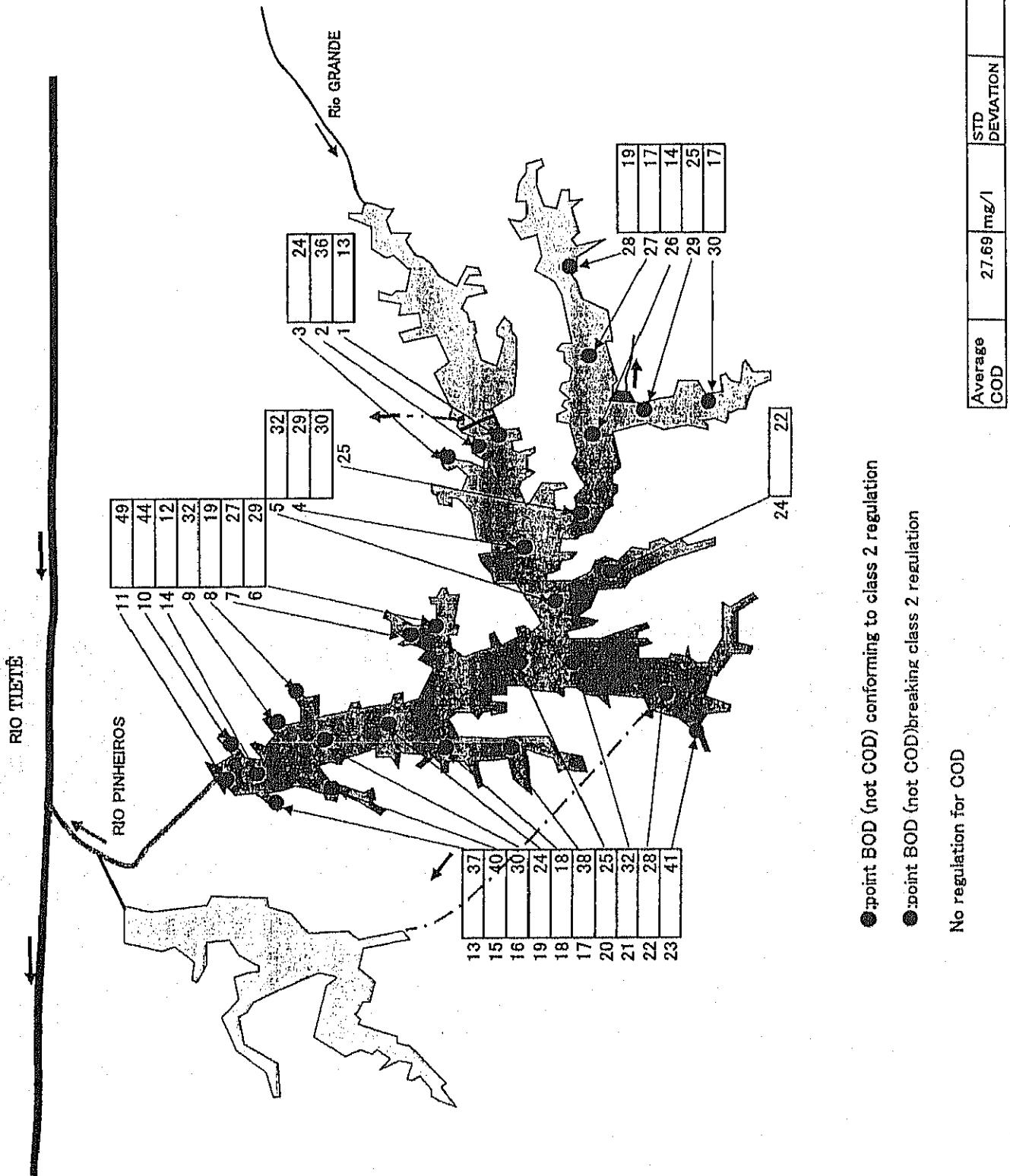
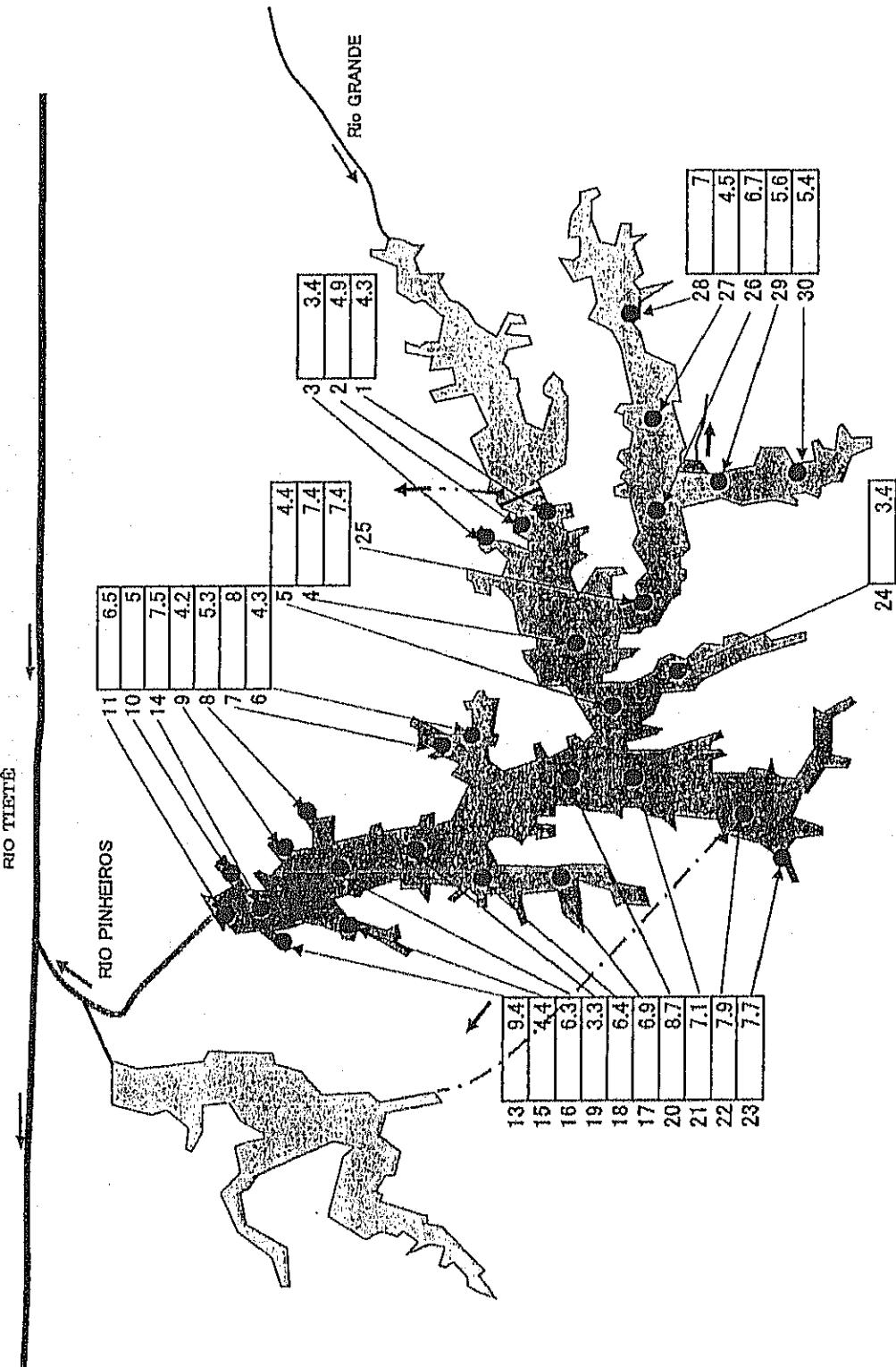


Figure -110 COD distribution



Average TOC	5.98 mg/l	STD DEVIATION	1.69 mg/l
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Figure -10-2 TOC distribution

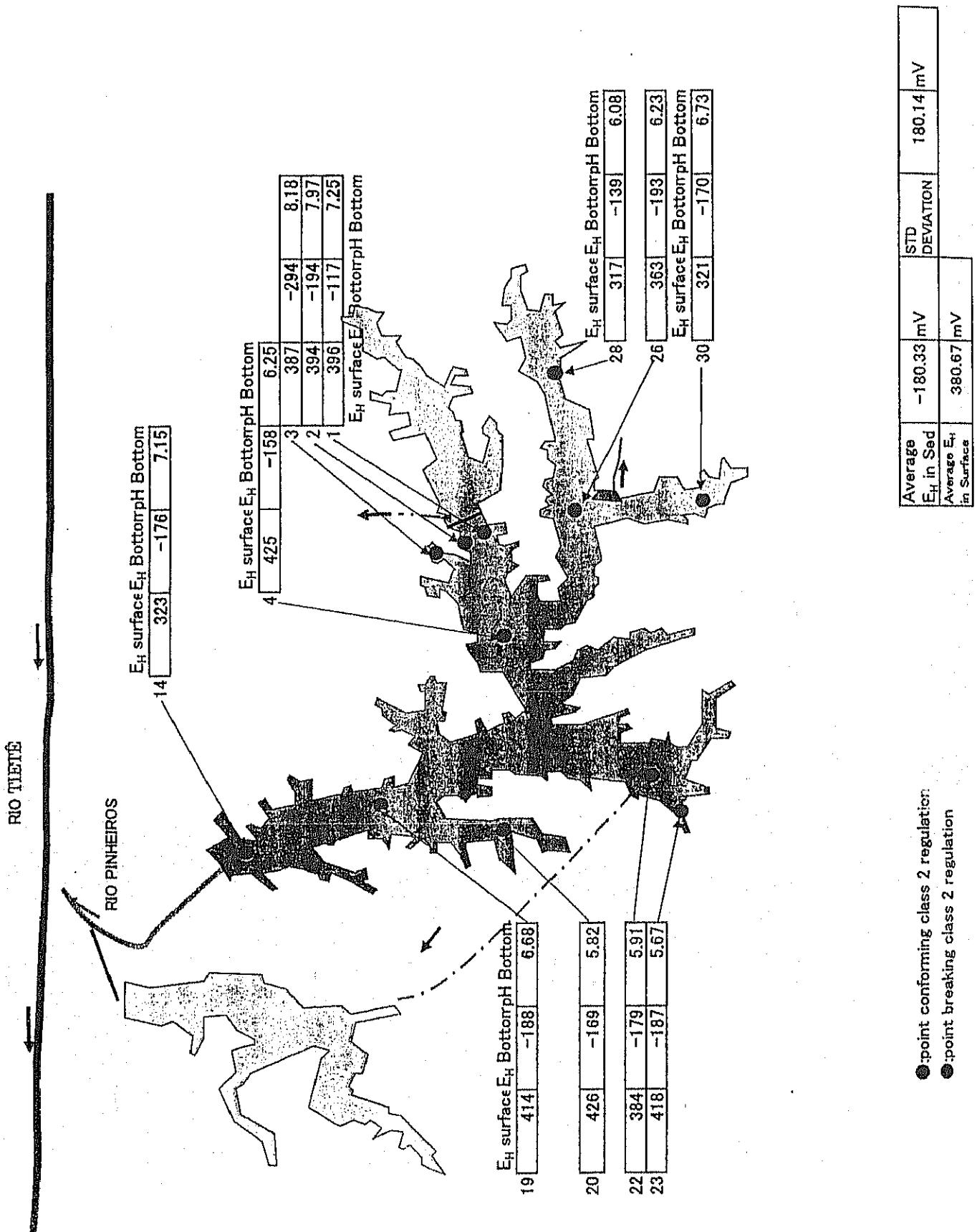
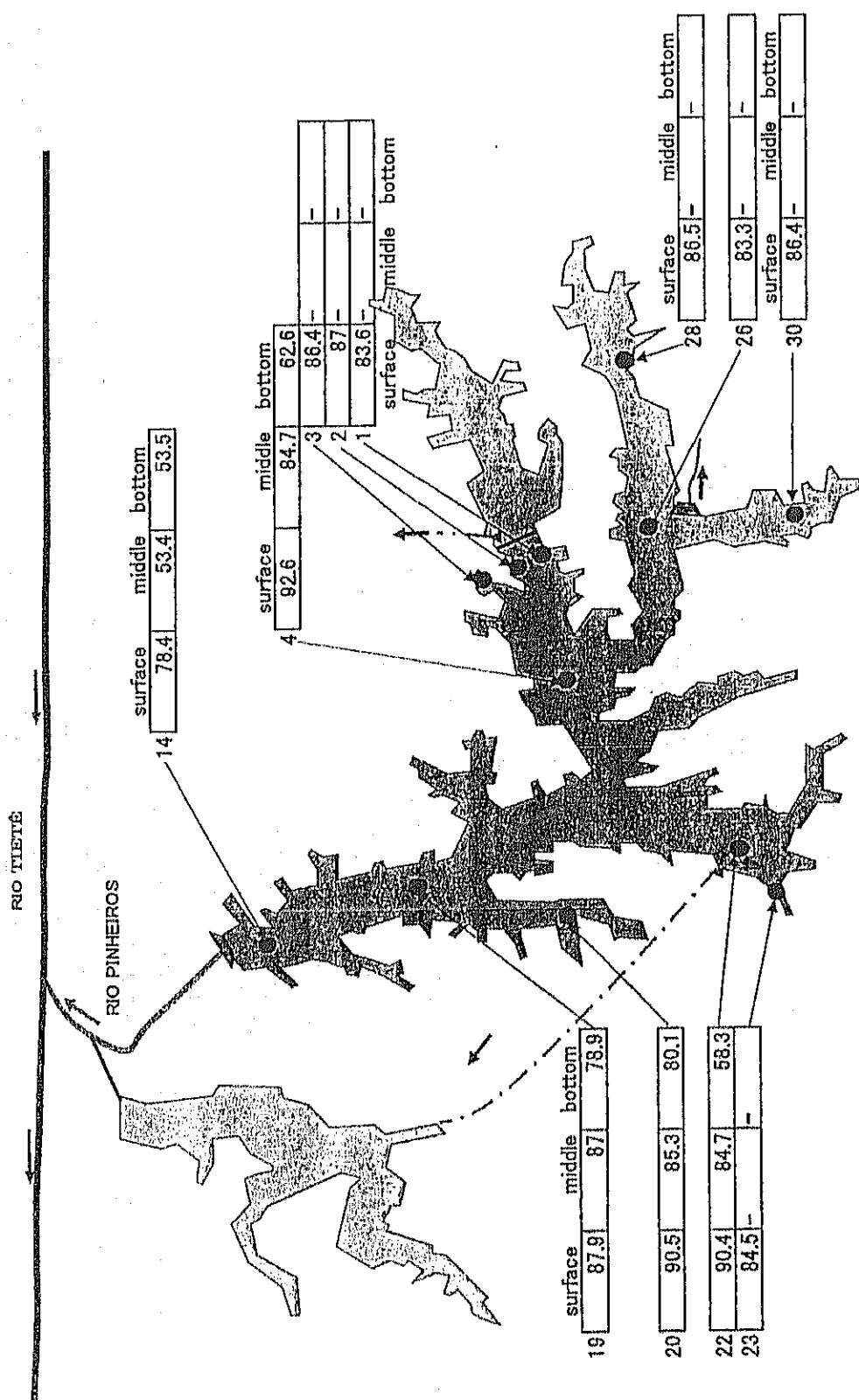


Figure -11 E_H in sediment



Surface: Surface of the sediment.

Middle: Depth is about 15cm to 50cm depending on sediment thickness.

Bottom: Bottom of the core sample.

	surface	middle	bottom
Average Water Content	86.46	79.02	66.68

- point conforming class 2 regulation
- point breaking class 2 regulation

Figure -12 Water content in sediment

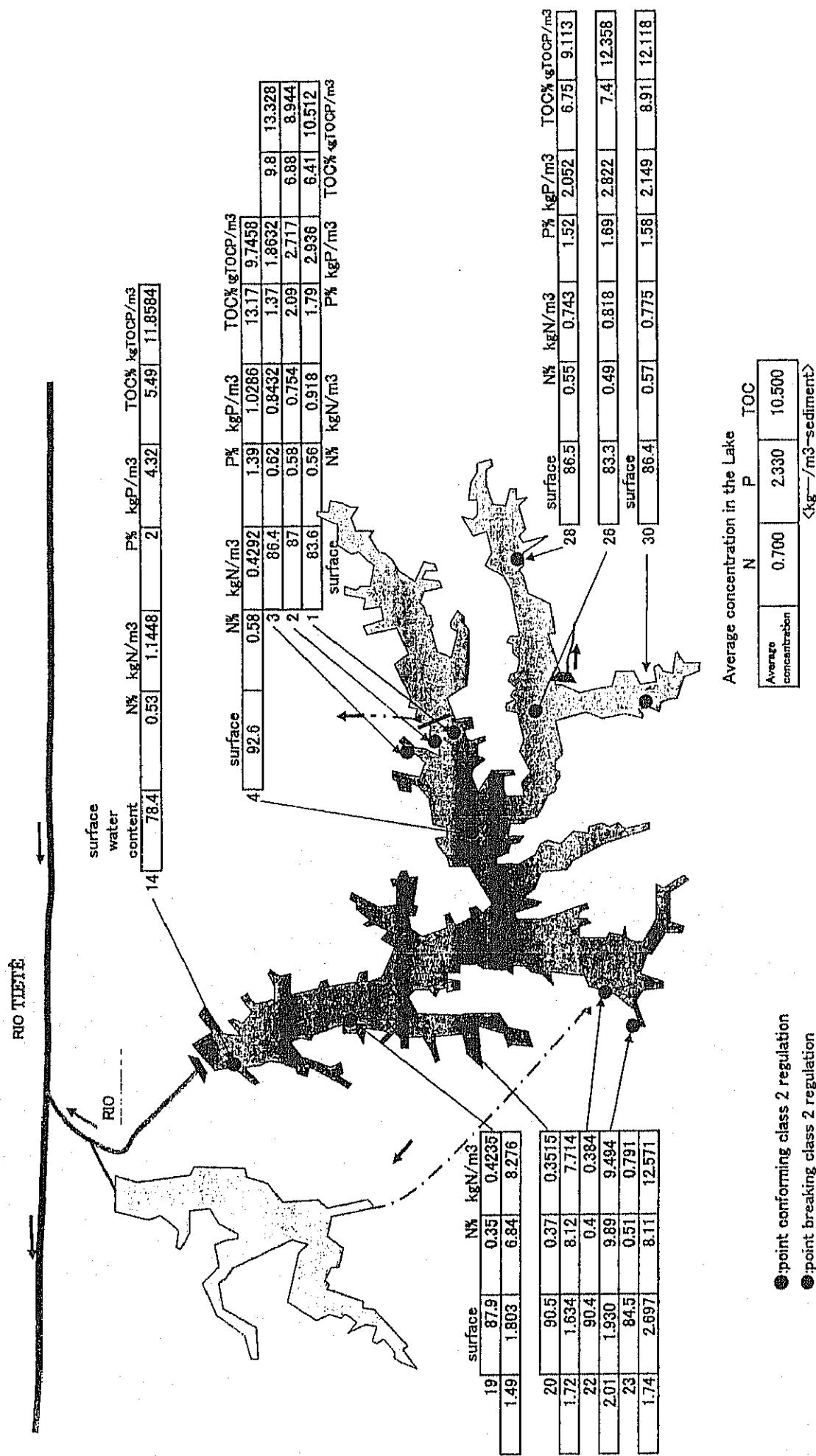


Figure -13 N, P and TOC distribution in the sediment surface

Volume of the accumulated in the bottom of the Lake for each indices

Case 1 Total sediment volume and N,P and TOC

Thickness of sediment
 Billings 51 cm
 Rio Grandi 34 cm

Table -4 Total sediment volume

Area and Volume

Number	Area ha	Surface sed volume m ³	Sedimentation						Water		
			N ton	P ton	TOC ton	volume m ³	N mg/l	P mg/l	TOC mg/l	N ton	P ton
a	3256.9	16,610,190	11,627.1	38,701.7	174,407.0	227,983,000	3.5	0.32	0.0	797.9	73.0
b	58.5	298,350	208.8	695.2	3,132.7	4,095,000	3.5	0.32	0.0	14.3	1.3
c	55.9	285,090	199.8	664.3	2,993.4	3,913,000	3.5	0.32	0.0	13.7	1.3
d	122.9	626,790	438.8	1,460.4	6,581.3	8,603,000	3.5	0.32	0.0	30.1	2.8
e	164.3	837,930	586.6	1,952.4	8,798.3	11,501,000	3.5	0.32	0.0	40.3	3.7
f	509.2	2,596,920	1,817.8	6,050.8	27,267.7	35,644,000	3.5	0.32	0.0	124.8	11.4
g	300.7	1,533,570	1,073.5	3,573.2	16,102.5	21,049,000	3.5	0.32	0.0	73.7	6.7
h	1,732	8,833,200	6,183.2	20,581.4	92,748.6	121,240,000	3.5	0.32	0.0	424.3	38.8
i	304.4	1,552,440	1,086.7	3,617.2	16,300.6	21,308,000	3.5	0.32	0.0	74.6	6.8
j	1,022.50	5,240,250	3,668.2	12,209.8	55,022.6	71,925,000	3.5	0.32	0.0	251.7	23.0
k	578.2	2,948,820	2,064.2	6,870.8	30,962.6	40,474,000	3.5	0.32	0.0	141.7	13.0
l	1236.7	6,307,170	4,415.0	14,895.7	66,225.3	86,569,000	3.5	0.32	0.0	303.0	27.7
Sub Total	9,347.2	9,347,200	33,370	111,073	500,543	654,304,000				2,290	210
RG	1,467.0	4,987,800	3,491.5	11,621.6	52,371.9	102,690,000	3.5	0.32	0.0	359.4	32.9
Total	10,814.2	10,814,200	36,886.0	122,694.5	552,914.5	756,984,000				2,649.5	242.4
											4,541.9

