11.2 Verification Test of Hydrodynamic Model

11.2.1 Results

The tidal current simulation in Guanabara Bay was carried out using a two-level model mentioned in the previous chapter. For representative distributions of the currents in the bay, current maps for the flood and ebb tides in the upper and lower layers are shown in **Fig. 11.2-1.** A residual current map is also shown in **Fig. 11.2-2.** On the these maps, the thickness of the upper layer is three (3) meters as mentioned before.

Though we did the calculation for the dry and rainy seasons, large differences in current pattern were not found. Therefore, we only showed current maps for the annual mean condition of river discharge.

11.2.2 Verification of Hydrodynamic Model

In order to evaluate the verification of the hydrodynamic model, we compared the observed velocity and the calculated velocity at each point with tidal current ellipses in **Fig. 11.2-3.**

It was found that the calculated velocities satisfactorily agreed with the observed values, though there are some differences, particularly in the upper layer at St. B and St. H.

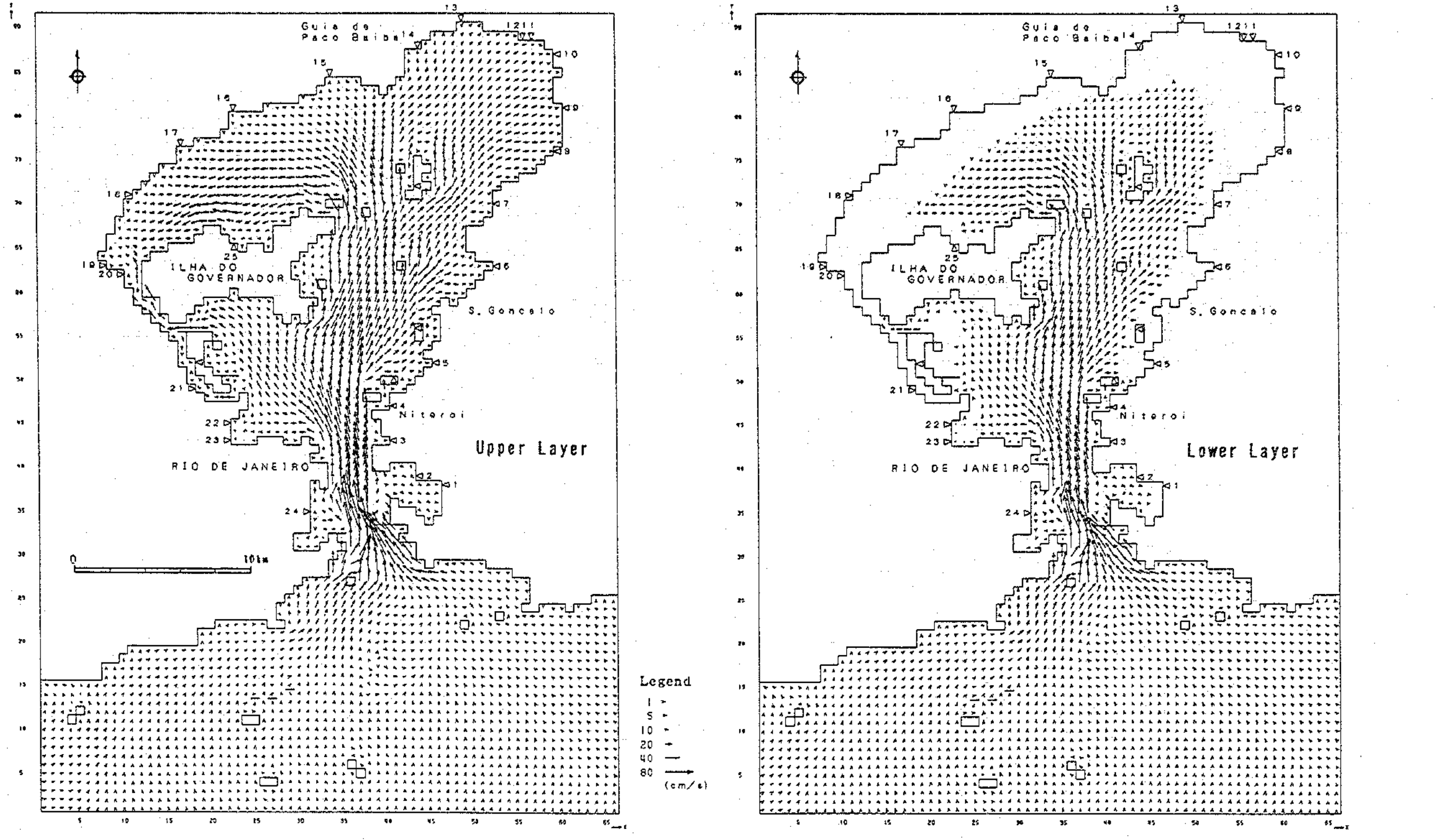


Fig.11.2-1(1) Calculated Tidal Current (Annual Mean:Flood Stream)

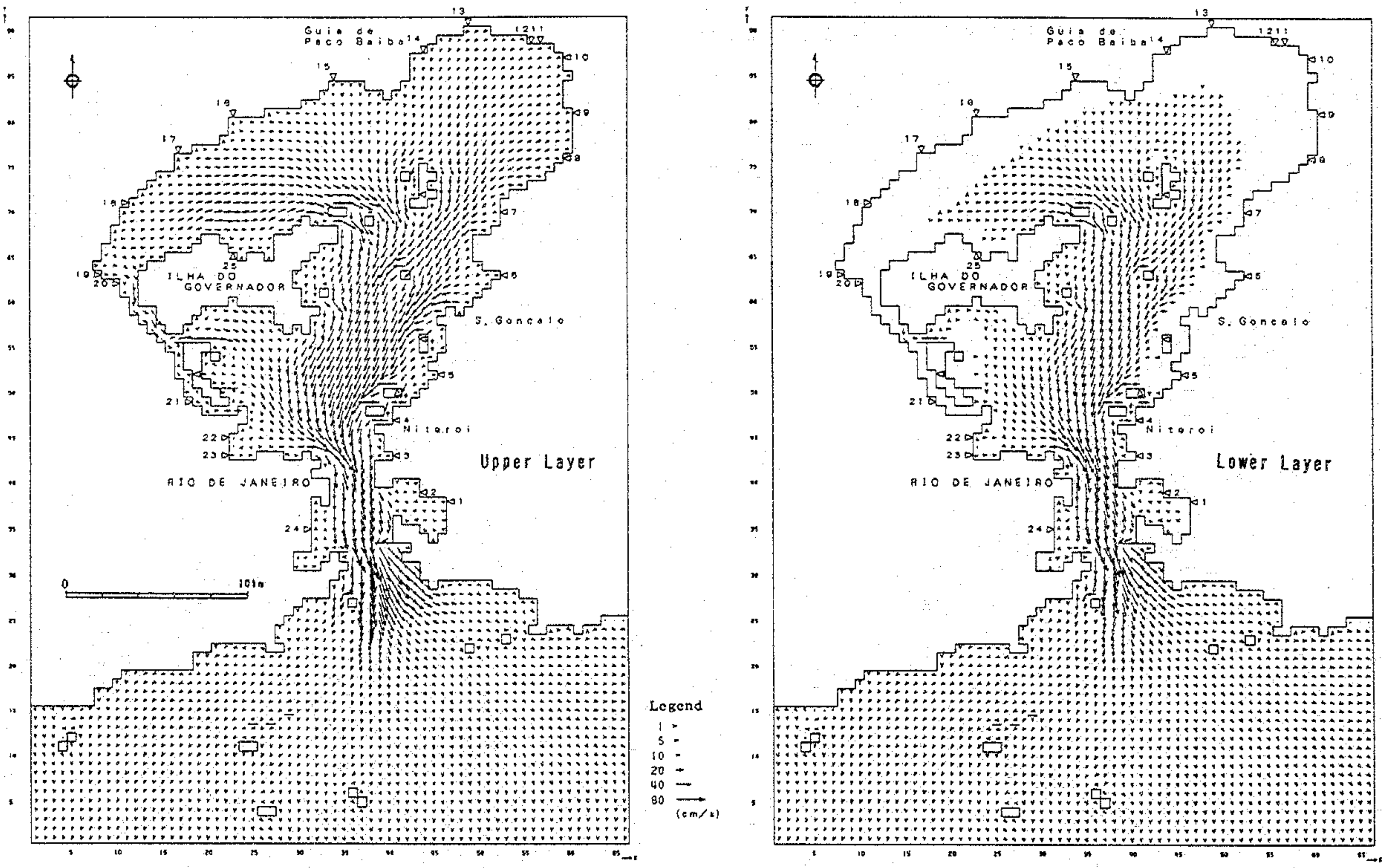


Fig.11.2-1(2) Calculated Tidal Current (Annual Mean:Ebb Stream)