Average water depth is assumed to be 7m.

e-3 Diffusive flux and Depositional flux of N and P

Species	Location	Depositional Flux	
		mg/cm ² /ton/ha/yr	mg/cm ² /ton/ha/yr
Nitrogen	GU101	338.5	73.0
	GU104	277.9	40.0
Average		308.2	56.5
Phosphorus	GU101	7.7	7.3
	GU104	17.3	7.3
Average		12.5	7.3
COD			

Diffusive and depositional Flux of the nutrient *Reference 2)

Number	Area ha	Surface sed volume m ³	Sedimentation						Water		
			N ton	P ton	TOC ton	volume m ³	N mg/l	P mg/l	TOC mg/l	N ton	P ton
a	3256.9	16,610,190	11,627.1	38,701.7	174,407.0	227,983,000	3.5	0.32	0.0	797.9	73.0
b	58.5	298,350	208.8	695.2	3,132.7	4,095,000	3.5	0.32	0.0	14.3	1.3
c	55.9	285,090	199.8	664.3	2,993.4	3,913,000	3.5	0.32	0.0	13.7	1.3
d	122.9	626,790	438.8	1,460.4	6,581.3	8,603,000	3.5	0.32	0.0	30.1	2.8
e	164.3	837,930	586.6	1,952.4	8,798.3	11,501,000	3.5	0.32	0.0	40.3	3.7
f	509.2	2,596,920	1,817.8	6,050.8	27,267.7	35,644,000	3.5	0.32	0.0	124.8	11.4
g	300.7	1,533,570	1,073.5	3,573.2	16,102.5	21,049,000	3.5	0.32	0.0	73.7	6.7
h	1,732	8,833,200	6,183.2	20,581.4	92,748.6	121,240,000	3.5	0.32	0.0	424.3	38.8
i	304.4	1,552,440	1,086.7	3,617.2	16,300.6	21,308,000	3.5	0.32	0.0	74.6	6.8
j	1,022.50	5,240,250	3,668.2	12,209.8	55,022.6	71,925,000	3.5	0.32	0.0	251.7	23.0
k	578.2	2,948,820	2,064.2	6,870.8	30,962.6	40,474,000	3.5	0.32	0.0	141.7	13.0
l	1236.7	6,307,170	4,415.0	14,895.7	66,225.3	86,569,000	3.5	0.32	0.0	303.0	27.7
Sub Total	9,347.2	9,347,200	33,370	111,073	500,543	654,304,000	3.5	0.32	0.0	2,290	210
RG	1,467.0	4,987,800	3,491.5	11,621.6	52,371.9	102,690,000	3.5	0.32	0.0	359.4	32.9
Total	10,814.2	10,814,200	36,886.0	122,694.5	552,914.5	756,984,000				2,649.5	242.4
											4,541.9

6.71 0.2 0.81

Table - 5 Trial calculation of diffusion for each species

Number	Area ha	N ton	e for Diffusion		P ton	Time for Diffusion		TOC ton	Time for Diffusion	
			coefficient	yrs		coefficient	yrs		coefficient	yrs
a	3256.9	11,627.1	0.116	38,701.7		9.506	174,407.0		3.605	
b	58.5	208.8	0.116	695.2		9.507	3,132.7		3.605	
c	55.9	199.6	0.116	664.3		9.507	2,993.4		3.605	
d	122.9	438.8	0.116	1,460.4		9.506	6,581.3		3.605	
e	164.3	586.6	0.116	1,952.4		9.507	8,798.3		3.605	
f	509.2	1,817.8	0.116	6,050.8	1.3	9.506	27,267.7		3.605	
g	300.7	1,073.5	0.116	3,573.2		9.506	16,102.5		3.605	
h	1,732	6,183.2	0.116	20,581.4		9.506	92,748.6		3.605	
i	304.4	1,086.7	0.116	3,617.2		9.506	16,300.6		3.605	
j	1,027.50	3,668.2	0.116	12,209.8		9.506	55,022.6		3.605	
k	578.2	2,064.2	0.116	6,870.8		9.506	30,962.6		3.605	
l	1,236.7	4,415.0	0.116	14,695.7		9.506	66,225.3		3.605	
Sub Total	9,347.2	33,370		111,073			500,543			
RG	1,467.0	3,491.5	30.8	0.077	11,621.6	1.3	6,338	52,371.9	30.8	0.146
Total	10,814.2	36,861.0		122,594.5			552,914.5			

Case 2 Yearly sediment volume and N, P, TOC

Thickness of sediment
 Billings 0.4 cm
 Rio Grandi 0.4 cm

From the result of site survey, a figure of 32cm sedimentation per 80 years was obtained in Rio Pequeno.

Table -6 Yearly sediment volume and NP and TOC

Number	Area ha	Surface sed volume		N ton	P ton	TOC ton
		0.4cm thick	m ³			
a	3256.9	130.276		91.2	303.5	1,367.9
b	58.5	2,340		1.6	5.5	24.6
c	55.9	2,236		1.6	5.2	23.5
d	122.9	4,916		3.4	11.5	51.6
e	164.3	6,572		4.6	15.3	69.0
f	509.2	20,363		14.3	47.5	213.9
g	300.7	12,023		8.4	28.0	126.3
h	1,732	69,280		48.5	161.4	727.4
i	304.4	12,176		8.5	28.4	127.8
j	1,027.50	41,100		28.8	95.8	431.6
k	578.2	23,128		16.2	53.9	242.8
l	1,236.7	49,468		34.6	115.3	519.4
Sub Total	9,347.2	9,347,200		262	871	3,926
RG	1,467.0	58,680		41.1	136.7	616.1
Total	10,814.2	10,814,200		302.8	1,008.0	4,541.9

ANNEX 5.3.5

DATA REPORT ON
SURVEY WORK

FOR THE WATER QUALITY AND SEDIMENT QUALITY FOR THE
STUDY ON INTEGRATED PLAN OF ENVIRONMENTAL
IMPROVEMENT IN THE CATCHMENT AREA OF LAKE BILLINGS

IN SAN BERNARDO DO CAMPO

IN THE FEDERATIVE REPUBLIC OF BRASIL

BETWEEN

NJS CONSULTANTS CO., LTD.

AND

Prof. Dr. Antonio A. Mozeto
Dr. Marcos R. L. do Nascimento
MSc Erida F. Araújo Silva
Independent Consultants
São Carlos, SP-Brazil

August 11th / 2006

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Preamble

Water and sediment samples were collected in the Billings reservoir on the period of July 11 to 13/2006. Below is given a brief description of the activities and weather conditions prevailed during the 3 days of field trip.

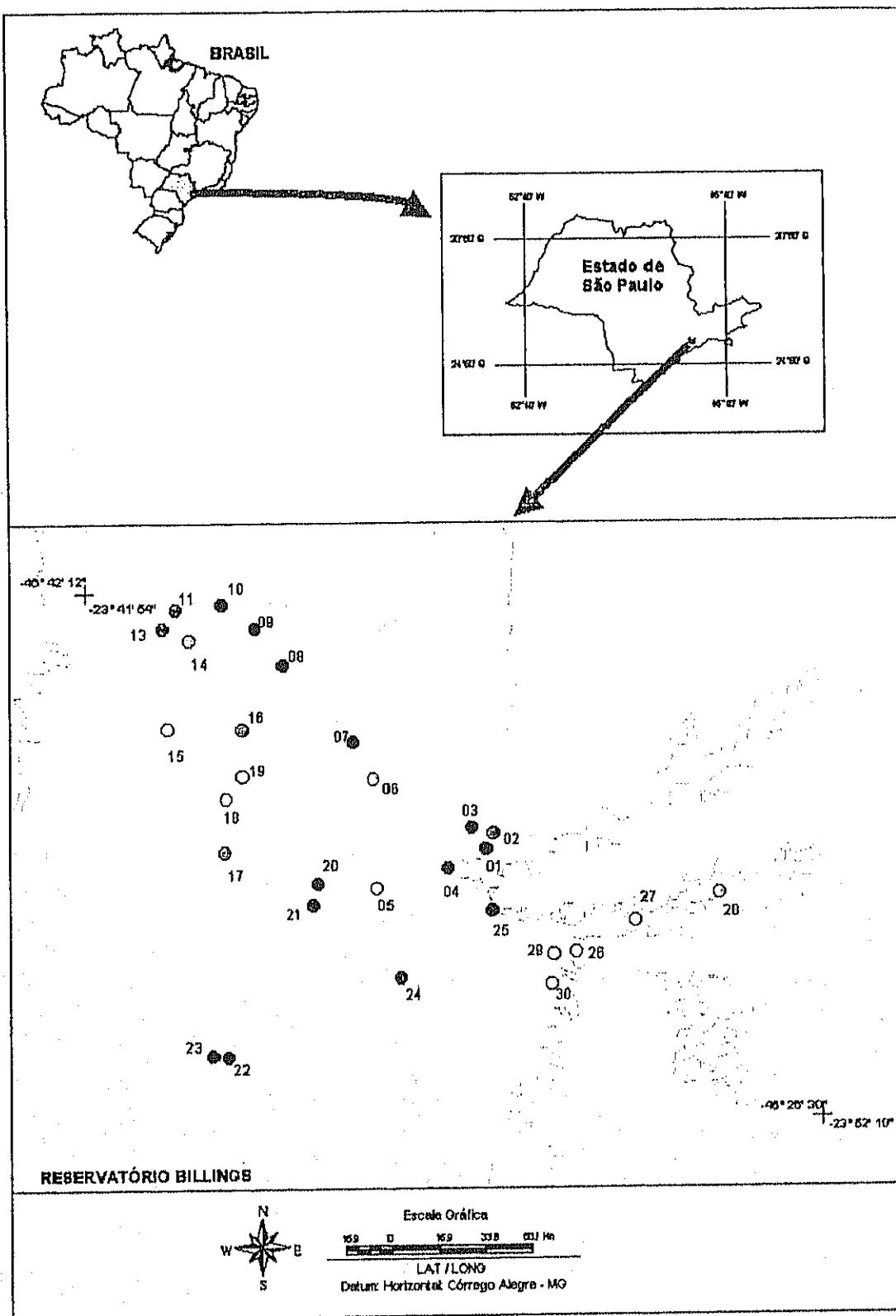
Day 1: July 11th/2006 – work has been done in sampling points # 01, 02, 03, 04 and 30. Work on point # 01 started at 10:40 AM and the day was mostly cloudy with weak to moderate winds which changed to sunny skies which evolved to a very dense fog by 15:05 PM while sampling in point # 30 was being done. Activities had to be stopped as visibility was close to zero.

Day 2: July 12th/2006 – work has been done in sampling points # 29, 27, 28, 26, 25, 04, 05, 24, 23, 22 and 21. The entire day was completely sunny with no clouds in the sky and weak or barely any wind. Air temperature increased in the morning at 09:59 AM from 19.08 °C to around noon time at 12:18 PM of 24.50 °C and decreased to about 19.97 °C at about 17:18 PM at the end of the work.

Day 3: July 13th/2006 – work has been done in sampling points 20, 06, 07, 19, 17, 18, 16, 08, 09, 14, 10 11, 13 and 15. Weather conditions were basically the same as the day before. Work has started at 08:36 AM at sampling point # 20 and ended at sampling point # 15 at 15:20 PM.

The Figure 1 shows the map of the Billings reservoir with the sampling points plotted according to their geographical coordinates.

Figure 1: Map of the Billings reservoir with the sampling points plotted according to their geographycal coordinates.



I Materials & Methods

1.1 Water

1.1.1 Physico -chemical parameters

The parameters temperature, pH, dissolved oxygen (DO), specific electric conductance (SpC) and oxidation-reduction potential (ORP or Eh) was determined *in situ* with a Hydrolab Quanta Water Monitoring System. The turbidity was measured with a portable turbidimeter by Hach model 2100P, and geographical coordinates were determined with a GPS by Garmin model 12CX.

1.1.2 DOC, TOC and TSS determinations

The dissolved organic carbon (DOC) was determined in vacuum filtered samples using deionized water pre-washed and dried 0.45 µm acetate cellulose membranes in a TOC Analyzer by Shimadzu model TC 5000 while the total organic carbon (TOC) was determined in unfiltered samples using the same equipment.

Samples were automatically injected by the equipment three times in order to obtain a standard deviation which is less than 2.0. Concentrations are expressed in mg L⁻¹ units.

The TSS (total suspended solids) was gravimetrically determined by filtering known volumes of water in pre-dried and pre-weighted cellulose acetate membranes of 0.45µm pore diameter which were afterwards dried in an oven at 60°C and again weighted until constant weight.

1.1.3 Metals

Following the Brazilian National environmental law named "Resolução CONAMA # 357/2005" that classifies natural waters according to their use, those waters of Class 2, require analysis of total dissolved for metals Cu and Fe and of total metals (dissolved + particulate) for Cd, Pb, Hg, Ni, Mn, Cr and Zn.

Table 1 shown ahead brings the description of sample pre-treatment as well as methods of chemical analysis done for different metals.

Table 1: Methods of water sample pre-treatment and chemical analysis for metals.

Sample type	Sample pre-treatment	Metals	Methods of chemical analysis
Total dissolved metals	Samples were initially vacuum filtered using deionized water pre-washed and dried 0.45 µm acetate cellulose membranes and latter acidified to pH ≈ 2 with ultra pure nitric acid and preserved at about 4°C.	Cu	Atomic absorption spectrophotometry using graphite furnace (GF-AAS)
		Fe	Atomic emission inductively coupled plasma (ICP - OES)
Total metals (dissolved + particulate)	Samples were initially acidified to pH ≈ 2 and preserved at about 4°C and latter extracted with nitric and hydrochloric acid according to the USEPA method # 200.2 (in: Methods for the determination of environmental samples - Supplement I - EPA/600/R-94-111 – May 1994).	Cd	Atomic absorption spectrophotometry using graphite furnace (GF-AAS)
		Pb	
		Hg	Atomic absorption spectrophotometry using cold vapor (CV-AAS)
		Ni	
		Mn	
		Cr	Atomic emission inductively coupled plasma (ICP - OES)
		Zn	

1.1.4 Nutrients

Dissolved nutrients in waters were determined according to the different methods that can be described as follows:

1.1.4.1 ammonium: method # 8038 proposed by Hach - DR/2010 Spectrophotometer, adapted from the Standard Methods for the Examination of Water and Wastewater, and approved by the USEPA 44(85) 25505 (May, 1979). This method is a colorimetric method (visible spectrophotometry) in which ammonium ions react with the Nessler reagent (an alkaline solution of potassium tetrabromomercury (II)) yielding a yellow color complex of proportional intensity to the ammonium ion concentration in the sample.

1.1.4.2 nitrite: method # 8507 proposed by Hach - DR/2010 Spectrophotometer, adapted from the Standard Methods for the Examination of Water and Wastewater, and approved by the USEPA 44(85) 25505 (May, 1979). This is also a colorimetric method in which nitrite ions react with sulfanilic acid to form a diazo salt, which under acidic medium, form a pink colored complex whose concentration is proportional to the nitrite content of the water. Standard solution to construct standard curve: sodium nitrite.

1.1.4.3 nitrate: method # 8192 proposed by Hach - DR/2010 Spectrophotometer. Determination is made via a colorimetric method in which the nitrate reacts with the cromotropic acid in highly acidic conditions to

form a yellow colored complex whose concentration is proportional to the nitrate concentration of the water sample. Standard solution to construct standard curve: potassium nitrate.

1.1.4.4 total N and total P: The total P was extracted according to the method described in Standard Methods for the Examination of Water and Wastewater # 4500 – P-B¹, these extraction consisted in a chemical attack with sulfuric and nitric acid, and the concentration was colorimetrically determined by a method in which the molybdophosphoric acid is formed and reduced by stannous chloride to form the colored molybdenum blue according to the Standard Methods for the Examination of Water and Wastewater # 4500 – P-D². Total nitrogen was determined according to methods described in the "Standard Methods for the Examination of Water and Wastewater" number 4500 – N_{org}-B (Macro-Kjeldahl Method)³.