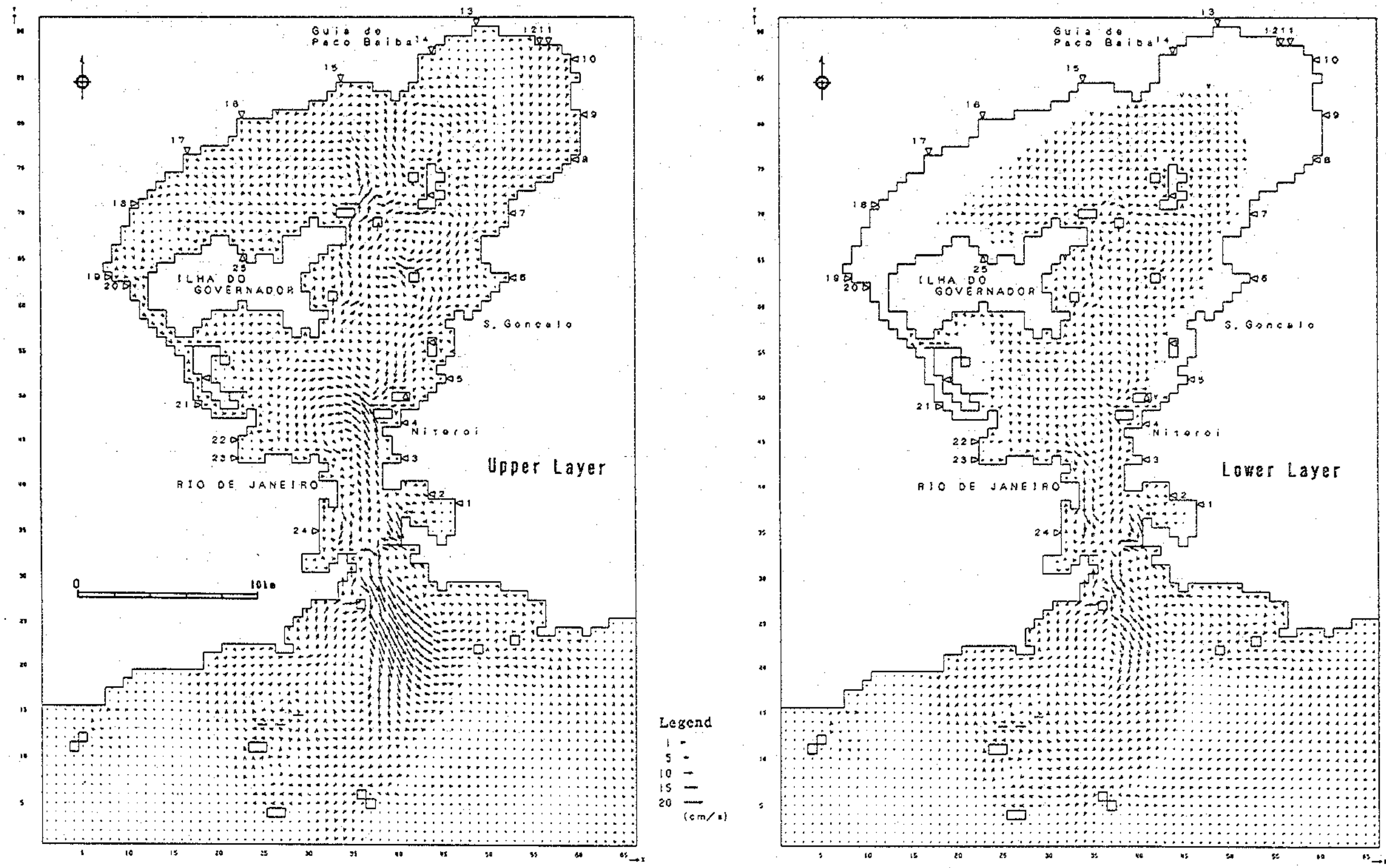


Fig.11.2-2 Calculated Residual Current (Annual Mean)

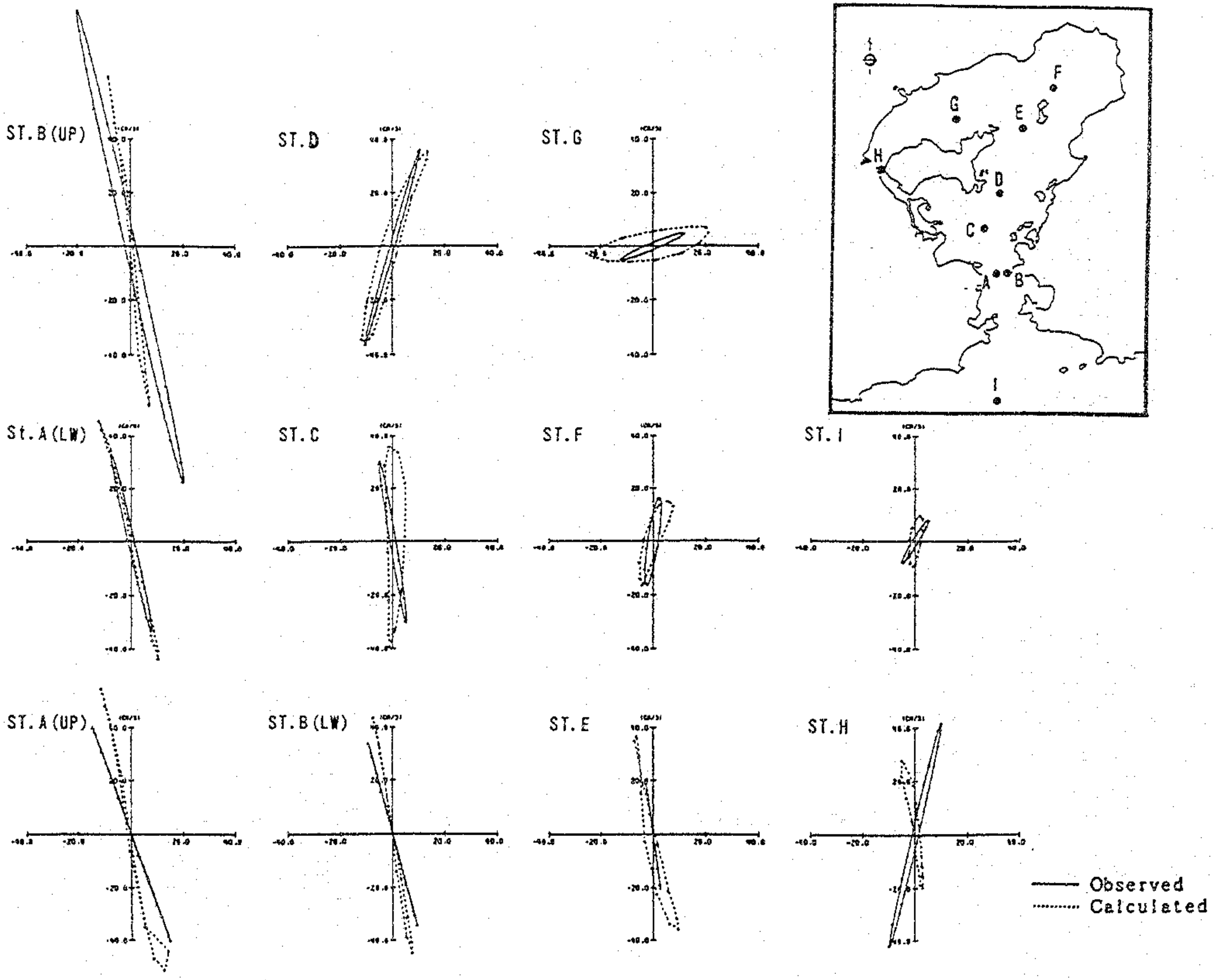


Fig.11.2-3 Comparison of Observed and Calculated Velocity by Tidal Current Ellipses (M_2+S_2)

11.3 Verification Test of Diffusion Model

11.3.1 Results

The simulation for the distribution of salinity in Guanabara Bay was carried out using the Diffusion Model mentioned in the previous chapter. The main purpose of this model was to determine the dispersion coefficient in the area concerned.

We did trial calculations using various dispersion coefficient and finally set the coefficient at 10^6 cm^2/sec for most of the bay area. **Fig. 11.3-1** shows the calculated distribution of salinity in the dry and rainy seasons.

11.3.2 Verification of Diffusion Model

The comparison of calculated salinity and observed salinity is shown in **Fig. 11.3-2**. The calculated concentrations are lower than the observed values in the inner part of the bay, particularly in the dry season. There was, however, a large variation in the salinity values in different weather conditions. Therefore, it is concluded that the distribution pattern is rather important for salinity.

However, it is concluded that the distribution pattern of the calculated values sufficiently agree with that of observed values, particularly in the rainy season.

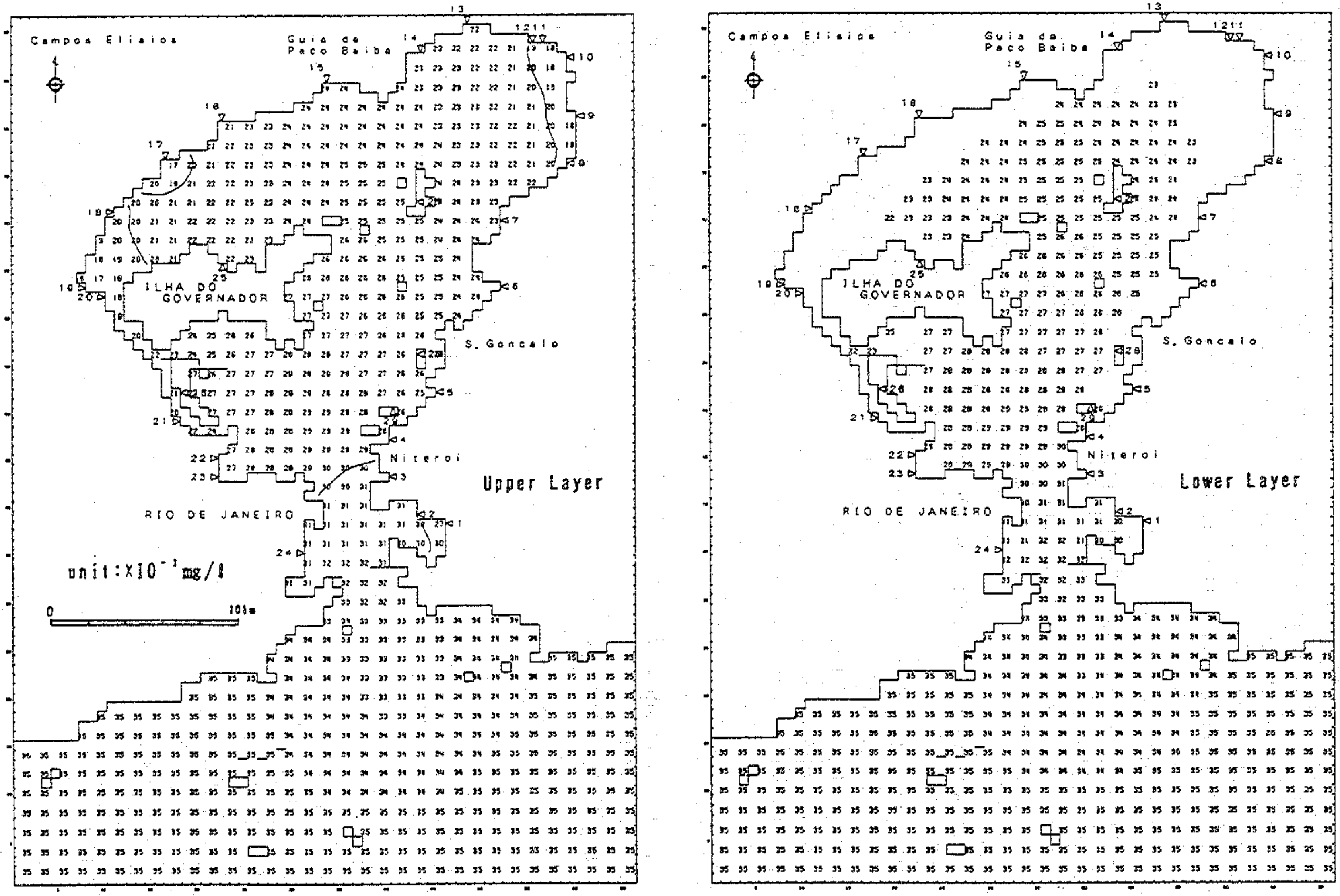


Fig.11.3-1(1) Calculated Water Quality Distribution of Salinity (Dry Season)