1.1.5 Chlorophyll 'a'

The chlorophyll 'a' concentration was quantified through the seston (suspended particulate) retained in 0.45 µm cellulose nitrate membrane after filtration a known volume of water sample. These membranes were carefully kept in the dark wrapped in aluminum foil and under low temperature (4°C). The pigment was extracted in the dark with 10 mL of 90 v/v of acetone. After twenty four hours under low temperature samples were centrifuged at 4000 rpm for 15 minutes. The absorbance, which is proportional to the chlorophyll 'a' concentration, was then measured in a Hewlett Packard spectrophotometer equipped with a diode lamp.

This method is described in Talling and Driver (1961)⁴.

1.1.6 Phytoplankton

Total density of the phytoplankton community expressed as number of cells mL⁻¹ was quantified according to the sedimentation chamber method described by Utermöhl (1958)⁵. The cell counting was done through transects using an inverted microscope Zeiss-model Axiovert with maximum magnification of 1,000 times. Each cell, colony or filament was considered as an individual. The time of sedimentation was of three hours

¹ Standard Methods for the Examination of Water and Wastewater, 20th Edition, APHA AWWA, 1998, Method 4500-P B, page 4-143 / 4-144

² Standard Methods for the Examination of Water and Wastewater, 20th Edition, APHA AWWA, 1998, Method 4500-P D, page 4-145 / 4-146

³ Standard Methods for the Examination of Water and Wastewater, 20th Edition, APHA AWWA, 1998, Method 4500-N_{org} B, page 4-124 / 4-125

⁴ Talling, J. F.; Driver, D. Some problems in the estimation of chlorophyll-a in phytoplankton. Proc. In: Conference of Productivity Measurements, Marine and Freshwaters, 1961, University of Hawaii. Proceedings. 1961, p. 142-146.

⁵ UTERMÖHL, H. Zur Vervollkommenung der quantitativen phytoplankton: methodic. Internationale Vereinigung für Theoretische und Angewandte Limnologie Mitteilungen, v. 9, p. 1-38, 1958.

(set as a minimum) for each centimeter of height in the chamber (Margalef, 1983)⁶. The counting limit was determined by means of the species curve stabilization in which a sufficient number of fields are counted until the number of species added for each field is stabilized (Sant'Anna et al., 2006)⁷.

The results were expressed as number of individual/mL and were calculated according to Ros (1979)⁸.

1.1.7 Coliform

Total coliform were quantified through the standard method number 9222 from Standard Methods (1998)⁹ (membrane filter technique for members of the coliform group).

1.1.8 COD and BOD

COD (open reflux method) and BOD (five-days test) were quantified through standard methods, respectively, numbers 5220¹⁰ and 5210 from Standard Methods (1998)¹¹ (membrane filter technique for members of the coliform group).

1.2. Sediments

1.2.1 Physico-chemical parameters

Redox potential (ORP or EH) was measured with a platinum ($\text{Pt}_{(s)}$) electrode using a $\text{Ag}_{(s)}/\text{AgCl}_{(s)}$ reference electrode through a standard pHmeter set to measure potential (mV) instead of pH. The EH electrode was calibrated against standard ZoBell solution. pH was measured with the same pHmeter using a standard glass electrode routinely calibrated with pH 4.01 and pH 7.0 buffer solutions. Water content was determined gravimetrically weighting an amount of sediment sample before and after drying the samples in an oven at 60°C until constant weight.

⁶ MARGALEF, R. Limnología. Barcelona: Omega, 1983. 1010p.

⁷ SANT'ANNA, C. L.; AZEVEDO, M. T. P.; AGUJARO, L. F.; CARVALHO, M. C; CARVALHO, L. R. & SOUZA, R. C. R. 2006. Manual ilustrado para identificação e contagem de cianobactérias planctônicas da águas continentais brasileiras. Editora Interciência, 58p.

⁸ ROS, J. Prática de ecologia. Barcelona: Omega, 1979. 181p.

⁹ Standard Methods for the Examination of Water and Wastewater. 20th Edition. APHA AWWA. 1998. Method 9222. page 9-56.

¹⁰ Standard Methods for the Examination of Water and Wastewater. 20th Edition. APHA AWWA. 1998. Method 5220. page 5-14

¹¹ Standard Methods for the Examination of Water and Wastewater. 20th Edition. APHA AWWA. 1998. Method 5210. page 5-2

1.2.2 TOC, N_{total} and P_{total}

The total organic carbon (TOC) was determined using a TOC 5000 connected to a SSM (Solid Sample Module) 5000A by Shimadzu.

Total P was extracted from the sample with a mixture of sulfuric and nitric acid and determined via colorimetric method described in the "Standard Methods for the Examination of Water and Wastewater" number 4500 – P-B¹² e 4500-P-C (colorimetric method of vanadomolybdophosphoric acid)¹³.

Total N was determined using Kjeldahl method described in the "Standard Methods for the Examination of Water and Wastewater" number 4500 – N_{org}-B (Macro-Kjeldahl Method)¹⁴.

1.2.3 Metals

Metal (Cd, Cr, Cu, Hg, Ni, Pb e Zn) were extracted according to the method 3050B by USEPA (1996)¹⁵. Such method consisted in weighing a mass close 2.0000 ± 0.0001 g of dried sediment and performing the chemical attack with HNO₃, H₂O₂ and HCl.

The concentration determination were done by atomic emission inductively coupled plasma (ICP - AES) except for Cd which was determined through the GF-AAS technique.

Specifically for Hg the method 245.6 from the USEPA was used for sediments analysis. The only modification introduced was that the extraction temperature was modified to 95°C instead of 60°C as described in Fadini (1999)¹⁶. Hg was determined by the CV-AAS technique. Replicates were done for 30% of the samples and the average variation obtained was <5 %.

Table 2 shows the average percentage recovery for different metals from the NIST reference material # 8704 (Buffalo River Sediment) as part of the QA/QC (quality assurance/quantity control) procedures of our laboratory.

¹² Standard Methods for the Examination of Water and Wastewater. 20th Edition. APHA AWWA. 1998. Method 4500-P B. page 4-143 / 4-144

¹³ Standard Methods for the Examination of Water and Wastewater. 20th Edition. APHA AWWA. 1998. Method 4500-P C. page 4-144 / 4-145

¹⁴ Standard Methods for the Examination of Water and Wastewater. 20th Edition. APHA AWWA. 1998. Method 4500-N_{org} B. page 4-124 / 4-125

¹⁵ USEPA. United States Environmental Protection Agency. 1996. Acid Digestion of Sediments, Sludges, and Soils. Method 3050B.

¹⁶ FADINI, P. S. 1999. Comportamento biogeoquímico do mercúrio na bacia do Rio Negro (AM). Tese de doutorado. UNICAMP. Instituto de Química. Campinas, SP-Brazil.

Table 2: Average percentage recovery for different metals (NIST reference material # 8704 - Buffalo River Sediment).

Element	Average Recovery (%)
Cd	108,5
Cr	96,0
Co	107,3
Pb	111,3
Mn	100,4
Ni	93,2
Zn	102,0

Observation: Except for Cr for which the reference sediment sample was open via fusion process (temperature between 900-1,000°C in an oven using tetra borate of lithium, Li₂B₄O₇) all the other elements were open using a mixture of strong acid attack. Both chemical treatments allow a good recovery of studied metals present in this matrix.

II Results and Discussion

2.1 Water

2.1.1 Physico -chemical parameters

In Table 3 are shown the physico-chemical parameter results obtained for water collected at 50 cm depth in different sampling station in Billings reservoir.

Considering the parameters shown in Table 3 (temperature, pH, DO, EH, conductivity, turbidity and Secchi disc), those that have limiting values in CONAMA 357/05, that is, pH, turbidity and DO, only for pH and DO revealed violations of this environmental law.

The levels of DO measured in these waters are indeed quite low, specially in sampling points located in the Billings arms such as those close to the Pedreira Dam (sampling points # 10, 11, 13 and 14) where DO concentration even reached zero at point # 10. This is one of the most remarkable feature of highly eutrophied ecosystem, such as Billings reservoir.

High discharge of urban sewage is the most important source of these extremely low DO content in the water column where oxygen is consumed by organic matter oxidation. The occurrence of an extremely high number of gas bubbles at the surface of the water column is evidently associated to high oxidation of anaerobic oxidation of organic matter that is realized at the costs of denitrification, sulfate reduction and methanogenesis processes. These bubbles are, obviously mainly composed by carbonic gas e methane. There exists in the literature an extensive work that describe this phenomenon.

Very high values of pH such as 9.0 (which violate the standard Class 2 water of the CONAMA 357/05) were measured for sampling points # 21, 22 and 23 at Taquacetuba branch. Such high values are again a response of the Billings reservoir to the discharge of untreated urban sewage.

Secchi disc depth is also a measure of the degradation of the water quality at Billings reservoir. Almost in all sampling points we have measured low depths and in some cases, extremely low values have been measured. This trend is also corroborated by the turbidity *in situ* determinations as well as by the other parameters we have just presented above (see Table 3)

Table 3: Physico-chemical parameters results obtained for water at 50 cm depth in different sampling points in Billings reservoir.

Sampling point #	Altitude (m.a.s.l.)	Coordinates	Air	Water	CONAMA 357/05 - Class 2: pH 6.0 - 9.0	DO saturation (%)	DO (mg/L)	pH	CONAMA 357/05 - Class 2: DO > 5.0 mg/L		Specific electric conductance (mS/cm)	Turbidity (UNT)	Secchi Disk (m)
									CONAMA 357/05 - Class 2: DO > 5.0 mg/L	CONAMA 357/05 - Class 2: DO > 5.0 mg/L			
1	753	23K0342281 UTM73690722	17.48	18.38	7.29	3.49	41.2	396	0.175	7.54	0.8		
2	751	23K0341790 UTM73790131	16.61	18.33	8.07	3.58	42.2	394	0.176	8.18	0.9		
3	752	23K0340548 UTM7370044	17.80	18.39	7.79	3.30	38.2	387	0.174	9.48	0.7		
4	753	23K0339568 UTM7368306	18.70	18.40	7.76	4.34	51.0	425	0.176	7.04	1.1		
5	748	23K0336917 UTM7367563	22.11	19.26	8.03	3.69	44.0	405	0.187	7.93	1.0		
6	748	23K0336799 UTM7371569	18.72	18.41	7.23	2.89	33.2	407	0.208	6.5	0.8		
7	750	23K0336654 UTM7372627	19.00	18.11	6.94	0.07	0.1	282	0.839	23.0	0.4		
8	754	23K0333485 UTM7375565	21.16	19.20	7.55	0.05	0	399	0.211	11.9	0.7		
9	749	23K0332421 UTM7376891	20.27	19.16	7.33	2.74	31.6	409	0.218	16.9	0.6		
10	753	23K0331216 UTM7377749	25.50	20.56	7.20	0.00	0	91	0.263	42.1	0.2		
11	753	23K0329600 UTM7377530	22.98	19.23	7.06	0.28	1.6	22	0.267	45.3	0.1		
13	754	23K0329100 UTM7376857	22.70	19.32	6.93	0.97	10.7	76	0.25	47.1	0.2		
14	755	23K0330079 UTM7376424	22.87	19.23	7.16	0.81	7.6	323	0.232	44.2	0.3		
15	763	23K0329320 UTM7313643	22.13	20.41	7.37	6.24	75.8	313	0.237	28.6	0.5		
16	755	23K0332004 UTM7373251	20.72	19.14	7.70	5.98	69.0	409	0.202	18.3	0.6		
17	749	23K0331430 UTM7368819	19.00	19.40	8.75	10.06	120.0	377	0.187	18.9	0.6		
18	745	23K0331413 UTM7370755	22.32	19.38	8.89	9.77	116.6	375	0.192	19.9	0.7		
19	744	23K0332018 UTM7311577	18.98	18.70	7.86	7.96	94.5	414	0.196	33.3	0.6		
20	747	23K0334825 UTM7367728	16.38	18.44	7.47	7.87	90.5	426	0.187	11.5	0.9		
21	746	23K0334657 UTM7365960	19.47	20.27	9.38	4.92	58.5	397	0.191	21.2	0.6		
22	746	23K0331646 UTM7362088	20.46	19.41	9.34	4.11	50.1	384	0.174	21.4	0.5		
23	753	23K0331076 UTM7361592	21.29	20.46	9.32	4.16	50.8	418	0.172	29.4	0.4		
24	749	23K0337884 UTM7364383	23.70	19.66	8.67	3.96	48.3	415	0.185	9.31	0.9		
25	754	23K0341175 UTM7368112	21.72	19.46	8.36	3.85	46.1	386	0.173	8.27	1.0		
26	750	23K034243 UTM7365343	24.50	18.78	8.42	4.41	51.9	363	0.455	9.83	0.8		
27	747	23K0346594 UTM7365905	18.57	18.77	8.44	3.64	43.1	298	0.114	11.3	0.7		
28	748	23K0349436 UTM7367511	20.12	18.41	8.01	3.93	46.1	317	0.058	9.44	0.6		
29	752	23K0343417 UTM7365263	19.08	18.42	7.93	3.35	39.5	389	0.157	10.1	0.6		
30	752	23K0342228 UTM7363869	18.90	19.36	8.24	3.74	44.9	321	0.159	9.18	0.7		

2.1.2 DOC, TOC and TSS concentrations

In Table 4 are shown the DOC, TOC and TSS (total suspended solids) results obtained for water samples collected at 50 cm depth in different sampling points in Billings reservoir.

There is no limit established in the Brazilian environmental law for these parameters. However, the content of DOC and TOC in the water are directly related to the primary productivity rate of the water body, which indeed is better represented by the chlorophyl 'a' content. This variable has limiting value in the CONAMA 357/05 for Class 2 waters can be seen in Table 5 in section 2.1.3.

Table 4: DOC, TOC and TSS results obtained for water samples collected at 50 cm depth in different sampling points in Billings reservoir.

Sampling point #	Coordinates	DOC		TOC		TSS (mg L ⁻¹)
		DOC (mg L ⁻¹ ± sd)		TOC (mg L ⁻¹ ± sd)		
01	23K0342281 UTM 7369022	4.433	0.278	4.300	0.408	<0.02
02	23K0341790 UTM 73790131	3.866	0.168	4.915	1.186	<0.02
03	23K0340548 UTM 7370044	4.582	0.587	3.440	0.703	5.33
04	23K0339568 UTM 7368306	4.967	0.907	7.387	0.644	7.33
05	23K0336977 UTM 7367563	5.118	0.817	4.380	0.795	0.33
06	23K0336799 UTM 7371509	4.470	0.623	4.310	0.456	4.33
07	23K0336054 UTM 7372827	4.290	0.414	7.990	2.502	31.33
08	23K0333485 UTM 7375565	4.470	0.938	5.310	0.787	8.33
09	23K0332421 UTM 7376891	4.680	0.510	4.240	0.755	6.33
10	23K0331216 UTM 7377749	5.630	0.663	5.003	1.199	29.33
11	23K0329600 UTM 7377530	5.980	1.124	6.460	0.287	44.33
13	23K0329100 UTM 7376857	4.310	0.497	9.350	0.577	29.33
14	23K0330079 UTM 7376424	5.410	0.898	7.530	0.628	24.33
15	23K0329320 UTM 7373843	4.780	0.451	4.350	1.761	17.33
16	23K0332004 UTM 7373251	4.824	0.207	6.340	0.530	4.33
17	23K0331430 UTM 7368819	5.283	0.187	6.870	0.514	5.33
18	23K0331413 UTM 7370755	4.938	0.869	6.430	0.346	7.33
19	23K0332018 UTM 7371577	3.030	0.556	3.310	0.939	6.33
20	23K0334825 UTM 7387728	3.155	0.286	8.650	2.000	4.33
21	23K0334057 UTM 7366960	6.137	0.311	7.060	1.399	1.33
22	23K0331046 UTM 7362088	5.246	0.223	7.870	1.072	7.33
23	23K0331078 UTM 7361502	6.019	0.271	7.652	0.516	15.33
24	23K0337884 UTM 7364383	3.786	0.151	3.410	0.360	3.33
25	23K0341175 UTM 7366812	3.978	0.234	7.387	0.000	<0.02
26	23K0344243 UTM 7365343	2.781	0.369	6.667	0.260	<0.02
27	23K0346394 UTM 7366505	4.467	0.166	4.450	0.408	0.33
28	23K0349436 UTM 7367511	4.259	0.240	7.030	0.135	<0.02
29	23K0343417 UTM 7365263	4.833	1.401	5.559	0.405	<0.02
30	23K0342228 UTM 7363889	4.453	0.347	5.385	0.875	3.33

2.1.3 Chlorophyll 'a'

The chlorophyll 'a' data are shown in Table 5. It can be observed that there are several violations of the limit established by the CONAMA 357/05 for Class 2 water bodies. Sampling points # 15, 16 and 22 are among the ones for which it was measured the highest values of this parameter. Points # 15 and 16 belong to the Pedreira Dam area and the last one (# 22) to the Taquacetuba branch.

Widespread in the Billings reservoir it could be noted the typical greenish colour of algal blooms in the water column surface as it can be seen in the pictures taken during the field trips (these pictures are annexed to this final report).

Table 5: Chlorophyll 'a' concentration of water samples from Billings collected at 50 cm depth in the water column and the reference value from the Resolução CONAMA # 357/05.

Coordinates	Sampling point #	Chlorophyll 'a' ($\mu\text{g L}^{-1}$) Limit of Class 2 waters of CONAMA # 357/05 = 30 $\mu\text{g L}^{-1}$	Coordinates	Sampling point #	Chlorophyll 'a' ($\mu\text{g L}^{-1}$) Limit of Class 2 waters of CONAMA # 357/05 = 30 $\mu\text{g L}^{-1}$
23K0342281 UTM 7369022	01	37.06	23K0331430 UTM7368819	17	70.42
23K0341790 UTM 73790131	02	36.59	23K0331413 UTM7370755	18	70.49
23K0340548 UTM 7370044	03	26.27	23K0332018 UTM7371577	19	84.29
23K0339568 UTM 7368306	04	35.86	23K0334825 UTM7367728	20	62.67
23K0336977 UTM7367563	05	23.91	23K0334657 UTM7366960	21	64.48
23K0336799 UTM7371509	06	22.18	23K0331646 UTM7362088	22	81.61
23K0336054 UTM7372827	07	29.23	23K0331076 UTM7361502	23	79.76
23K0333485 UTM7375565	08	23.04	23K0337884 UTM7364383	24	38.53
23K0332421 UTM7376891	09	15.95	23K0341175 UTM7368812	25	33.30
23K0331216 UTM7377749	10	31.41	23K0344243 UTM7365343	26	48.73
23K0329600 UTM7377530	11	5.59	23K0346394 UTM7366505	27	38.86
23K0329100 UTM7376857	13	24.19	23K0349436 UTM7367511	28	24.05
23K0330078 UTM7376424	14	26.47	23K0343417 UTM7365263	29	45.42
23K0329320 UTM7373643	15	117.35	23K0342228 UTM 7363889	30	37.51
23K0332004 UTM7373251	16	99.76			

2.1.4 Metals

Table 6 shown below contains metal concentration on analyzed samples and reports the LQ (limit of quantification) for each metal accordingly to the method of analysis used and the established limits by the so-called Resolução CONAMA # 357/2005.