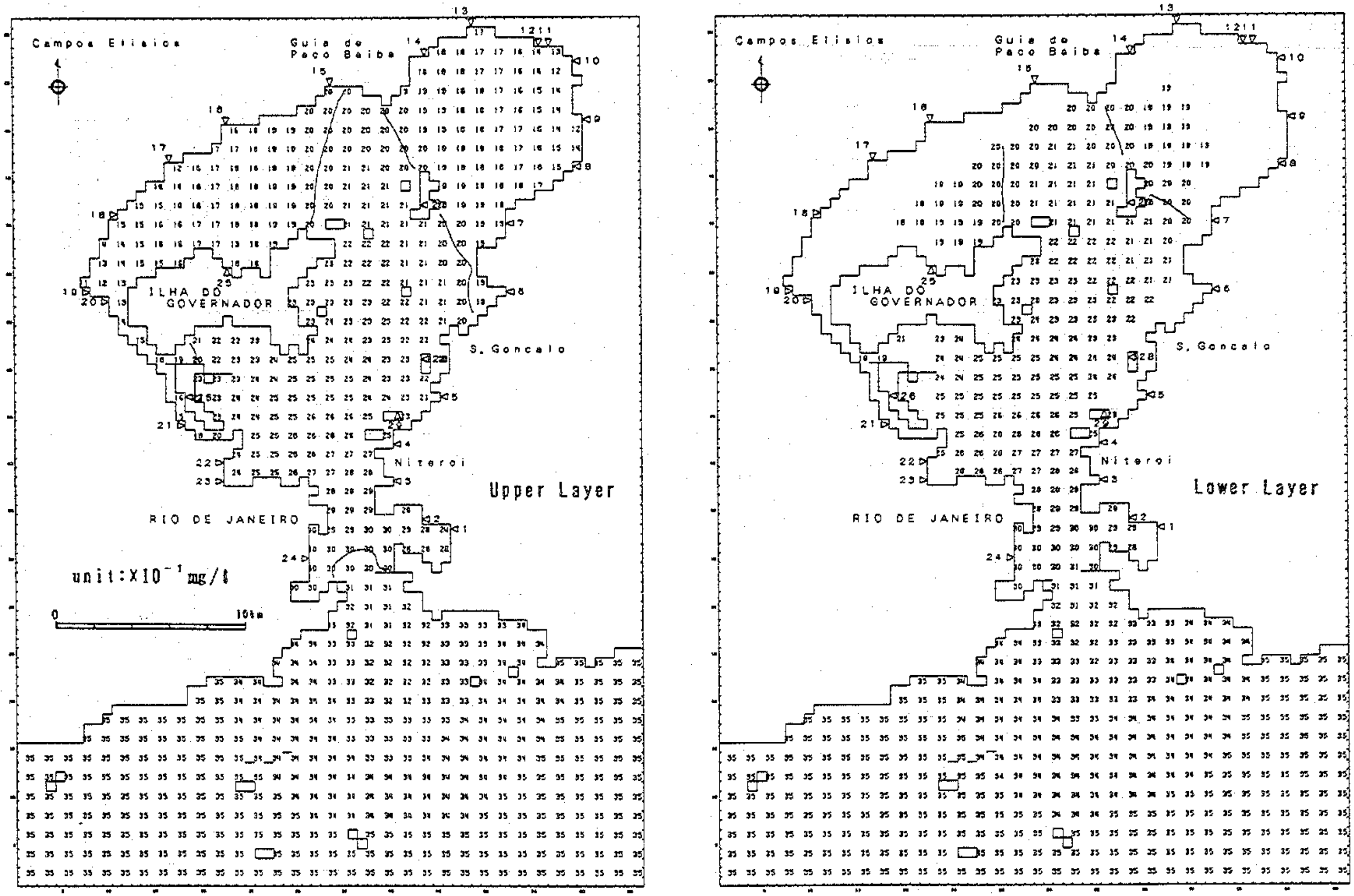
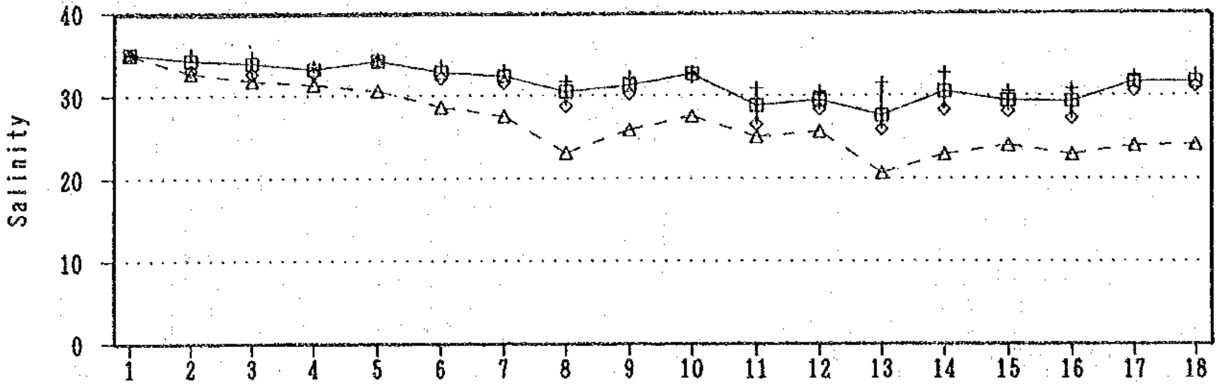
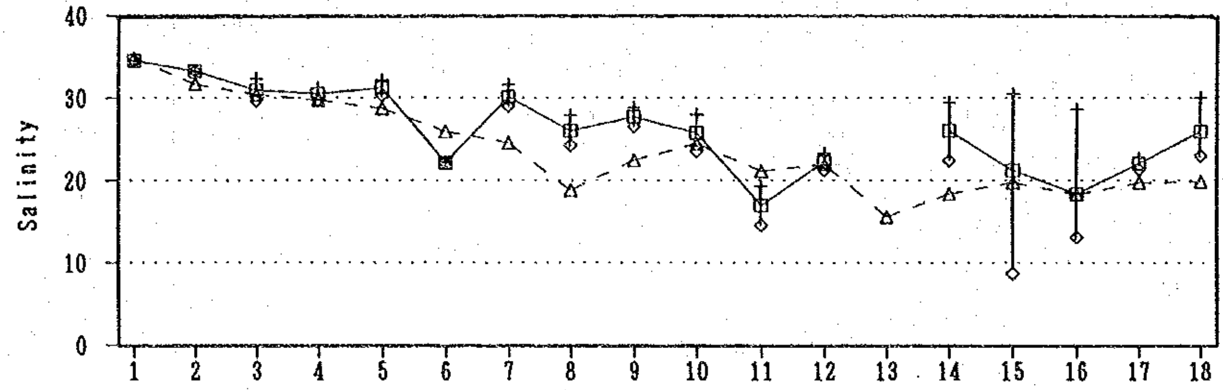


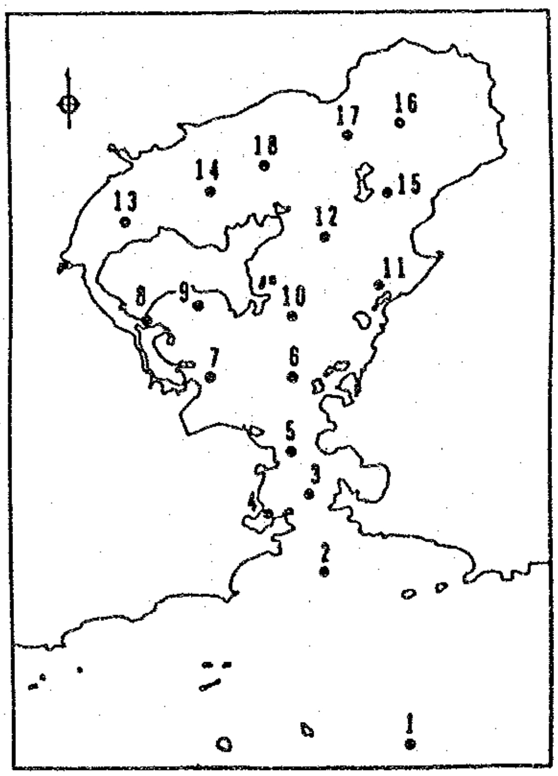
Fig.11.3-1(2) Calculated Water Quality Distribution of Salinity (Rainy Season)

Dry Season(Upper Layer)



Rainy Season(Upper Layer)





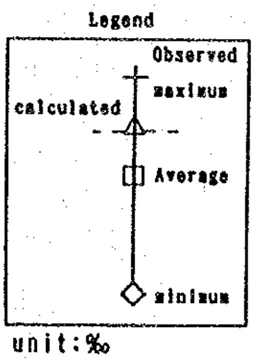


Fig.11.3-2 Comparison of Observed and Calculated Salinity

11.4 Verification Test of Eutrophication Model

11.4.1 Results

The simulation for the distribution of organic matter (COD and BOD), nutrient salts (O-P and PO_4-P) and DO in Guanabara Bay was carried out using the two-level Eutrophication Model mentioned in the previous chapter.

Results are shown in **Fig. 11.4-1** and **Fig. 11.4-2** as the mean concentration of one tidal in the upper and lower layers for BOD, COD, PO_4-P, O-P, T-P and DO in both the dry and rainy seasons.

Here, T-P concentration is equal to the sum of the O-P and PO_4-P concentrations.

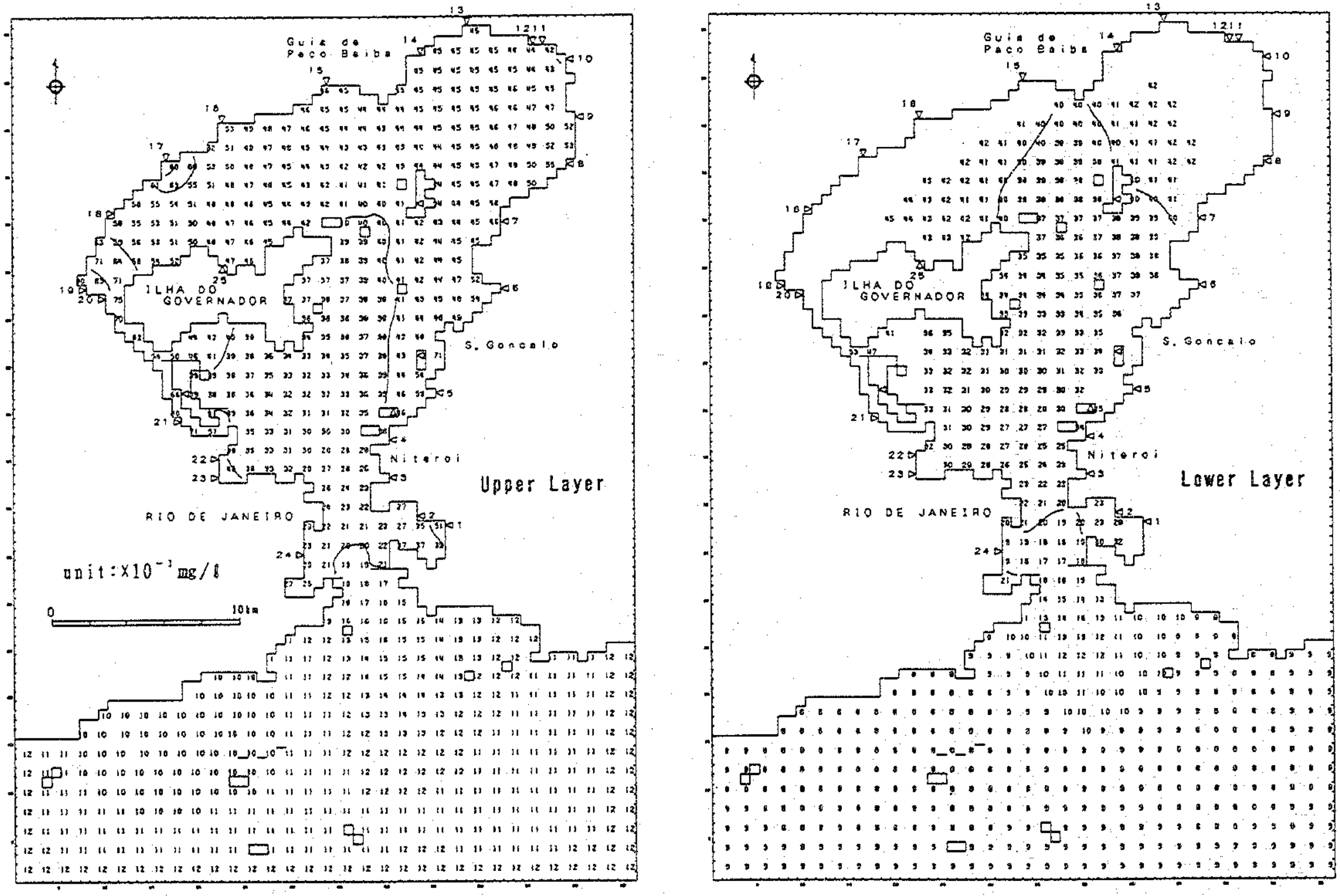


Fig.11.4-1(1) Calculated Water Quality Distribution in Dry Season (BOD)

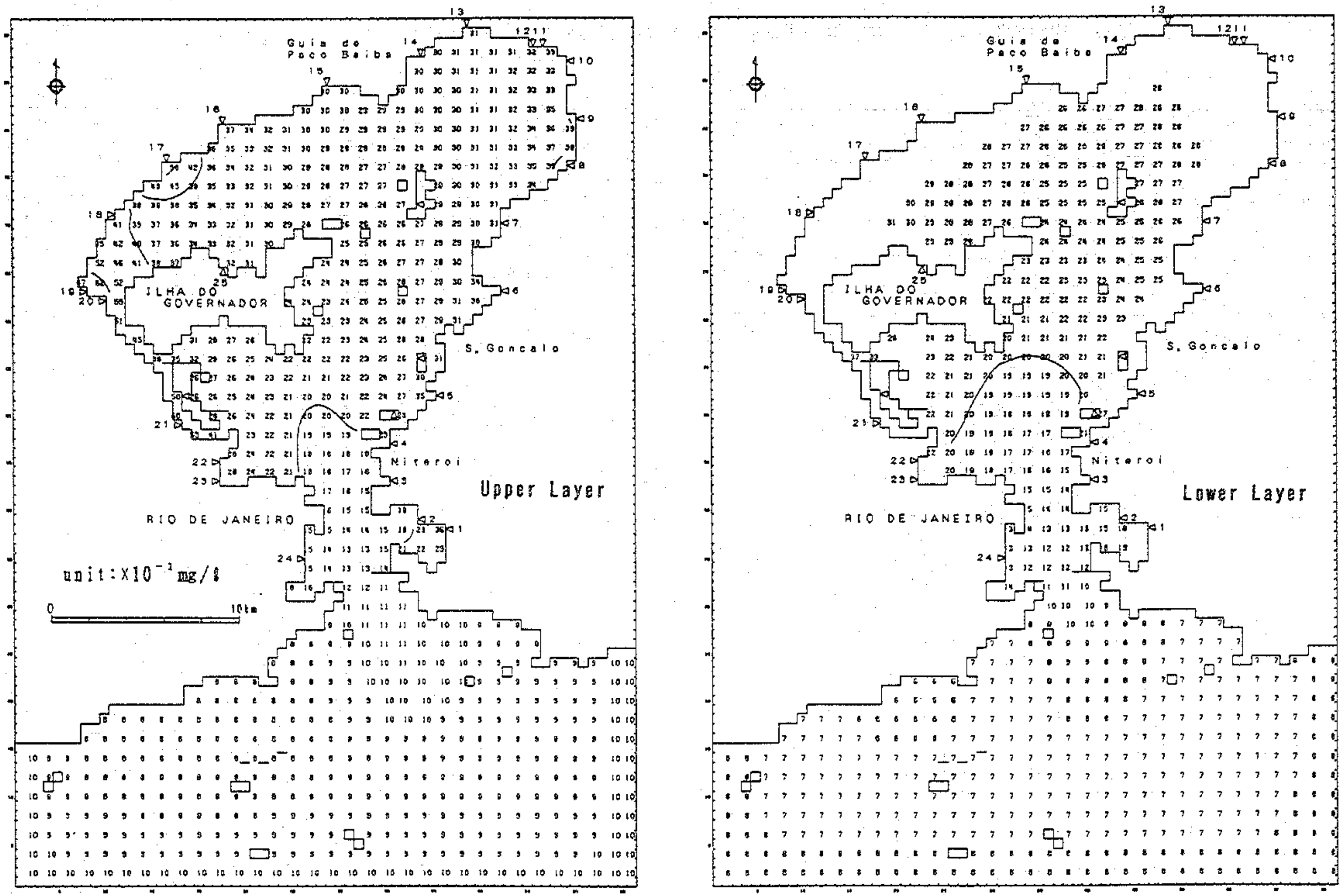
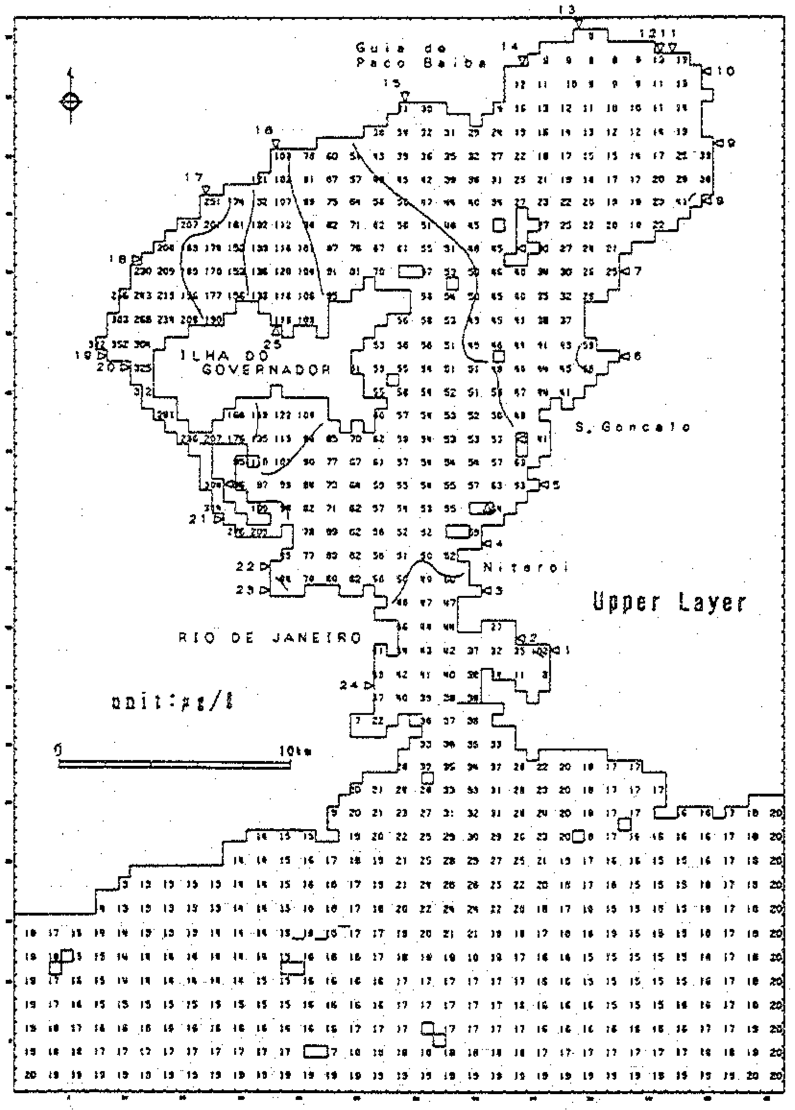