As it can be observed in the data shown in Table 6 metal concentrations in the water are relatively low in spite the fact that all studied metals, except for Cu and Fe, which were determined in bulk water sample (i.e., without filtration which corresponds to the total metal concentration in the dissolved and in the particulate). It could be expected then, if one considers the fact the particles scavenge metals from the water, larger concentrations as the TSS in the water was relatively large. Therefore, the only CONAMA 357/05 violation detected was for Mn in water samples collected in the area close to the Pedreira Dam (sampling points # 10, 11 and 13).

It must be also noted that for several elements and relative to all collected samples the LQ (quantification limits of different techniques) (which, by the way, perfectly obey limits of the CONAMA 357/05) were not achieved such as for Cd, Cr, Hg and Ni. For some of the samples and for elements such as Pb, Zn and Fe the respective LQs were not achieved either. The only element detected in all collected sample was copper.

As it can be seen ahead in this report (see 'Sediments' section) the water data do not demonstrate that this water body is not contaminated with metals. It means that these elements are scavenged from the water column by the fine and very fine particles (silt and clay particles). Combined or associated processes such as adsorption (first step) and flocculation (second step) onto Fe and Mn hydrated oxides particles surfaces associated to the organic matter precipitate these metals to the bottom of the reservoir and become the sediment compartment.

Table 6: Metal concentrations (mg/L) in water samples collected in Billings reservoir at 50 cm depth. Values of the LQ (limit of quantification) and of the Resolução CONAMA # 357/2005 are also shown.

Coordinates	Sampling point #	Cd	Cr	Hg	Ni	Mn	Pb	Zn	Cu	Fe
	LQ	0.0001	0.0025	0.00001	0.0025	0.010	0.0005	0.010	0.0004	0.020
	357/05	0.0010	0.05	0.0002	0.025	0.1	0.01	0.180	0.009	0.3
23K0342281 UTM 7369022	1	<LQ	<LQ	<LQ	<LQ	0.025	<LQ	<LQ	0.0040	<LQ
23K0341790 UTM 73790131	2	<LQ	<LQ	<LQ	<LQ	0.024	<LQ	<LQ	0.0051	0.111
23K0340548 UTM 7370044	3	<LQ	<LQ	<LQ	<LQ	0.058	0.0007	<LQ	0.0079	0.153
23K0339568 UTM 7368306	4	<LQ	<LQ	<LQ	<LQ	0.030	<LQ	<LQ	0.0024	<LQ
23K0336977 UTM7367563	5	<LQ	<LQ	<LQ	<LQ	0.040	0.0007	<LQ	0.0047	0.047
23K0336799 UTM7371509	6	<LQ	<LQ	<LQ	<LQ	0.060	0.0006	<LQ	0.0080	0.117
23K0336054 UTM7372827	7	<LQ	<LQ	<LQ	<LQ	0.112	0.0020	<LQ	0.0035	0.088
23K0333485 UTM7375565	8	<LQ	<LQ	<LQ	<LQ	0.074	0.0025	<LQ	0.0071	0.076
23K0332421 UTM7376891	9	<LQ	<LQ	<LQ	<LQ	0.097	0.0019	<LQ	0.0082	0.124
23K0331216 UTM7377749	10	<LQ	<LQ	<LQ	<LQ	0.154	0.0028	0.016	0.0044	0.334
23K0329600 UTM7377530	11	<LQ	<LQ	<LQ	<LQ	0.188	0.0028	0.036	0.0063	0.774
23K0329100 UTM7376857	13	<LQ	<LQ	<LQ	<LQ	0.150	0.0048	0.012	0.0027	0.241
23K0330079 UTM7376424	14	<LQ	<LQ	<LQ	<LQ	0.138	0.0018	0.011	0.0039	0.248
23K0329320 UTM7373643	15	<LQ	<LQ	<LQ	<LQ	0.057	<LQ	<LQ	0.0033	0.027
23K0332004 UTM7373251	16	<LQ	<LQ	<LQ	<LQ	0.061	0.0007	<LQ	0.0055	0.095
23K0331430 UTM7368819	17	<LQ	<LQ	<LQ	<LQ	0.024	<LQ	<LQ	0.0067	0.122
23K0331413 UTM7370756	18	<LQ	<LQ	<LQ	<LQ	0.034	<LQ	<LQ	0.0067	0.059
23K0332018 UTM7371577	19	<LQ	<LQ	<LQ	<LQ	0.049	0.0015	<LQ	0.0029	0.034
23K0334825 UTM7367728	20	<LQ	<LQ	<LQ	<LQ	0.026	0.0039	0.017	0.0073	0.234
23K0334657 UTM7366960	21	<LQ	<LQ	<LQ	<LQ	0.037	0.0006	<LQ	0.0063	0.041
23K0331648 UTM7362088	22	<LQ	<LQ	<LQ	<LQ	0.017	0.0019	<LQ	0.0024	<LQ
23K0331076 UTM7361502	23	<LQ	<LQ	<LQ	<LQ	0.018	<LQ	<LQ	0.0039	0.056
23K0337884 UTM7364383	24	<LQ	<LQ	<LQ	<LQ	0.020	<LQ	<LQ	0.0012	<LQ
23K0341175 UTM7366812	25	<LQ	<LQ	<LQ	<LQ	0.024	0.0008	<LQ	0.0026	<LQ
23K0344243 UTM7365343	26	<LQ	<LQ	<LQ	<LQ	0.016	0.0008	<LQ	0.0023	<LQ
23K0346394 UTM7366505	27	<LQ	<LQ	<LQ	<LQ	0.010	<LQ	<LQ	0.0013	<LQ
23K0349436 UTM7367511	28	<LQ	<LQ	<LQ	<LQ	0.018	0.0006	<LQ	0.0019	0.025
23K0343417 UTM7365263	29	<LQ	<LQ	<LQ	<LQ	0.018	<LQ	<LQ	0.0018	<LQ
23K0342228 UTM 7363889	30	<LQ	<LQ	<LQ	<LQ	0.018	<LQ	<LQ	0.0025	<LQ

2.1.5 Nutrients

In Table 7 are shown the data obtained for dissolved nitrogen species and total N and total P in water samples collected at 50 cm depth in Billings reservoir.

Ammonium concentrations violated the CONAMA 357/05 limiting value specially for sampling points at the Pedreira Dam region. These data corroborate the normally low DO values (see section 2.1.1) as well as the elevated values for COD and BOD (see section 2.1.8). Other data shown in this table show similar trend.

The literature on Billings water quality is really amazing. When we check these documents it can be seen that the data in Table 7, is in an overall basis, similar to those found in these published studies and demonstrate the water quality evolution in the Billings reservoir. It can be quoted, amongst the various studies, the following: Lamparelli (2004)¹⁷, Lamparelli et al. (1996)¹⁸, as well as the many reports on fresh water quality in the Estado de São Paulo published by CETESB in recent years¹⁹. We believe, that without doubt, these documents truly show that the water quality in Billings reservoir is becoming worse in the last 2 or even 3 decades.

Table 7: Dissolved nitrogen species and total P and total N concentrations in water samples collected at 50 cm depth in Billings reservoir.

¹⁷ LAMPARELLI, M. Graus de trofa em copos d'água do Estado de São Paulo: Avaliação dos métodos de monitoramento. 2004. 207 f. Anexos. Tese (Doutorado em Ciências- Área de Ecossistemas Terrestres e Aquáticos) - Instituto de Biociências, Universidade de São Paulo, São Paulo, SP, 2004.

¹⁸ LAMPARELLI, M. C.; KUHLMANN, M. L.; CARVALHO, M. C.; SALVADOR, M. E. P.; SOUZA, R. C.; BOTELHO, M. J. C.; COSTA, M. P.; MARTINS, M. C.; CARVALHO, P. M.; ARAÚJO, R. P. A.; HACHICH, E. M.; BARI, M.; CURSIO, R. L. S.; TOLEDO, JR, A. P.; LORENZETTI, M. D. L.; TRUZZI, A. C.; NAVAS-PEREIRA, D.; VARGAS-BOLDRINI, C. Avaliação do complexo Billings: comunidades aquáticas, água, sedimento - out/92 a out/93. São Paulo: CETESB, 1996. 53 p. Anexos.

¹⁹ CETESB, 1992. Relatório de qualidade das águas interiores do Estado de São Paulo. CETESB, São Paulo, Série Relatórios.
CETESB, 1995. Relatório de qualidade das águas interiores do Estado de São Paulo. CETESB, São Paulo, Série Relatórios.
CETESB, 1996. Relatório de qualidade das águas interiores do Estado de São Paulo. CETESB, São Paulo, Série Relatórios.
CETESB, 1998. Relatório de qualidade das águas interiores do Estado de São Paulo. CETESB, São Paulo, Série Relatórios.
CETESB, 1999a. Relatório de qualidade das águas interiores do Estado de São Paulo. CETESB, São Paulo, Série Relatórios.
CETESB, 1999b. Monitoramento integrado -- Bacias do Alto e Médio Tietê. Avaliação da qualidade – água, sedimento e peixes. Relatório final. Dez/99. Relatório Técnico. São Paulo: CETESB. 138p. Contrato de prestação de serviços 020/97 – SABESP.
CETESB, 2000. Relatório de qualidade das águas interiores do Estado de São Paulo. CETESB, São Paulo, Série Relatórios.
CETESB, 2001. Relatório de qualidade das águas interiores do Estado de São Paulo 2000 – CETESB, São Paulo, Série Relatórios.

Coordinates	Sampling point #	Ammonium LQ = 0.06 mg/L		Nitrite LQ = 0.001 mg/L	Nitrate LQ = 0.01 mg/L	N _{Kjeldahl} LQ=0.1 mg/L	N _{total} (*) mg L ⁻¹	P _{TOTAL} LQ=0.01 mg/L
		CONAMA 357/05: 3.7 mg/L N (pH ≤ 7.5) 2.0 mg/L N (7.0 < pH ≤ 8.0) 1.0 mg/L N (8.0 < pH ≤ 8.5) 0.5 mg/L N (pH > 8.5)		CONAMA 357/05: 1.0 mg/L N	CONAMA 357/05: 10.0 mg/L N	-	-	COMAMA 357/05: 0.030 mg/L P* ou 0.050 mg/L P**
		pH	N-NH ₃ (mg/L)	N-NO ₂ (mg/L)	N-NO ₃ (mg/L)	N _{Kjeldahl} (mg/L)	N _{total} (*) mg L ⁻¹	P _{TOTAL} (mg/L)
23K0342281 UTM 7369022	1	7.29	0.09	0.029	4.00	1.00	5.03	<0.01
23K0341790 UTM 73790131	2	8.07	<0.06	0.023	2.00	0.68	2.70	0.01
23K0340548 UTM 7370044	3	7.79	0.46	0.015	0.40	1.20	1.62	0.02
23K0339568 UTM 7368306	4	7.76	<0.06	0.013	0.50	0.97	1.48	0.01
23K0336977 UTM7367563	5	8.03	<0.06	0.01	0.50	1.00	1.51	0.01
23K0336799 UTM7371509	6	7.23	1.50	0.035	0.80	1.70	2.54	0.18
23K0336054 UTM7372827	7	6.94	3.60	0.083	1.00	4.00	5.08	0.28
23K0333485 UTM7375565	8	7.55	1.10	0.045	1.50	1.60	3.15	0.09
23K0332421 UTM7376891	9	7.33	5.00	0.051	3.00	2.60	5.65	0.14
23K0331216 UTM7377749	10	7.2	6.00	0.005	2.00	5.70	7.71	1.10
23K0329600 UTM7377530	11	7.06	6.50	0.004	0.06	5.20	5.30	1.20
23K0329100 UTM7376857	13	6.93	5.00	0.003	12.00	5.10	17.10	0.80
23K0330079 UTM7376424	14	7.16	4.50	0.001	0.19	4.90	5.09	0.27
23K0328320 UTM7373643	15	7.37	4.50	0.082	0.60	3.20	3.88	0.21
23K0332004 UTM7373251	16	7.7	0.70	0.011	1.00	1.70	2.71	0.08
23K0331430 UTM7368819	17	8.75	0.20	0.015	0.20	1.00	1.22	0.02
23K0331413 UTM7370755	18	8.89	<0.06	0.013	1.50	0.95	2.46	0.04
23K0332018 UTM7371577	19	7.86	<0.06	0.006	2.00	1.40	3.41	0.05
23K0334825 UTM7367728	20	7.47	<0.06	0.007	0.39	1.10	1.50	0.02
23K0334657 UTM7366960	21	9.38	<0.06	0.011	0.43	1.50	1.94	0.03
23K0331646 UTM7362088	22	9.34	0.12	0.009	1.50	0.94	2.45	0.02
23K0331076 UTM7361502	23	9.32	0.04	0.008	0.20	1.10	1.31	0.02
23K0337884 UTM7364383	24	8.67	<0.06	0.009	0.90	0.93	1.84	0.02
23K0341175 UTM7366812	25	8.36	0.07	0.012	0.40	1.00	1.41	0.01
23K0344243 UTM7365343	26	8.42	<0.06	0.009	0.19	1.20	1.40	0.01
23K0346394 UTM7366505	27	8.44	<0.06	0.005	4.50	0.97	5.48	0.01
23K0349436 UTM7367611	28	8.01	<0.06	0.002	0.11	0.78	0.89	0.01
23K0343417 UTM7365263	29	7.03	<0.06	0.007	4.00	0.74	4.75	0.01
23K0342228 UTM 7363889	30	8.24	<0.06	0.007	0.30	0.92	1.23	0.01

* Resolução CONAMA 357/05 Class 2 waters limit for P_{TOTAL} = 0,030 mg/L in lentic water bodies

** Resolução CONAMA 357/05 Class 2 waters limit for P_{TOTAL} = 0,050 mg/L in intermediate water bodies with residence time between 2 and 40 days, as well as having tributaries discharging into lentic water bodies.

Importance should also be given to violations of the CONAMA 357/05 in P_{TOTAL} concentrations based on limit of 0,030 mg/L in lentic water bodies, that coincide or match very well the ammonium and nitrate violations for sampling points in the Pedreira Dam area (see Table 7).

2.1.6 Phytoplankton

Table 8 shows phytoplankton density data determined in water samples collected at Billings reservoir.

If we compare these data to the limit established by the CONAMA 357/05 we can see no violation of the law for this parameter.

Table 8: Total density of the phytoplankton community expressed as the number cells mL⁻¹ measured in water samples from Billings reservoir.

Limit of Class 2 of CONAMA # 357/05 = up to 50,000 cells mL ⁻¹					
Coordinates	Sampling point #	Density of cyanobacteria (number of cells mL ⁻¹)	Coordinates	Sampling point #	Density of cyanobacteria (number of cells mL ⁻¹)
23K0342281 UTM 7369022	1	7,318	23K0331430 UTM7368819	17	4,683
23K0341700 UTM 73700131	2	4,318	23K0331413 UTM7370756	18	4,843
23K0340548 UTM 7370044	3	1,505	23K0332018 UTM7371577	19	8,627
23K0339568 UTM 7368306	4	4,921	23K0334825 UTM7367728	20	5,413
23K0336977 UTM7367563	5	2,842	23K0334657 UTM7369960	21	3,859
23K0336769 UTM7371509	6	1,011	23K0331646 UTM7362088	22	4,992
23K0336054 UTM7372827	7	4,000	23K0331076 UTM7361502	23	8,189
23K0333485 UTM7375565	8	1,675	23K0337884 UTM7364383	24	885.0
23K0332421 UTM7376891	9	2,312	23K0341175 UTM7366812	25	4,736
23K0331216 UTM7377749	10	1,289	23K0344243 UTM7365343	26	4,178
23K0329600 UTM7377530	11	2,656	23K0346394 UTM7366505	27	12,843
23K0329100 UTM7376857	13	1,763	23K0349436 UTM7367511	28	14,025
23K0330079 UTM7378424	14	3,534	23K0343417 UTM7365263	29	9,642
23K0329320 UTM7373643	15	1,480	23K0342228 UTM 7363889	30	13,499
23K0332004 UTM7373251	16	2,682			

The data set (all types or taxons of identified algae in terms of total density) is presented in the appendix 2 of this final report. It can be seen that we have measured relatively high densities which explain the high rates of phytoplankton productivity that may prevail in this water body.

2.1.7 Coliform

Table 9 show total coliform, *E. coli* data in water samples collected in Billings at 50 cm depth at different sampling points.

It were observed violations of these parameters according to the CONAMA 357/05 specially in sampling points close to the Pedreira Dam (sampling points # 10 and 14).

Table 9: Total coliform, *E. coli* data in water samples collected in Billings at 50 cm depth at different sampling points.

Limit of Class 2 waters from Resolução CONAMA # 357/05: thermo tolerant coliform maximum of 1,000 UFC/100 mL					
Sampling point #	Total Coliform (UFC/100 mL)	<i>E. coli</i> (UFC/100 mL)	Sampling point #	Total Coliform (UFC/100 mL)	<i>E. coli</i> (UFC/100 mL)
1	3.5X10 ⁴	220	16	1.6X10 ⁵	6.7X10 ²
2	7.0X10 ³	50	17	2.8X10 ⁴	30
3	2.7X10 ⁴	470	18	2.2X10 ⁴	20
4	1.1X10 ⁵	10	19	7.9X10 ⁴	3.1X10 ²
5	4.9X10 ⁵	10	20	3.3X10 ⁴	10
6	6.2X10 ⁶	5,0X10 ³	21	2.7X10 ⁴	30
7	7.1X10 ⁵	2,1X10 ⁴	22	1.6X10 ⁴	3.3X10 ²
8	1.5X10 ⁵	8,0X10 ³	23	1.8X10 ⁴	30
9	3.5X10 ⁶	9,0X10 ³	24	1.3X10 ⁵	10
10	2.1X10 ⁶	6,5X10 ⁴	25	4.8X10 ⁴	30
11	6.3X10 ⁵	8,6X10 ⁴	26	3.8X10 ⁴	90
13	9.2X10 ⁵	9,1X10 ⁴	27	7.0X10 ³	40
14	4.3X10 ⁵	6,4X10 ⁴	28	9.0X10 ³	30
15	3.5X10 ⁵	4,0X10 ³	29	1.9X10 ⁴	40
			30	3.0X10 ⁴	10

As it was expected those violations shown in Table 9 are typical of water bodies strongly affected by the discharge of untreated urban sewage.

2.1.8 COD and BOD

Tables 10 show COD (chemical oxygen demand) and BOD (biochemical oxygen demand) data from water samples collected in Billings at 50 cm depth at different sampling points.

Please note that the reference value for waters of Class 2 in the CONAMA 357/05 for the BOD is 5.0 mg O₂/L, while for COD no reference is made in this Brazilian environmental legislation.

CONAMA 357/05 violations highlighted in Table 10 were observed in several sampling points across the Billings reservoir but predominantly in those at the Billings arms in the Pedreira Dam region, as it were observed for many other parameters discussed earlier.

Tables 10: COD (chemical oxygen demand) and BOD (biochemical oxygen demand) data from water samples collected in Billings at 50 cm depth at different sampling points.