Fig.11.4-1(2) Calculated Water Quality Distribution in Dry Season (COD)



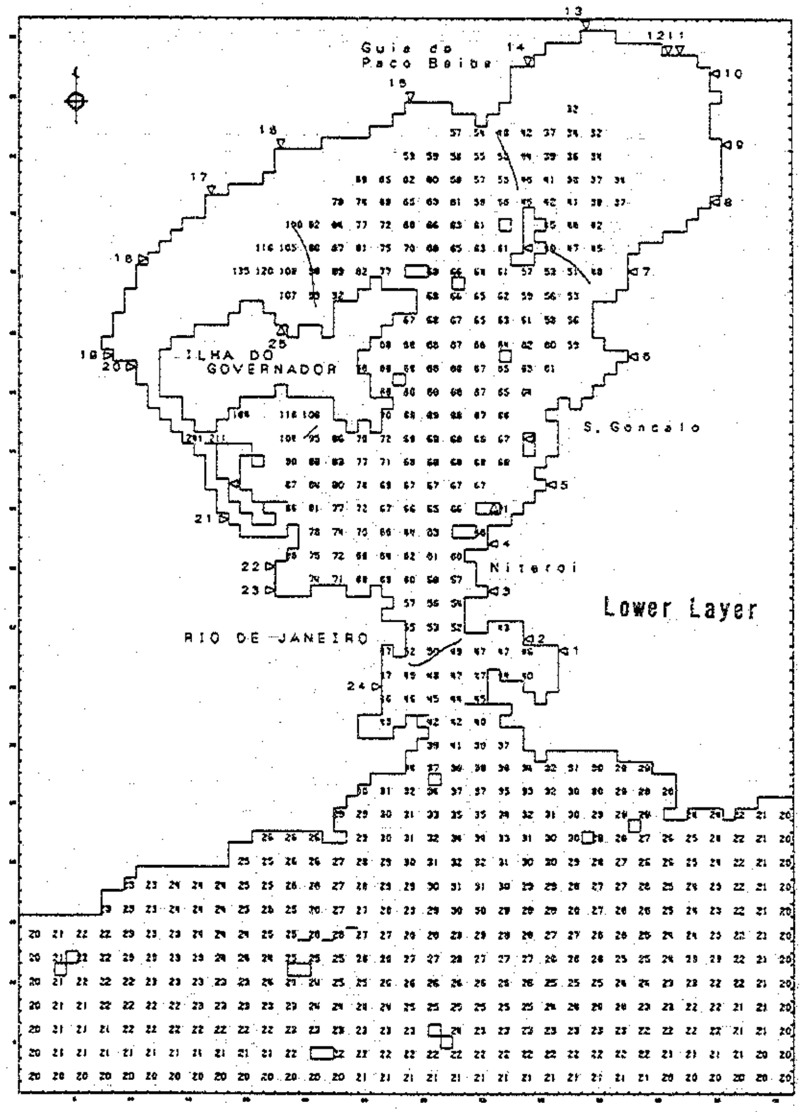
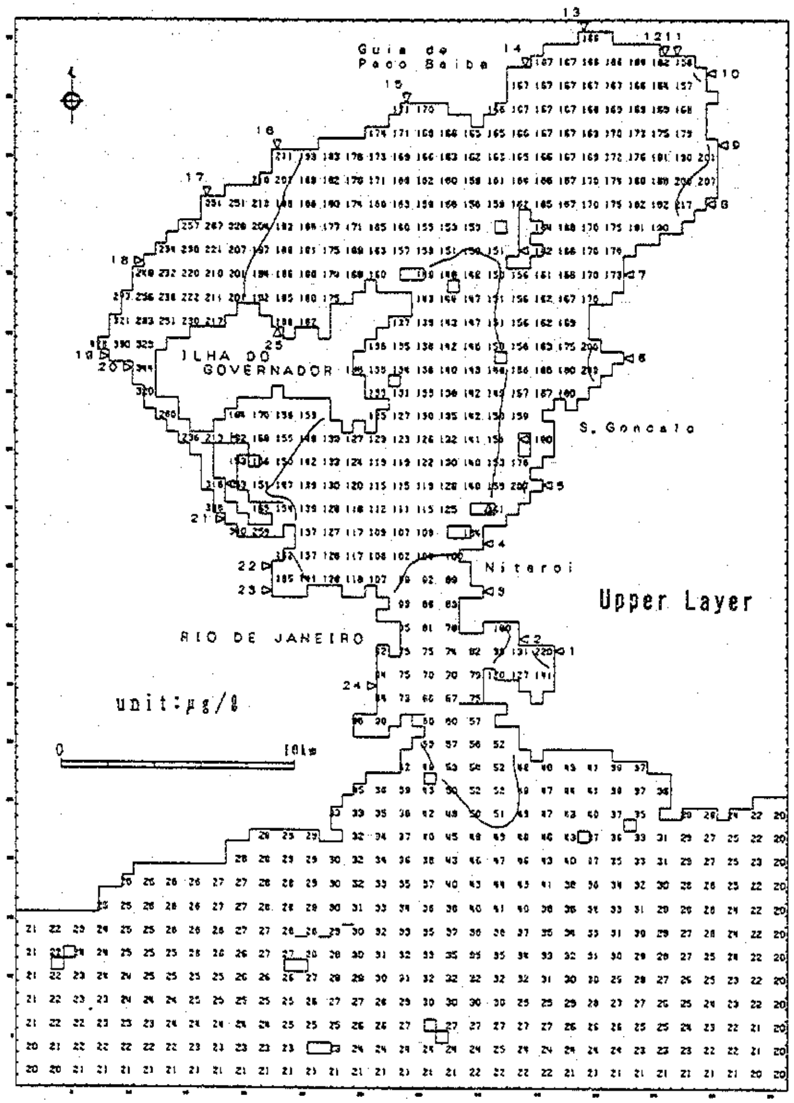