Sampling point #	COD (mg O ₂ /L)	BOD (mg O ₂ /L)	Sampling point #	COD (mg O ₂ /L)	BOD (mg O ₂ /L)
1	13	4	17	38	10
2	36	15	18	18	6
3	24	5	19	24	8
4	29	7	20	25	7
5	32	6	21	32	10
6	29	8	22	28	10
7	27	6	23	41	18
8	19	5	24	22	6
9	32	14	25	30	9
10	44	18	26	14	3
11	49	21	27	17	5
13	37	17	28	19	5
14	39	12	29	25	8
15	40	17	30	17	5
16	30	10			

As it was expected those violations shown in Table 10 are typical of water bodies strongly affected by the discharge of untreated urban sewage.

2.2. Sediments

2.2.1 Physico-chemical parameters

In Table 11 we can see the physico-chemical parameter results obtained for sediment collected at different sampling points in Billings reservoir.

Table 11: Physico-chemical parameter results obtained for sediment collected at different sampling points in Billings reservoir. (*) Please note that the DO (dissolved oxygen) values refer, obviously, to the water column and they are presented here again as a mean to establish a correlation with the EH and pH data.

Sampling point #	Coordinates	(*) DO (mg/L)	pH	EH (mV)	Water content (%)
1	23K0342281 UTM 7369022	3.49	7.25	-117	83.6
2	23K0341790 UTM 7370131	3.58	7.97	-194	87.0
3	23K0340548 UTM 7370044	3.30	8.18	-294	86.4
4 (0-12 cm)	23K0339568 UTM 7368306	4.34	6.25	-158	92.6
4 (29-41 cm)		-	-	-	84.7
4 (58-70 cm)		-	-	-	62.6
14 (0-10 cm)	23K0330079 UTM7376424	0.81	7.15	-176	78.4
14 (12-22 cm)		-	-	-	53.4
14 (24-34 cm)		-	-	-	53.5
19 (0-10 cm)	23K0332018 UTM7371577	7.96	6.68	-188	87.9
19 (45-55 cm)		-	-	-	87.0
19 (90-100 cm)		-	-	-	78.9
20 (0-10 cm)	23K0334825 UTM7367728	7.87	5.82	-169	90.5
20 (23-33 cm)		-	-	-	85.3
20 (46-56 cm)		-	-	-	80.1
22 (0-12 cm)	23K0331646 UTM7362088	4.11	5.91	-179	90.4
22 (15-27 cm)		-	-	-	84.7
22 (28-40 cm)		-	-	-	58.3
23	23K0331076 UTM7361502	4.16	5.67	-187	84.5
26	23K0344243 UTM7365343	4.41	6.23	-193	83.3
28	23K0349436 UTM7367511	3.93	6.08	-139	86.5
30	23K0342228UTM 7363889	3.74	6.73	-170	86.4

It can highlighted in Table 11 the low values of EH which are typical of anoxic sediments and which have high organic matter contents (see also Table 12). pH values are somewhat low in several sampling points which demonstrate that anaerobic oxidation of the organic matter is taken place as it generates CO₂, a weak but important environmental acid in the sediment pore water.

Redox potential values are low, in general, and are followed by the high values of acid volatilization sulfides (AVS) and there are sufficient information in the literature that show that AVS attenuate or even eliminate toxicity due to metals in

sediments. However, toxicity tests have to be done in order to check this important role (see Mozeto et al., 2003²⁰; Silvério et al., 2005²¹).

2.2.2 COT, N_{total} and P_{total}.

Table 12 presents concentrations of total N, total P and total organic carbon (TOC) determined in the sediment samples collected at Billings reservoir.

Table 12: Concentrations of total N, total P and total organic carbon (TOC) determined in the sediment samples collected at Billings reservoir.

Sampling Points	Coordinates	N total (%)	P total (%)	COT (%)
		LQ=0.03 %	0.39 %	LQ=0.3 %
1	23K0342281 UTM 7369022	0.56	1.79	6.41
2	23K0341790 UTM 7370131	0.58	2.09	6.88
3	23K0340548 UTM 7370044	0.62	1.37	9.80
4 (0-12 cm)	23K0339568 UTM 7368306	0.58	1.39	13.17
4 (29-41 cm)		0.43	1.60	5.76
4 (58-70 cm)		0.30	1.27	10.40
14 (0-10 cm)	23K0330079 UTM7376424	0.53	2.00	5.49
14 (12-22 cm)		0.52	1.65	3.39
14 (24-34 cm)		0.24	1.28	3.95
19 (0-10 cm)	23K0332018 UTM7371577	0.35	1.49	6.84
19 (45-55 cm)		0.38	1.43	5.00
19 (90-100 cm)		0.42	1.48	5.82
20 (0-10 cm)	23K0334825 UTM7367728	0.37	1.72	8.12
20 (23-33 cm)		0.35	1.60	7.47
20 (46-56 cm)		0.61	1.45	9.82
22 (0-12 cm)	23K0331646 UTM7362088	0.40	2.01	9.89
22 (15-27 cm)		0.75	1.51	9.28
22 (28-40 cm)		0.59	1.68	5.77
23	23K0331076 UTM7361502	0.51	1.74	8.11
26	23K0344243 UTM7365343	0.49	1.69	7.40
28	23K0349436 UTM7367511	0.55	1.52	6.75
30	23K0342228UTM 7363889	0.57	1.58	8.91

2.2.3 Metals

Results of metal concentration in sediments are shown in Table 13. Table 14 presents the sediment quality guidelines widely employed to metal contamination assessments around the world in sediment studies.

²⁰ Mozeto, A.A.; Silvério, P.F.; DePaula, F.C.F.; Bevilacqua, J.E.; Patella, E.; Jordim, W.F. 2003. Weakly-bound metals and total nutrient concentrations of bulk sediments from some water reservoirs in São Paulo, SE Brazil. IN: M. Munawar (Ed.). Sediment Quality Assessment and Management: Insight and Progress. Ecovision Monograph Series. pp. 221-239.

²¹ Silvério, P.F.; Fonseca, A.L.; Botta-Paschoal, C.M.R.; Mozeto, A.A. 2005. Release, bioavailability and toxicity of metals in lacustrine sediments: A case study of reservoirs and lakes in Southeast Brazil. Aquat Ecosyst Health Manag 8(3): 1-10.

Table 13: Potentially bioavailable metal concentration for sediments samples collected at different points in Billings reservoir (mg/kg).

Coordinates	Sampling point #	Cd	Cr	Cu	Ni	Pb	Zn	Hg
23K0342281 UTM 7369022	1	0.33	91.22	823.93	65.23	53.95	154.49	0.1941
23K0341790 UTM 7370131	2	0.32	97.46	349.95	55.62	63.00	112.22	0.1531
23K0340548 UTM 7370044	3	0.08	65.49	472.34	33.74	26.79	166.71	0.1205
23K0339568 UTM 7368306	4 (0-12 cm)	3.34	455.74	441.89	303.35	127.07	936.32	0.3440
	4 (29-41 cm)	0.08	48.76	17.07	13.65	33.65	67.78	0.1252
	4 (59-70 cm)	0.89	7.20	159.79	6.45	99.74	66.99	0.1913
23K0330079 UTM7376424	14 (0-10 cm)	0.90	161.09	289.26	63.84	113.21	508.70	0.5488
	14 (12-22 cm)	1.19	183.97	199.79	88.03	159.73	442.61	0.9379
	14 (24-34 cm)	1.30	186.42	226.30	95.13	141.26	480.47	0.8168
23K0332018 UTM7371577	19 (0-10 cm)	6.62	577.06	619.28	399.25	213.00	1,566.97	0.1467
	19 (45-55 cm)	3.88	500.05	339.35	217.50	287.89	1,267.11	0.1381
	19 (90-100 cm)	2.59	238.52	237.03	50.79	210.64	1,712.98	0.3395
23K0334825 UTM7367728	20 (0-10 cm)	1.66	229.47	213.39	104.26	114.49	540.78	0.3086
	20 (23-33 cm)	4.21	515.39	339.46	224.00	236.38	1,184.40	0.2409
	20 (46-56 cm)	1.60	209.75	159.31	52.94	156.31	1,108.67	2.1157
23K0331646 UTM7362088	22 (0-12 cm)	0.22	82.21	46.21	61.78	57.89	73.94	0.0681
	22 (15-25 cm)	0.34	163.29	48.20	80.66	60.99	141.16	0.0000
	22 (30-40 cm)	0.09	68.61	32.31	20.88	38.78	87.00	0.2220
23K0331076 UTM7361502	23	0.16	71.48	34.75	47.16	45.67	40.21	0.0596
23K0344243 UTM7365343	26	0.39	131.38	91.92	59.95	56.45	150.36	0.1641
23K0349436 UTM7367511	28	0.15	61.85	29.93	29.43	52.87	61.35	0.1180
23K0342228 UTM 7363889	30	0.25	112.75	78.06	60.71	34.69	106.49	0.0819

Table 14: Values of sediment quality guidelines (SQG's) known as cause-effect guidelines (or empirical guidelines) (mg/kg). TEL = threshold effect level; PEL = probable effect level; SEL = severe effect level.

SQG's	Cd	Cr	Cu	Ni	Pb	Zn	Hg
TEL	0.596	37.3	35.7	18	35	123.1	0.17
PEL	4	90	197	36	91.3	315	0.486
SEL	10	110	110	75	250	820	2

Measured concentrations that violate TEL guideline are highlighted in blue, while those that are larger than PEL guideline are marked with light red; violations of SEL guideline values are highlighted in dark red. Note: Please see the electronic version of this report.

To better understand the meaning of the above mentioned sediment quality guidelines TEL, PEL and SEL the readers are directed to Silvério et al. (2006)²². This publication brings an extensive discussion on the topic, as well as cites many other international references that may also be studied.

Although the use of SQGs numerical values alone to assess sediment contamination due to metal in sediments is not recommended for several reasons (e.g., Burton, 2002; Mozeto et al., 2006)²³ it should be kept in mind that SQGs violations such as those of SEL are of great significance and really troublesome as they represent real cases of toxicity to the aquatic life (water column and sediment fauna) due to metals in sediments. Evidently, as specified earlier in this document, toxicity tests are necessary to confirm effects as AVS and TOC in sediments, as well as DOC in the pore water are extremely high in this water body^{20,21,22,23} and may be attenuating or even eliminating toxicity as it was just specified above. Even though, toxicity and a negative impact in aquatic life may occur as many species of this fauna swallow particles (as food) thus do not use or remove their food only from the dissolved phase (water from the water column or pore water which truly represent the real bioavailable phase of food and contaminants!). Therefore, chemical analyses of metal concentrations in the water from the sediment water-interface, as well as pore water are really a necessity (or, are a real requirement) to assess metal bioavailability.

²² Silvério, P.F.; Nascimento, M.R.L.; Mozeto, A.A. 2006. Valores-guia de qualidade de sedimentos de ambientes aquáticos continentais e valores de referência de metais e metalóides em sedimentos. In: Mozeto, A.A.; Umbuzeiro, G.A.; Jardim, W.F. (Eds.). Métodos de coleta, análises físico-químicas e ensaios biológicos de sedimentos de água doce. Cubo Multi Mídia Editora. São Carlos, SP, Brasil. p. 71-89.

²³ Burton, G. A., Jr. Sediment quality criteria in use around the world. *Limnology*, v. 3, n. 2, p. 65-75, 2002.

Mozeto, A.A.; Umbuzeiro, G.A.; Araújo, R.P. de A.; Jardim, W. F. 2006. Esquema de avaliação integrada e hierárquica da qualidade de sedimentos (AIHQs). IN: Mozeto, A.A.; Umbuzeiro, G.A.; Jardim, W. F. (Eds.). Métodos de coleta, análises físico-químicas e ensaios biológicos e ecotoxicológicos de sedimentos de água doce. São Carlos, SP, Brasil. Cubo Multimídia. 192-224 p.

São Carlos, SP-Brazil

August 11th/2006

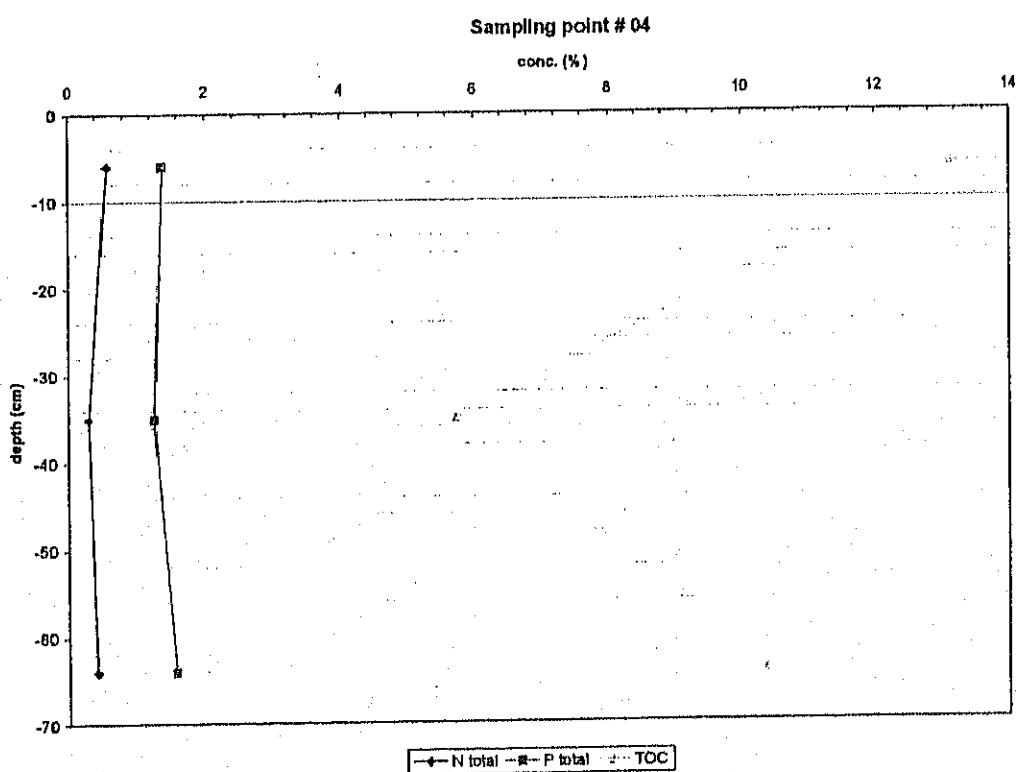
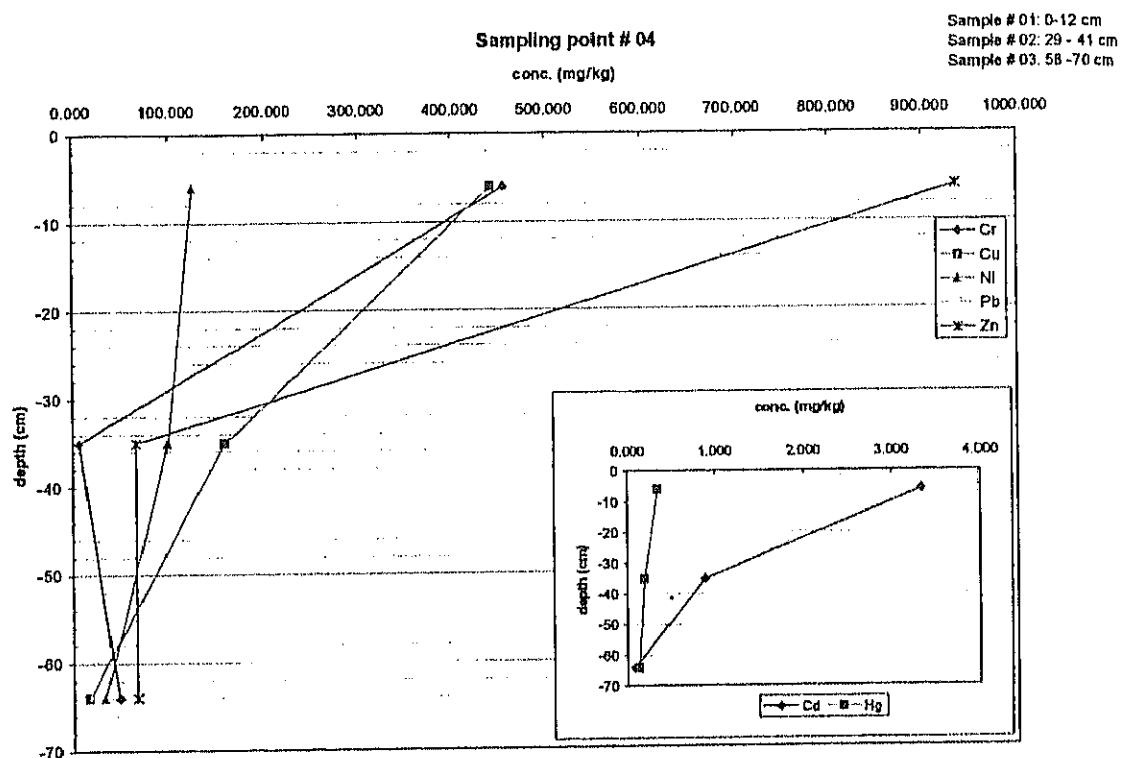
Prof. Dr. Antonio A. Mozeto – Environmental Biogeochemist, PhD in Earth Sciences (University of Waterloo, Canada) – *Project's Coordinator*

Dr. Marcos R. L. do Nascimento – Environmental Chemist, Doctor of Science in Environmental Chemistry (UFSCar, São Carlos, SP-Brazil)

MSc Erida F. Araújo Silva – Environmental Chemist, Master of Science in Environmental Chemistry (UFSCar, São Carlos, SP-Brazil)

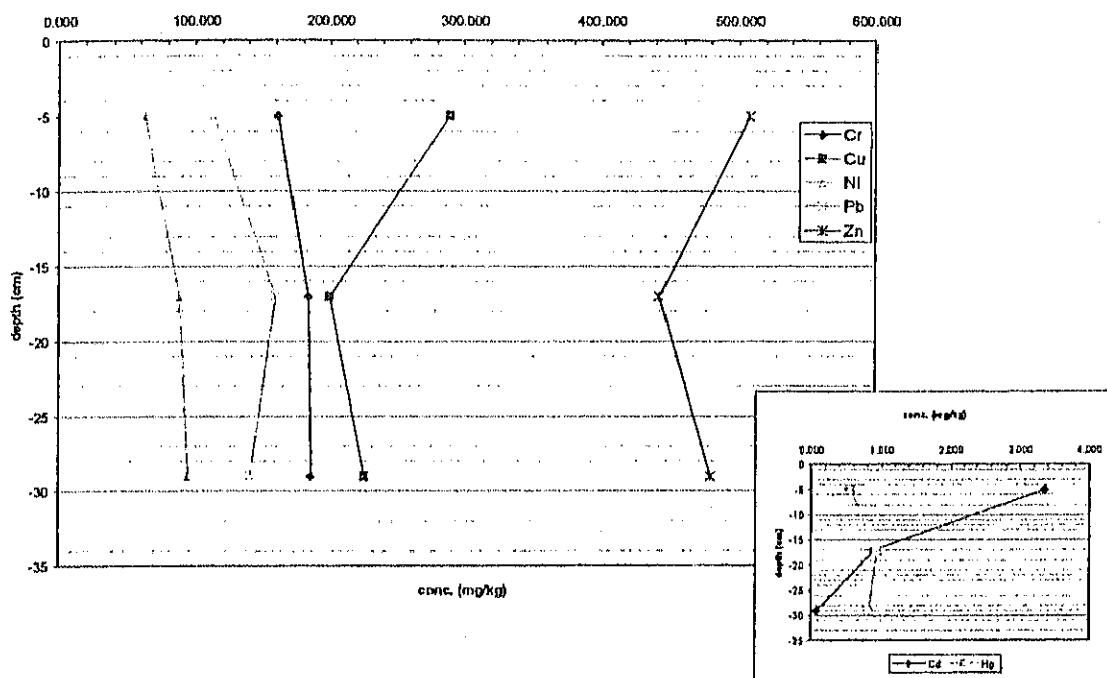
Independent Consultants

**APPENDIX 1– 'metal and nutrient concentrations' versus 'depth'
for sampling points in which cores have been collected, sectioned
and chemically analyzed – Billings Reservoir – SP/BRAZL**

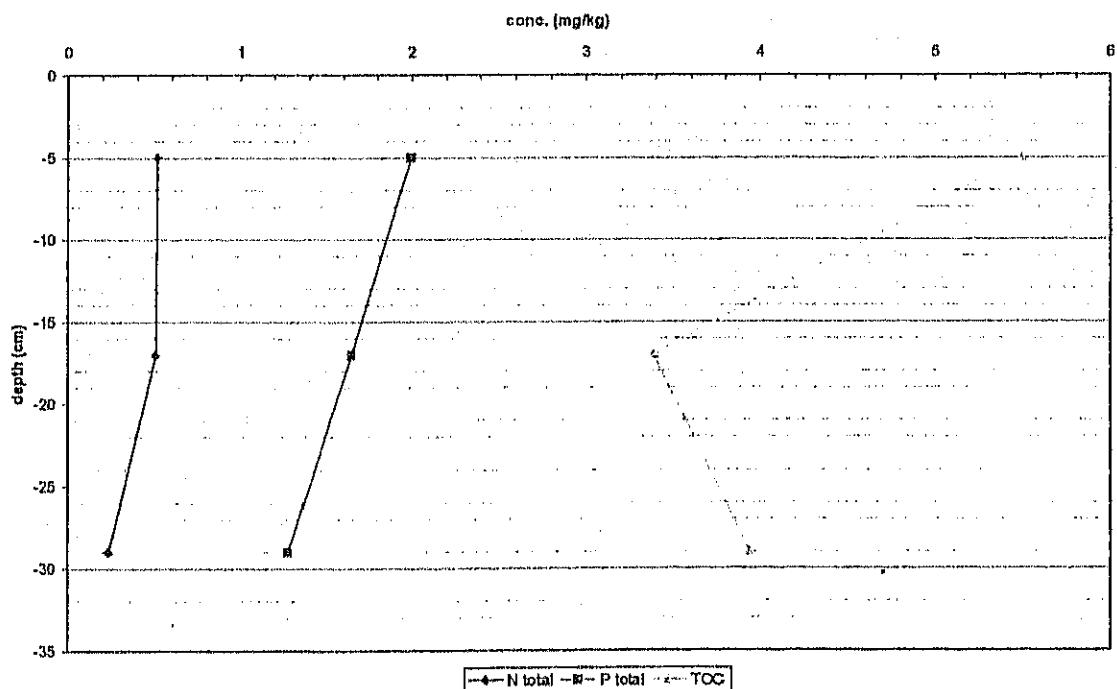


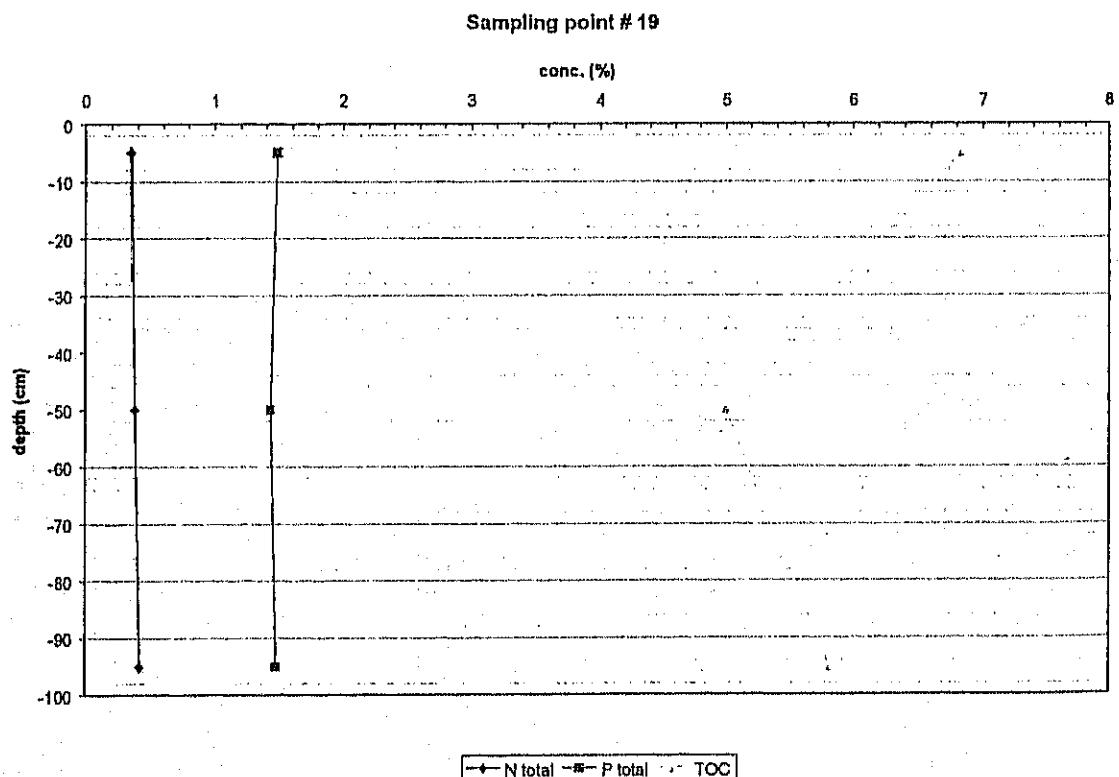
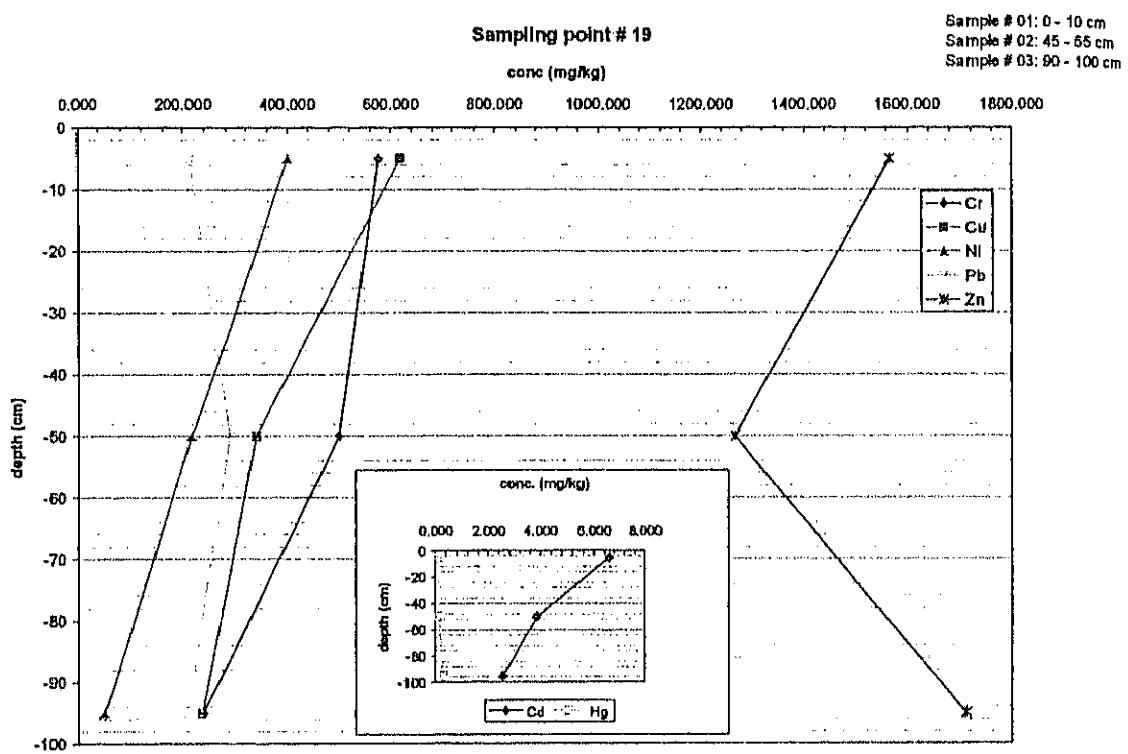
Sampling point # 14

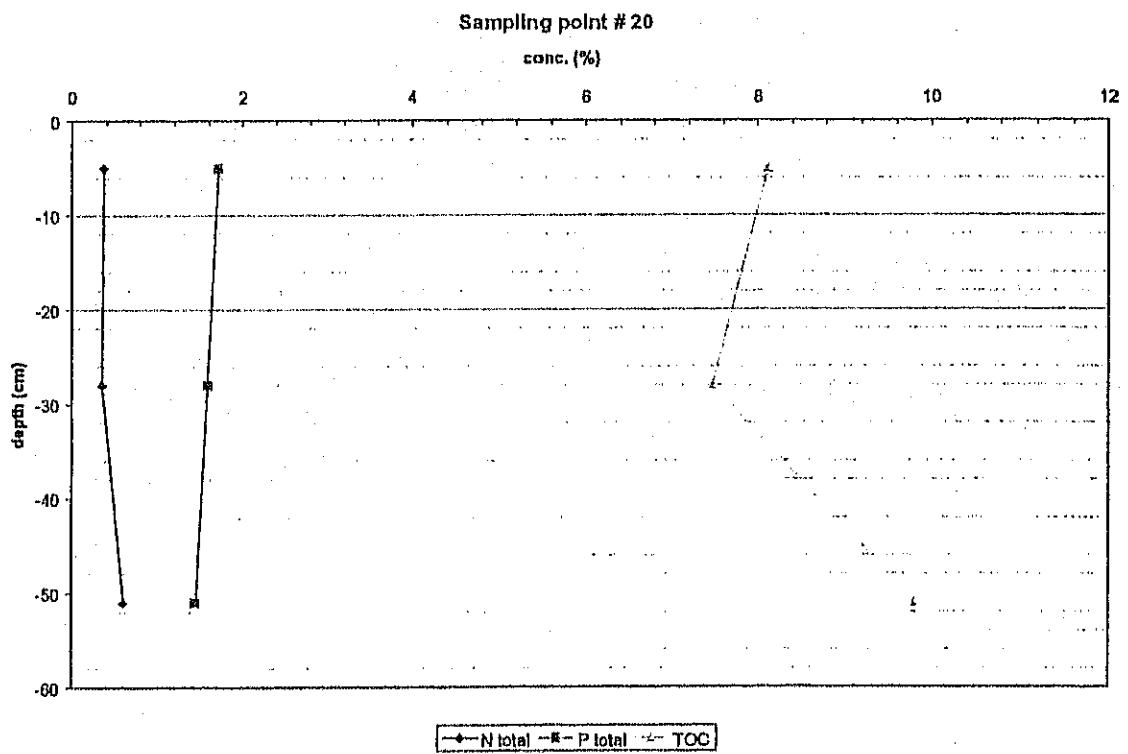
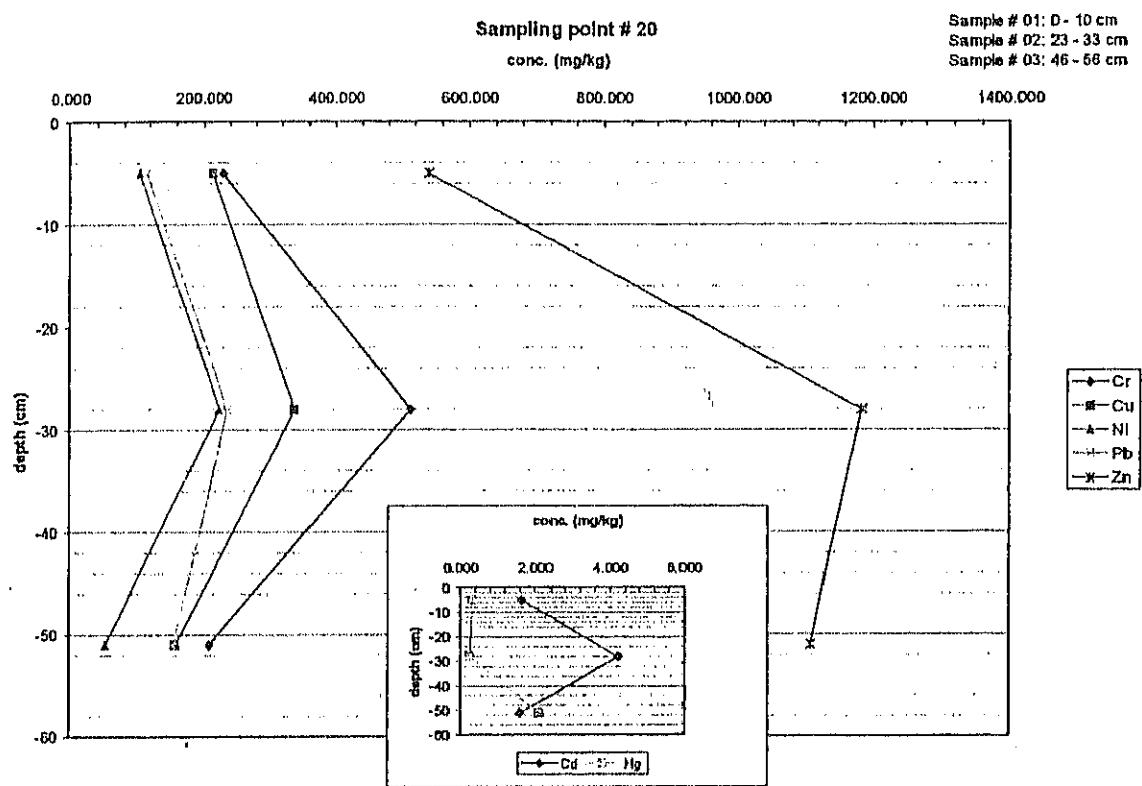
Sample # 01: 0 - 10 cm
 Sample # 02: 12 - 22 cm
 Sample # 03: 24 - 34 cm

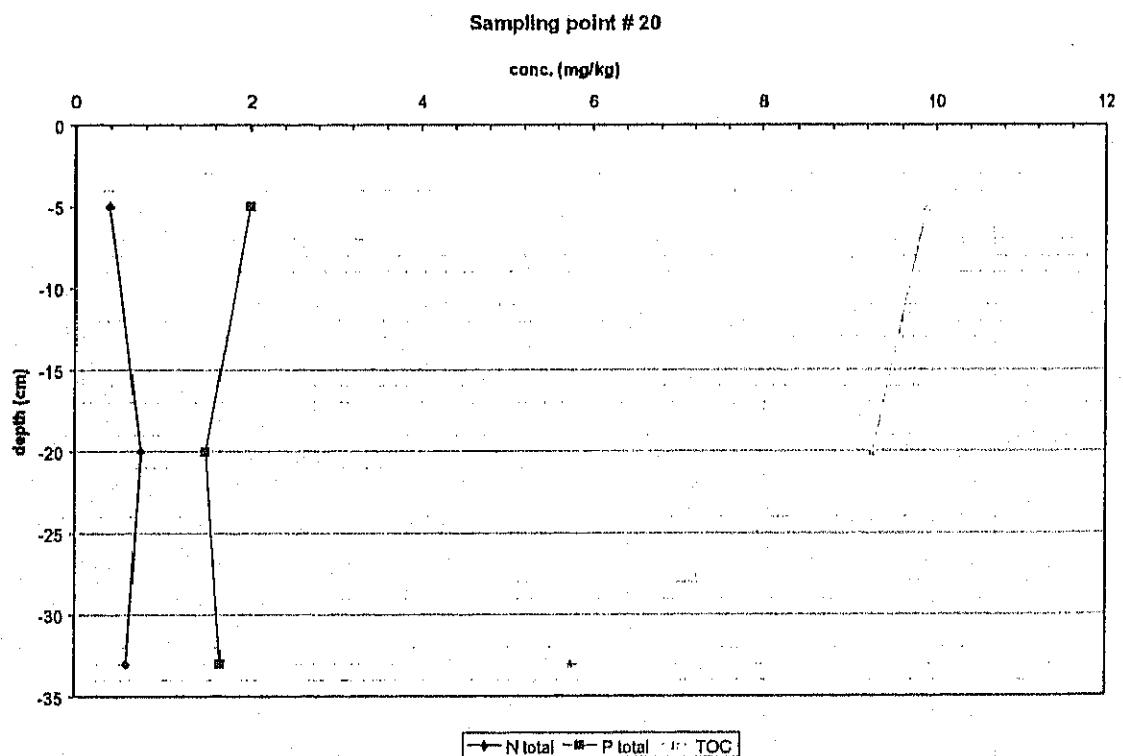
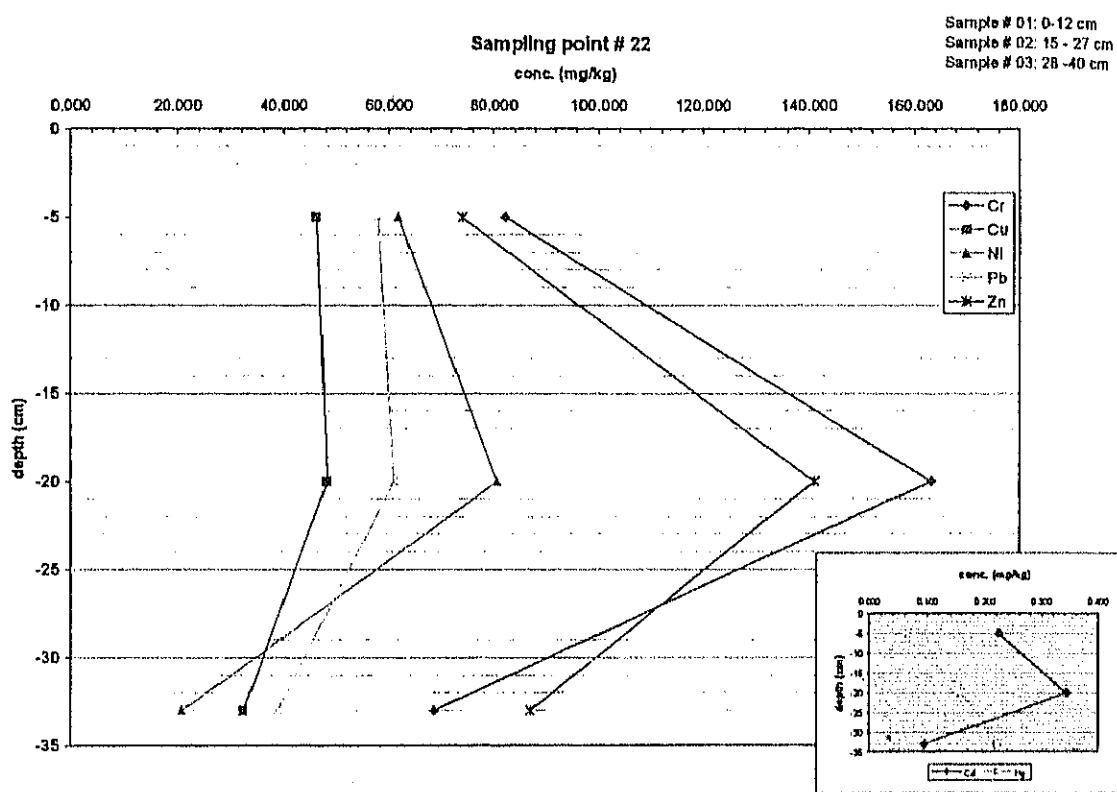