Fig.11.4-1(3) Calculated Water Quality Distribution in Dry Season (PO_4-P)



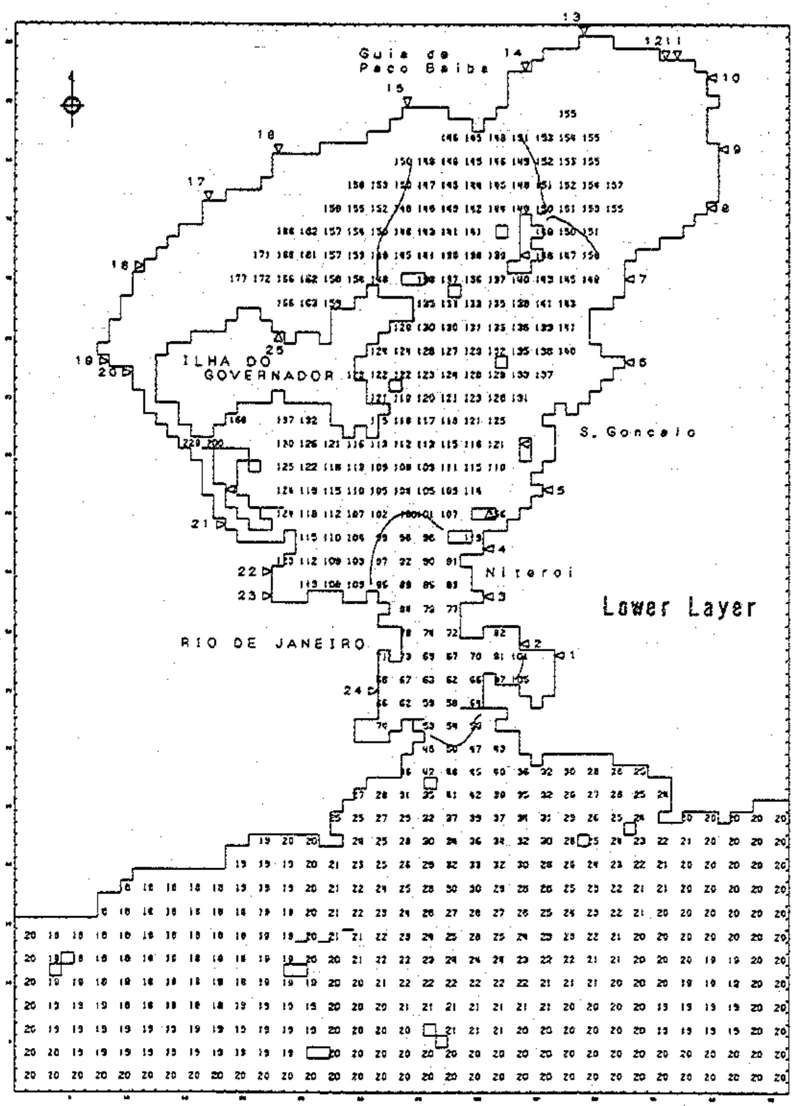


Fig.11.4-1(4) Calculated Water Quality Distribution in Dry Season (O-P)

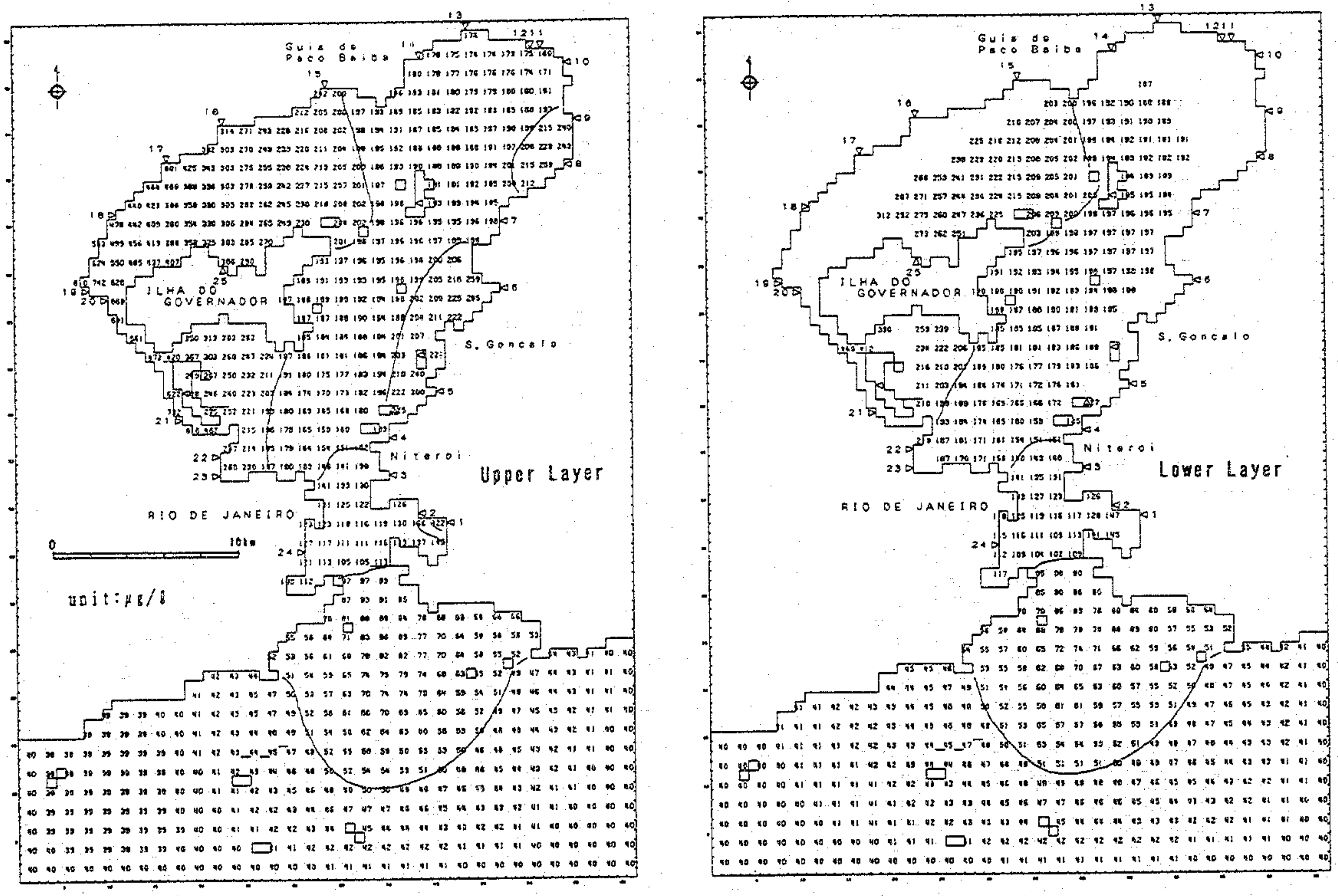
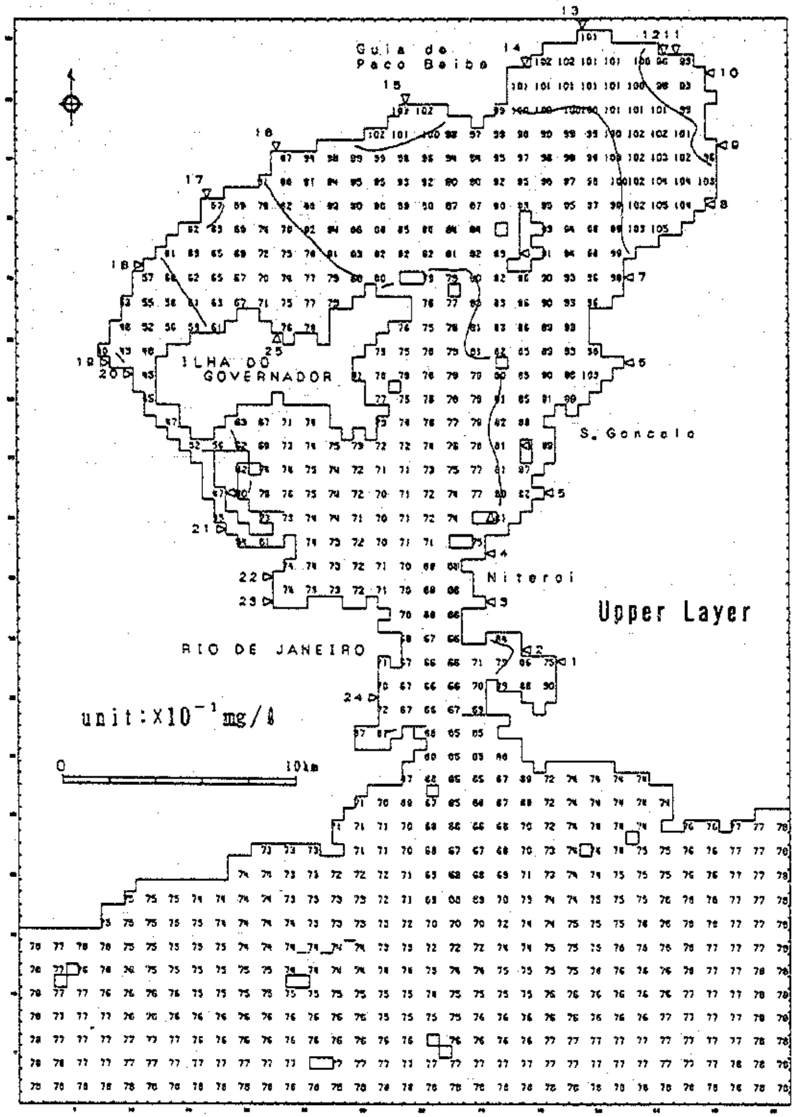