Sampling point # 14









**APPENDIX 2 – all types of taxons of algae found in Billings water samples
expressed in terms of density 'd' (ind.mL⁻¹).**

Sampling Point # 01	
Taxons	d (ind.mL⁻¹)
Cyanophyceae	7318
<i>Anabaena spiroides</i>	50
<i>Cylindrospermopsis cf. raciborskii</i>	6265
<i>Geitlerinema unigranulatum</i>	601
<i>Planktothrix</i> sp	351
<i>Pseudanabaena</i> sp.1	50
Bacillariophyceae	652
<i>Aulacoseira granulata</i>	50
<i>Cyclotella</i> sp	301
<i>Fragillaria</i> spp	301
Chlorophyceae	1654
<i>Ankistrodesmus gracilis</i>	50
<i>Dictyosphaerium pulchellum</i>	50
<i>Monoraphidium circinale</i>	50
<i>Monoraphidium Irregularare</i>	501
<i>Mougeotia</i> sp	802
<i>Pediastrum tetras</i>	50
<i>Scenedesmus denticulatus</i>	50
<i>Scenedesmus opollensis</i>	100
Euglenophyceae	150
<i>Trachelomonas volvocina</i>	150
Chrysophyceae	50
<i>Synura uvella</i>	50
Dinophyceae	50
<i>Peridinium</i> sp	50
Cryptophyceae	1153
<i>Cryptomonas</i> sp	1153
Conjugatophyceae	50
<i>Euastrum cf. verticosum</i>	50

Sampling Point # 02

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	4318
<i>Anabaena</i> sp	96
<i>Aphanocapsa</i> sp	36
<i>Cylindrospermopsis cf. raciborskii</i>	3164
<i>Glellerinema unigranulatum</i>	301
<i>Merismopedia tenuissima</i>	24
<i>Microcystis aeruginosa</i>	48
<i>Planktothrix</i> sp	565
<i>Pseudanabaena</i> sp.1	84
Bacillariophyceae	445
<i>Aulacoseira granulata</i>	120
<i>Cyclotella</i> sp	108
<i>Fragilaria</i> spp	192
<i>Navicula</i> spp	12
<i>Rizosolenia</i> sp	12
Chlorophyceae	1179
<i>Golenkinia radiata</i>	36
<i>Micractinium pusillum</i>	12
<i>Monoraphidium Irregularare</i>	397
<i>Mougeotia</i> sp	601
<i>Scenedesmus acuminatus</i>	12
<i>Scenedesmus opoliensis</i>	108
<i>Treubaria</i> sp	12
Euglenophyceae	301
<i>Trachelomonas volvocina</i>	301
Chrysophyceae	108
<i>Dinobryon</i> sp	48
<i>Mallomonas</i> sp	60
Dinophyceae	96
<i>Peridinium</i> sp	96
Cryptophyceae	601
<i>Cryptomonas</i> sp	601
Conjugatophyceae	36
<i>Euastrum cf. verrucosum</i>	36

Sampling Point # 03

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	1505
<i>Anabaena</i> sp	16
<i>Chroococcus</i> sp	16
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	1153
<i>Geitlerinema unigranulatum</i>	176
<i>Planktothrix</i> sp	144
Bacillariophyceae	112
<i>Aulacoseira granulata</i>	16
<i>Cyclotella</i> sp	32
<i>Fragilaria</i> spp	64
Chlorophyceae	368
<i>Monoraphidium irregularare</i>	64
<i>Mougeotia</i> sp	240
<i>Pediastrum tetras</i>	16
<i>Scenedesmus opoliensis</i>	48
Euglenophyceae	16
<i>Trachelomonas volvocina</i>	16
Cryptophyceae	192
<i>Cryptomonas</i> sp	192
Conjugatophyceae	16
<i>Euastrum</i> cf. <i>verrucosum</i>	16

Sampling Point # 04

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	4921
<i>Anabaena</i> sp	41
<i>Anabaena spiroides</i>	41
Células livres de <i>Microcystis</i> sp	287
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	3404
<i>Geitlerinema unigranulatum</i>	656
<i>Microcystis aeruginosa</i>	41
<i>Microcystis panniformis</i>	82
<i>Planktothrix</i> sp	369
Bacillariophyceae	287
<i>Aulacoseira granulata</i>	164
<i>Cyclotella</i> sp	82
<i>Rizosolenia</i> sp	41
Chlorophyceae	574
<i>Botriococcus</i> sp	41
<i>Monoraphidium irregularare</i>	123
<i>Mougeotia</i> sp	328
<i>Scenedesmus opoliensis</i>	82
Euglenophyceae	205
<i>Trachelomonas volvocina</i>	205
Chrysophyceae	82
<i>Mallomonas</i> sp	82
Dinophyceae	123
<i>Peridinium</i> sp	123
Cryptophyceae	820
<i>Cryptomonas</i> sp	820

Sampling Point # 05

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	2842
<i>Anabaena</i> sp	176
<i>Anabaena circinalis</i>	27
<i>Anabaena spiroides</i>	81
<i>Aphanocapsa</i> sp	14
<i>Coelomorpha</i> sp	41
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	988
<i>Geitlerinema unigranulatum</i>	68
<i>Merismopedia glauca</i>	14
<i>Microcystis aeruginosa</i>	135
<i>Planktothrix</i> sp	1177
<i>Pseudanabaena</i> sp.1	122
Bacillariophyceae	568
<i>Aulacoseira granulata</i>	122
<i>Cyclotella</i> sp	95
<i>Fragilaria</i> spp	352
Chlorophyceae	690
<i>Actinastrum hantzschii</i>	14
<i>Coelastrum microporum</i>	14
<i>Dictyosphaerium pulchellum</i>	14
<i>Monoraphidium irregularare</i>	162
<i>Mougeotia</i> sp	284
<i>Oocystis</i> sp	54
<i>Pediastrum tetras</i>	41
<i>Scenedesmus acuminatus</i>	14
<i>Scenedesmus denticulatus</i>	14
<i>Scenedesmus opoliensis</i>	81
Euglenophyceae	149
<i>Trachelomonas armata</i>	68
<i>Trachelomonas volvocina</i>	81
Chrysophyceae	27
<i>Mallomonas</i> sp	27
Dinophyceae	81
<i>Peridinium</i> sp	81
Cryptophyceae	298
<i>Cryptomonas</i> sp	298
Conjugatophyceae	54
<i>Euastrum</i> cf. <i>verrucosum</i>	14
<i>Staurastrum</i> sp.1	27
<i>Staurodesmus</i> sp	14

Sampling Point # 06

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	1011
<i>Anabaena</i> sp	50
<i>Anabaena spiroides</i>	30
<i>Aphanocapsa</i> sp	30
Células livres de <i>Microcystis</i> sp	69
<i>Coelomorion</i> sp	10
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	149
<i>Geitlerinema unigranulatum</i>	79
<i>Merismopedia glauca</i>	20
<i>Microcystis aeruginosa</i>	10
<i>Microcystis panniformis</i>	20
<i>Planktothrix</i> sp	545
Bacillariophyceae	337
<i>Aulacoseira granulata</i>	30
<i>Cyclotella</i> sp	10
<i>Fragilaria</i> spp	297
Chlorophyceae	327
<i>Actinastrum hantzschii</i>	79
<i>Chlamydomonas</i> sp	10
<i>Coelastrum microporum</i>	10
<i>Dictyosphaerium pulchellum</i>	50
<i>Micractinium bornhemiense</i>	10
<i>Monoraphidium circinale</i>	10
<i>Monoraphidium irregularare</i>	10
<i>Mougeotia</i> sp	119
<i>Pediastrum duplex</i>	10
<i>Pediastrum simplex</i>	10
<i>Scenedesmus opoliensis</i>	10
Euglenophyceae	40
<i>Trachelomonas volvocina</i>	40
Chrysophyceae	50
<i>Mallomonas</i> sp	40
<i>Synura uvella</i>	10
Dinophyceae	30
<i>Peridinum</i> sp	30
Cryptophyceae	268
<i>Cryptomonas</i> sp	268
Conjugatophyceae	20
<i>Staurastrum</i> sp.2	10
<i>Staurastrum</i> sp.3	10

Sampling Point # 07

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	4000
<i>Anabaena</i> sp	211
<i>Anabaena spiroides</i>	60
Células livres de <i>Microcystis</i> sp	180
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	571
<i>Gleißnerhema unigranulatum</i>	211
<i>Merismopedia glauca</i>	180
<i>Microcystis aeruginosa</i>	120
<i>Microcystis panniformis</i>	60
<i>Oscillatoria</i> sp	30
<i>Phormidium</i> sp	30
<i>Planktothrix</i> sp	2346
Bacillariophyceae	1263
<i>Aulacoseira granulata</i>	90
<i>Cyclotella</i> sp	211
<i>Fragilaria</i> spp	962
Chlorophyceae	1443
<i>Actinastrum hantzschii</i>	90
<i>Chlamydomonas</i> sp	30
<i>Coelastrum microporum</i>	30
<i>Dictyosphaerium pulchellum</i>	120
<i>Micractinium pusillum</i>	60
<i>Monoraphidium irregularare</i>	90
<i>Mougeotia</i> sp	992
<i>Scenedesmus opoliensis</i>	30
Euglenophyceae	331
<i>Trachelomonas hispida</i>	30
<i>Trachelomonas volvocina</i>	301
Chrysophyceae	30
<i>Mallomonas</i> sp	30
Cryptophyceae	481
<i>Cryptomonas</i> sp	481
Conjugatophyceae	30
<i>Euastrum</i> cf. <i>verticosum</i>	30

Sampling Point # 8	
Taxons	d (ind.mL ⁻¹)
Cyanophyceae	1675
<i>Anabaena</i> sp	129
<i>Aphanocapsa</i> sp	129
<i>Coelomorion</i> sp	64
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	258
<i>Geitlerinema ungranulatum</i>	193
<i>Merismopedia glauca</i>	193
<i>Microcystis aeruginosa</i>	64
<i>Planktothrix</i> sp	644
Bacillariophyceae	838
<i>Fragilaria</i> spp	838
Chlorophyceae	773
<i>Actinastrum hantzschii</i>	64
<i>Dictyosphaerium pulchellum</i>	129
<i>Micractinium bomhjemense</i>	129
<i>Monoraphidium irregularis</i>	129
<i>Mougeotia</i> sp	322
Euglenophyceae	193
<i>Trachelomonas armata</i>	129
<i>Trachelomonas volvocina</i>	64
Chrysophyceae	129
<i>Mallomonas</i> sp	129
Cryptophyceae	1547
<i>Cryptomonas</i> sp	1547

Sampling Point # 09

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	2312
<i>Anabaena spiroides</i>	56
Células livres de <i>Microcystis</i> sp	338
<i>Geitlerinema unigranulatum</i>	282
<i>Merismopedia glauca</i>	282
<i>Microcystis aeruginosa</i>	226
<i>Planktothrix</i> sp	1071
<i>Pseudanabaena</i> sp.1	56
Bacillariophyceae	677
<i>Fragilaria</i> spp	620
<i>Rizosolenia</i> sp	56
Chlorophyceae	733
<i>Actinastrum hantzschii</i>	113
<i>Dictyosphaerium pulchellum</i>	169
<i>Micractinium pusillum</i>	113
<i>Monoraphidium irregulare</i>	56
<i>Mougeotia</i> sp	282
Euglenophyceae	226
<i>Phacus longicauda</i>	56
<i>Trachelomonas hispida</i>	56
<i>Trachelomonas volvocina</i>	113
Dinophyceae	56
<i>Peridinium</i> sp	56
Cryptophyceae	846
<i>Cryptomonas</i> sp	846

Sampling Point # 10

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	1289
<i>Geitlerinema unigranulatum</i>	129
<i>Merismopedia glauca</i>	374
<i>Microcystis aeruginosa</i>	142
<i>Planktothrix</i> sp	644
Bacillariophyceae	180
<i>Cyclotella</i> sp	13
<i>Fragilaria</i> spp	168
Chlorophyceae	400
<i>Actinastrum hantzschii</i>	64
<i>Crucigenia tetrapedia</i>	26
<i>Crucigeniella rectangularis</i>	26
<i>Dictyosphaerium pulchellum</i>	77
<i>Monoraphidium irregularē</i>	103
<i>Mougeotia</i> sp	64
<i>Pediastrum tetras</i>	13
<i>Scenedesmus acuminatus</i>	26
Euglenophyceae	425
<i>Phacus longicauda</i>	39
<i>Phacus</i> sp	13
<i>Trachelomonas armata</i>	116
<i>Trachelomonas hispida</i>	77
<i>Trachelomonas volvocina</i>	180
Cryptophyceae	129
<i>Cryptomonas</i> sp	129
Conjugatophyceae	13
<i>Staurastrum</i> sp.1	13

Sampling Point # 11

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	2656
<i>Coelomorion</i> sp	150
<i>Geitlerinema unigranulatum</i>	200
<i>Merismopedia glauca</i>	702
<i>Microcystis aeruginosa</i>	150
<i>Planktothrix</i> sp	1453
Bacillariophyceae	652
<i>Aulacoseira granulata</i>	150
<i>Fragillaria</i> spp	301
<i>Navicula</i> spp	200
Chlorophyceae	752
<i>Actinastrum hantzschii</i>	50
<i>Botriococcus</i> sp	50
<i>Cruckigenia tetrapedia</i>	50
<i>Micractinium pusillum</i>	50
<i>Monoraphidium</i> sp	50
<i>Mougeotia</i> sp	401
<i>Pediastrum tetras</i>	50
<i>Scenedesmus opollensis</i>	50
Euglenophyceae	401
<i>Trachelomonas armata</i>	50
<i>Trachelomonas hispida</i>	100
<i>Trachelomonas volvocina</i>	251
Cryptophyceae	50
<i>Cryptomonas</i> sp	50

Sampling Point # 13

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	1763
<i>Aphanocapsa</i> sp	14
<i>Coelomoron</i> sp	14
<i>Cylindrospermopsis cf. raciborskii</i>	14
<i>Geitlerinema unigranulatum</i>	305
<i>Merismopedia glauca</i>	403
<i>Merismopedia tenuissima</i>	42
<i>Microcystis aeruginosa</i>	111
<i>Planktothrix</i> sp	861
Bacillariophyceae	250
<i>Aulacoseira granulata</i>	14
<i>Cyclotella</i> sp	14
<i>Fragilaria</i> spp	208
<i>Navicula</i> spp	14
Chlorophyceae	541
<i>Actinastrum hantzschii</i>	97
<i>Ankistrodesmus libralanus</i>	14
<i>Crucigenia tetrapedia</i>	14
<i>Dictyosphaerium pulchellum</i>	42
<i>Monoraphidium irregularis</i>	180
<i>Mougeotia</i> sp	111
<i>Scenedesmus opoliensis</i>	83
Euglenophyceae	361
<i>Euglena</i> sp	28
<i>Phacus longicauda</i>	42
<i>Phacus</i> sp	14
<i>Trachelomonas armata</i>	97
<i>Trachelomonas hispida</i>	28
<i>Trachelomonas volvocina</i>	153
Dinophyceae	69
<i>Peridinium</i> sp	69
Cryptophyceae	83
<i>Cryptomonas</i> sp	83

Sampling Point # 14

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	3534
<i>Células livres de Microcystis</i> sp	127
<i>Coelomoron</i> sp	96
<i>Geitlerinema unigranulatum</i>	478
<i>Merismopedia glauca</i>	1305
<i>Microcystis aeruginosa</i>	223
<i>Planktothrix</i> sp	1305
Bacillariophyceae	318
<i>Fragillaria</i> spp	255
<i>Navicula</i> spp	64
Chlorophyceae	1146
<i>Actinastrum hantzschii</i>	96
<i>Ankistrodesmus bibraianus</i>	64
<i>Chlamydomonas</i> sp	64
<i>Dictyosphaerium pulchellum</i>	223
<i>Monoraphidium irregulare</i>	96
<i>Mougeotia</i> sp	478
<i>Pediastrum simplex</i>	32
<i>Scenedesmus acuminatus</i>	64
<i>Scenedesmus opoliensis</i>	32
Euglenophyceae	796
<i>Phacus curvicauda</i>	64
<i>Phacus longicauda</i>	64
<i>Trachelomonas armata</i>	255
<i>Trachelomonas hispida</i>	64
<i>Trachelomonas volvocina</i>	350
Dinophyceae	32
<i>Peridinium</i> sp	32
Cryptophyceae	223
<i>Cryptomonas</i> sp	223

Sampling Point # 15

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	1480
<i>Anabaena</i> sp	72
<i>Anabaena spiroides</i>	72
<i>Chroococcus</i> sp (colonias)	12
<i>Coelomorion</i> sp	60
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	168
<i>Geitlerinema unigranulatum</i>	132
<i>Merismopedia glauca</i>	132
<i>Merismopedia tenuissima</i>	132
<i>Microcystis aeruginosa</i>	192
<i>Microcystis panniformis</i>	12
<i>Planktothrix</i> sp	481
<i>Pseudanabaena</i> sp.1	12
Bacillariophyceae	217
<i>Aulacoseira granulata</i>	12
<i>Fragilaria</i> spp	192
<i>Navicula</i> spp	12
Chlorophyceae	505
<i>Actinastrum hantzschii</i>	144
<i>Dictyosphaerium pulchellum</i>	72
<i>Micractinium bornhemiense</i>	36
<i>Monoraphidium irregularare</i>	60
<i>Mougeotia</i> sp	180
<i>Pediastrum duplex</i>	12
Euglenophyceae	144
<i>Phacus longicauda</i>	24
<i>Trachelomonas armata</i>	48
<i>Trachelomonas volvocina</i>	72
Chrysophyceae	12
<i>Mallomonas</i> sp	12
Dinophyceae	120
<i>Peridinium</i> sp	120
Cryptophyceae	469
<i>Cryptomonas</i> sp	469
Conjugatophyceae	60
<i>Staurastrum</i> sp.3	60

Sampling point # 16

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	2682
<i>Anabaena</i> sp	98
<i>Anabaena circinalis</i>	37
<i>Coelomorion</i> sp	74
<i>Cylindrospermopsis cf. raciborskii</i>	566
<i>Geitlerinema unigranulatum</i>	172
<i>Merismopedia glauca</i>	62
<i>Merismopedia tenuissima</i>	332
<i>Microcystis aeruginosa</i>	111
<i>Planktothrix</i> sp	1193
<i>Pseudanabaena</i> sp.1	37
Bacillariophyceae	652
<i>Aulacoseira granulata</i>	49
<i>Cyclofella</i> sp	37
<i>Fragilaria</i> spp	541
<i>Navicula</i> spp	25
Chlorophyceae	467
<i>Actinastrum hantzschii</i>	62
<i>Chlamydomonas</i> sp	49
<i>Coelastrum microporum</i>	25
<i>Dictyosphaerium pulchellum</i>	37
<i>Mougeotia</i> sp	234
<i>Pediastrum tetras</i>	25
<i>Scenedesmus denticulatus</i>	37
Euglenophyceae	234
<i>Phacus curvicauda</i>	12
<i>Trachelomonas armata</i>	62
<i>Trachelomonas volvocina</i>	160
Chrysophyceae	12
<i>Mallomonas</i> sp	12
Dinophyceae	49
<i>Peridinium</i> sp	49
Cryptophyceae	554
<i>Cryptomonas</i> sp	554

Sampling point # 17

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	4683
<i>Anabaena</i> sp	258
<i>Anabaena circinalis</i>	43
<i>Anabaena spiroides</i>	215
<i>Aphanocapsa</i> sp	43
<i>Aphanothecace</i> sp	43
Células livres de <i>Microcystis</i> sp	430
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	773
<i>Geitlerinema unilgranulatum</i>	172
<i>Microcystis aeruginosa</i>	430
<i>Microcystis panniformis</i>	43
<i>Microcystis wesenbergii</i>	86
<i>Planktothrix</i> sp	2148
Bacillariophyceae	430
<i>Aulacoseira granulata</i>	86
<i>Fragillaria</i> spp	344
Chlorophyceae	773
<i>Micractinium bomhemiense</i>	43
<i>Monoraphidium irregularis</i>	86
<i>Mougeotia</i> sp	601
<i>Scenedesmus opollensis</i>	43
Euglenophyceae	129
<i>Trachelomonas volvocina</i>	129
Dinophyceae	86
<i>Peridinium</i> sp	86
Cryptophyceae	2320
<i>Cryptomonas</i> sp	2320

Sampling point # 18

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	4843
<i>Anabaena</i> sp	427
<i>Anabaena circinalis</i>	47
<i>Anabaena spiroides</i>	427
<i>Aphanocapsa</i> sp	142
<i>Coelomorion</i> sp	95
<i>Cylindrospermopsis cf. raciborskii</i>	902
<i>Geitlerinema unigranulatum</i>	475
<i>Merismopedia tenuissima</i>	47
<i>Microcystis aeruginosa</i>	475
<i>Planktothrix</i> sp	1757
<i>Sphaerocavum brasiliense</i>	47
Bacillariophyceae	712
<i>Aulacoseira granulata</i>	47
<i>Cyclotella</i> sp	95
<i>Fragilaria</i> spp	570
Chlorophyceae	1519
<i>Actinastrum hantzschii</i>	95
<i>Dictyosphaerium pulchellum</i>	47
<i>Monoraphidium irregularare</i>	237
<i>Mougeotia</i> sp	950
<i>Pediastrum simplex</i>	47
<i>Pediastrum tetras</i>	47
<i>Scenedesmus opoliensis</i>	95
Euglenophyceae	332
<i>Trachelomonas armata</i>	47
<i>Trachelomonas volvocina</i>	285
Dinophyceae	47
<i>Peridinium</i> sp	47
Cryptophyceae	2279
<i>Cryptomonas</i> sp	2279
Conjugatophyceae	47
<i>Staurodesmus</i> sp	47

Sampling point # 19

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	8627
<i>Anabaena</i> sp	113
<i>Anabaena spiroides</i>	395
Células livres de <i>Microcystis</i> sp	451
<i>Coelomorion</i> sp	169
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	5582
<i>Geitlerinema unigranulatum</i>	226
<i>Merismopedia glauca</i>	56
<i>Microcystis aeruginosa</i>	113
<i>Phormidium</i> sp	56
<i>Planktothrix</i> sp	1410
<i>Pseudanabaena</i> sp.1	56
Bacillariophyceae	1071
<i>Aulacoseira granulata</i>	113
<i>Cyclotella</i> sp	169
<i>Fragilaria</i> spp	733
<i>Rizosolenia</i> sp	56
Chlorophyceae	1466
<i>Botriococcus</i> sp	56
<i>Chlamydomonas</i> sp	169
<i>Dictyosphaerium pulchellum</i>	282
<i>Monoraphidium Irregularē</i>	113
<i>Mougeotia</i> sp	564
<i>Pediastrum tetras</i>	56
<i>Scenedesmus acuminatus</i>	56
<i>Scenedesmus opollensis</i>	113
<i>Treubaria</i> sp	56
Euglenophyceae	395
<i>Phacus</i> sp	56
<i>Trachelomonas amata</i>	56
<i>Trachelomonas volvocina</i>	282
Dinophyceae	56
<i>Peridinium</i> sp	56
Cryptophyceae	564
<i>Cryptomonas</i> sp	564
Conjugatophyceae	113
<i>Euastrum</i> cf. <i>vermicosum</i>	113

Sampling point # 20

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	5413
<i>Anabaena</i> sp	237
Células livres de <i>Microcystis</i> sp	807
<i>Coelomorion</i> sp	190
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	1377
<i>Geitlerinema unigranulatum</i>	237
<i>Merismopedia tenuissima</i>	47
<i>Microcystis aeruginosa</i>	475
<i>Planktothrix</i> sp	1947
<i>Pseudanabaena</i> sp.1	95
Bacillariophyceae	712
<i>Aulacoseira granulata</i>	95
<i>Cyclotella</i> sp	47
<i>Fragilaria</i> spp	522
<i>Navicula</i> spp	47
Chlorophyceae	1424
<i>Coelastrum microporum</i>	190
<i>Coelastrum reticulatum</i>	47
<i>Dictyosphaerium pulchellum</i>	332
<i>Monoraphidium irregularē</i>	95
<i>Mougeotia</i> sp	712
<i>Pediastrum duplex</i>	47
Euglenophyceae	332
<i>Trachelomonas volvocina</i>	332
Chrysophyceae	47
<i>Mallomonas</i> sp	47
Dinophyceae	47
<i>Peridinium</i> sp	47
Cryptophyceae	1804
<i>Cryptomonas</i> sp	1804
Conjugatophyceae	95
<i>Euastrum</i> cf. <i>verrucosum</i>	47
<i>Staurastrum</i> sp.1	47

Sampling point # 21

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	9642
<i>Anabaena spiroides</i>	56
<i>Chroococcus</i> sp	56
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	9022
<i>Microcystis aeruginosa</i>	113
<i>Microcystis panniformis</i>	56
<i>Planktothrix</i> sp	282
<i>Pseudanabaena</i> sp.2	56
Bacillariophyceae	733
<i>Aulacoseira granulata</i>	226
<i>Fragilaria</i> spp	451
<i>Rizosolenia</i> sp	56
Chlorophyceae	1692
<i>Monoraphidium irregularare</i>	564
<i>Mougeotia</i> sp	789
<i>Pediastrum duplex</i>	56
<i>Scenedesmus opoliensis</i>	226
<i>Treubaria</i> sp	56
Euglenophyceae	282
<i>Trachelomonas volvocina</i>	282
Chrysophyceae	169
<i>Mallomonas</i> sp	169
Dinophyceae	56
<i>Peridinium</i> sp.	56
Cryptophyceae	1015
<i>Cryptomonas</i> sp	1015
Conjugatophyceae	282
<i>Euastrum</i> cf. <i>verrucosum</i>	56
<i>Staurastrum</i> sp.1	56
<i>Staurastrum</i> sp.2	56
<i>Staurastrum</i> sp.3	113

Sampling point # 22

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	4992
<i>Anabaena</i> sp	241
<i>Anabaena spiroides</i>	541
<i>Aphanocapsa</i> sp	120
<i>Cylindrospermopsis cf. raciborskii</i>	3007
<i>Geitlerinema unigranulatum</i>	541
<i>Microcystis aeruginosa</i>	60
<i>Planktothrix</i> sp	481
Bacillariophyceae	541
<i>Aulacoseira granulata</i>	60
<i>Cyclotella</i> sp	120
<i>Fragilaria</i> spp	361
Chlorophyceae	2285
<i>Dictyosphaerium pulchellum</i>	60
<i>Monoraphidium irregulare</i>	1564
<i>Mougeotia</i> sp	301
<i>Pediastrum tetras</i>	60
<i>Scenedesmus denticulatus</i>	60
<i>Scenedesmus opoliensis</i>	241
Euglenophyceae	60
<i>Trachelomonas volvocina</i>	60
Chrysophyceae	60
<i>Mallomonas</i> sp	60
Cryptophyceae	662
<i>Cryptomonas</i> sp	662

Sampling point # 23

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	8189
<i>Anabaena</i> sp	208
<i>Anabaena circinalis</i>	208
<i>Anabaena spiroides</i>	486
<i>Aphanocapsa</i> sp	139
<i>Chroococcus</i> sp (colônias)	69
<i>Coelomoron</i> sp	208
<i>Cylindrospermopsis cf. raciborskii</i>	5552
<i>Geitlerinema unigranulatum</i>	278
<i>Microcystis aeruginosa</i>	347
<i>Microcystis panniformis</i>	139
<i>Planktothrix</i> sp	555
Bacillariophyceae	347
<i>Aulacoseira granulata</i>	69
<i>Cyclotella</i> sp	69
<i>Fragilaria</i> spp	208
Chlorophyceae	1735
<i>Actinastrum hantzschii</i>	69
<i>Chlamydomonas</i> sp	69
<i>Dctyosphaerium pulchellum</i>	139
<i>Monoraphidium irregularē</i>	763
<i>Mougeotia</i> sp	486
<i>Scenedesmus apollensis</i>	208
Euglenophyceae	416
<i>Trachelomonas volvocina</i>	416
Dinophyceae	139
<i>Peridinium</i> sp	139
Cryptophyceae	1319
<i>Cryptomonas</i> sp	1319

Sampling point # 24

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	885
<i>Anabaena</i> sp	26
<i>Anabaena spiroides</i>	78
Células livres de <i>Microcystis</i> sp	26
<i>Chroococcus</i> sp (colônias)	13
<i>Coelomorion</i> sp	26
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	429
<i>Geitlerinema unigranulatum</i>	52
<i>Microcystis aeruginosa</i>	13
<i>Microcystis panniformis</i>	13
<i>Planktothrix</i> sp	208
Bacillariophyceae	91
<i>Aulacoseira granulata</i>	26
<i>Fragilaria</i> spp	52
<i>Rizosolenia</i> sp	13
Chlorophyceae	468
<i>Actinastrum hantzschii</i>	13
<i>Chlamydomonas</i> sp	39
<i>Dictyosphaerium pulchellum</i>	13
<i>Kirchneriella elongata</i>	13
<i>Monoraphidium circinale</i>	13
<i>Monoraphidium irregularē</i>	13
<i>Mougeotia</i> sp	325
<i>Pediastrum tetras</i>	13
<i>Scenedesmus acuminatus</i>	13
<i>Scenedesmus opoliensis</i>	13
Euglenophyceae	13
<i>Trachelomonas volvocina</i>	13
Chrysophyceae	26
<i>Mallomonas</i> sp	26
Cryptophyceae	143
<i>Cryptomonas</i> sp	143
Conjugatophyceae	13
<i>Staurastrum</i> sp.1	13

Sampling point # 25

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	4736
<i>Anabaena</i> sp	203
<i>Anabaena spiroides</i>	101
<i>Aphanizomenon</i> sp	34
<i>Aphanocapsa</i> sp	34
<i>Coelomorion</i> sp	34
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	2774
<i>Geitlerinema unigranulatum</i>	169
<i>Merismopedia glauca</i>	541
<i>Microcystis aeruginosa</i>	34
<i>Planktothrix</i> sp	778
<i>Sphaerocavum brasiliense</i>	34
Bacillariophyceae	440
<i>Aulacoseira granulata</i>	101
<i>Cyclotella</i> sp	101
<i>Fragilaria</i> spp	237
Chlorophyceae	677
<i>Botriococcus</i> sp	68
<i>Dictyosphaerium pulchellum</i>	135
<i>Monoraphidium irregulare</i>	135
<i>Mougeotia</i> sp	271
<i>Scenedesmus denticulatus</i>	34
<i>Scenedesmus opoliensis</i>	34
Euglenophyceae	135
<i>Trachelomonas hispida</i>	34
<i>Trachelomonas volvocina</i>	101
Chrysophyceae	34
<i>Dinobryon</i> sp	34
Dinophyceae	203
<i>Peridinium</i> sp.	203
Cryptophyceae	440
<i>Cryptomonas</i> sp	440

Sampling point # 26

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	4178
<i>Anabaena spiroides</i>	56
<i>Aphanocapsa</i> sp	28
<i>Cylindrospermopsis</i> cf. <i>raciborskii</i>	3775
<i>Geitlerinema unigranulatum</i>	83
<i>Microcystis aeruginosa</i>	28
<i>Microcystis panniformis</i>	14
<i>Microcystis wesenbergli</i>	14
<i>Planktothrix</i> sp	180
Bacillariophyceae	250
<i>Aulacoseira granulata</i>	97
<i>Cyclotella</i> sp	83
<i>Fragillaria</i> spp	69
Chlorophyceae	583
<i>Micractinium pusillum</i>	14
<i>Monoraphidium circinale</i>	28
<i>Monoraphidium irregularare</i>	153
<i>Mougeotia</i> sp	264
<i>Oocystis</i> sp	14
<i>Pediastrum duplex</i>	14
<i>Scenedesmus acuminatus</i>	56
<i>Scenedesmus opolensis</i>	28
<i>Tetrastrum</i> sp	14
Euglenophyceae	83
<i>Trachelomonas volvocina</i>	83
Chrysophyceae	14
<i>Mallomonas</i> sp	14
Dinophyceae	14
<i>Peridinium</i> sp	14
Cryptophyceae	389
<i>Cryptomonas</i> sp	389
Conjugatophyceae	42
<i>Euastrum</i> cf. <i>verrucosum</i>	14
<i>Staurastrum</i> sp.1	14
<i>Staurastrum</i> sp.2	14

Sampling point # 27

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	12843
<i>Aphanocapsa</i> sp	106
<i>Coelomoron</i> sp	106
<i>Cylindrospermopsis cf. raciborskii</i>	12206
<i>Geitlerinema unigranulatum</i>	265
<i>Planktothrix</i> sp	159
Bacillariophyceae	478
<i>Aulacoseira granulata</i>	106
<i>Cyclotella</i> sp	53
<i>Fragilaria</i> spp	318
Chlorophyceae	849
<i>Botriococcus</i> sp	53
<i>Dictyosphaerium pulchellum</i>	53
<i>Micractinium bomhemiense</i>	53
<i>Monoraphidium irregularis</i>	478
<i>Mougeotia</i> sp	53
<i>Scenedesmus opoliensis</i>	106
<i>Tetrastrum</i> sp	53
Chrysophyceae	53
<i>Mallomonas</i> sp	53
Dinophyceae	53
<i>Peridinium</i> sp	53
Cryptophyceae	371
<i>Cryptomonas</i> sp	371

Sampling point # 28

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	14025
<i>Cylindrospermopsis cf. raciborskii</i>	13861
<i>Geitlerinema unigranulatum</i>	164
Bacillariophyceae	820
<i>Aulacoseira granulata</i>	492
<i>Fragilaria</i> spp	328
Chlorophyceae	1066
<i>Chlamydomonas</i> sp	82
<i>Monoraphidium irregularare</i>	820
<i>Scenedesmus opoliensis</i>	164
Euglenophyceae	328
<i>Trachelomonas hispida</i>	82
<i>Trachelomonas volvocina</i>	246
Cryptophyceae	246
<i>Cryptomonas</i> sp	246

Sampling point # 29

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	9642
<i>Anabaena spiroides</i>	56
<i>Chroococcus</i> sp	56
<i>Cylindrospermopsis cf. raciborskii</i>	9022
<i>Microcystis aeruginosa</i>	113
<i>Microcystis panniformis</i>	56
<i>Planktothrix</i> sp	282
<i>Pseudanabaena</i> sp.2	56
Bacillariophyceae	733
<i>Aulacoseira granulata</i>	226
<i>Fragilaria</i> spp	451
<i>Rizosolenia</i> sp	56
Chlorophyceae	1692
<i>Monoraphidium irregularare</i>	564
<i>Mougeotia</i> sp	789
<i>Pediastrum duplex</i>	56
<i>Scenedesmus opoliensis</i>	226
<i>Treubaria</i> sp	56
Euglenophyceae	282
<i>Trachelomonas volvocina</i>	282
Chrysophyceae	169
<i>Mallomonas</i> sp	169
Dinophyceae	56
<i>Peridinium</i> sp	56
Cryptophyceae	1015
<i>Cryptomonas</i> sp	1015
Conjugatophyceae	282
<i>Euastrum cf. verrucosum</i>	56
<i>Staurastrum</i> sp.1	56
<i>Staurastrum</i> sp.2	56
<i>Staurastrum</i> sp.3	113

Sampling point # 30

Taxons	d (ind.mL ⁻¹)
Cyanophyceae	13499
<i>Anabaena</i> sp	135
<i>Anabaena spiroides</i>	135
<i>Cylindrospermopsis cf. raciborskii</i>	11638
<i>Geitlerinema unigranulatum</i>	372
<i>Merismopedia glauca</i>	304
<i>Microcystis aeruginosa</i>	135
<i>Phormidium</i> sp	34
<i>Planktothrix</i> sp	677
<i>Pseudanabaena</i> sp.1	68
Bacillariophyceae	1353
<i>Aulacoseira granulata</i>	609
<i>Cyclotella</i> sp	169
<i>Fragilaria</i> spp	575
Chlorophyceae	2199
<i>Botriococcus</i> sp	34
<i>Crucigenia tetrapedia</i>	541
<i>Dictyosphaerium pulchellum</i>	271
<i>Golenkinia radiata</i>	34
<i>Monoraphidium irregularare</i>	304
<i>Mougeotia</i> sp	677
<i>Pediastrum tetras</i>	34
<i>Scenedesmus denticulatus</i>	68
<i>Scenedesmus opoliensis</i>	237
Euglenophyceae	237
<i>Trachelomonas volvocina</i>	237
Chrysophyceae	68
<i>Mallomonas</i> sp	68
Dinophyceae	101
<i>Peridinium</i> sp	101
Cryptophyceae	1252
<i>Cryptomonas</i> sp	1252
Conjugatophyceae	68
<i>Euastrum cf. verrucosum</i>	68