Fig.11.4-1(5) Calculated Water Quality Distribution in Dry Season (T-P)



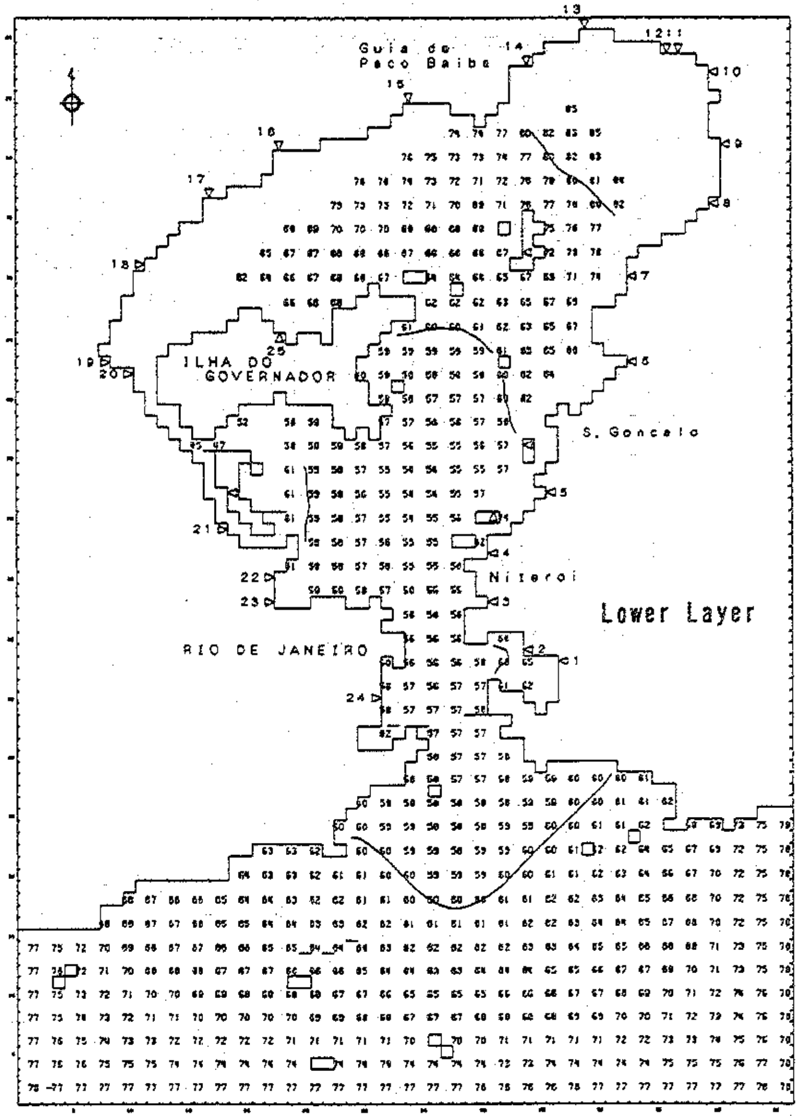
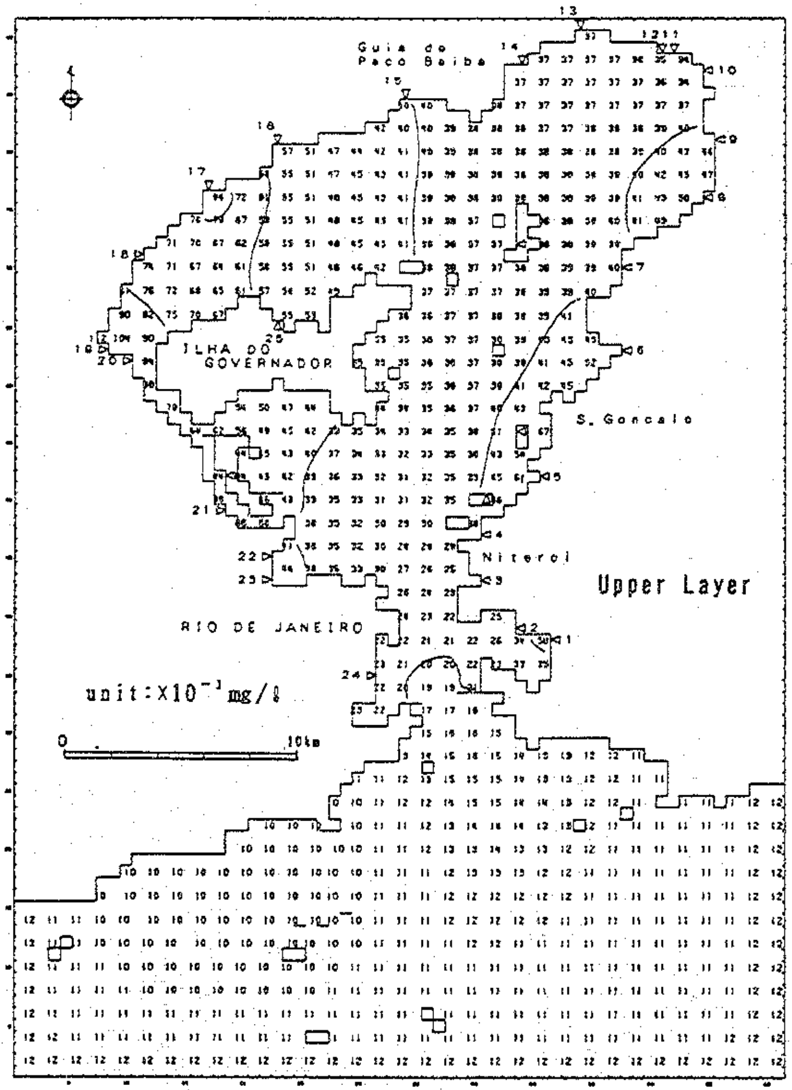


Fig.11.4-1(6) Calculated Water Quality Distribution in Dry Season (DO)



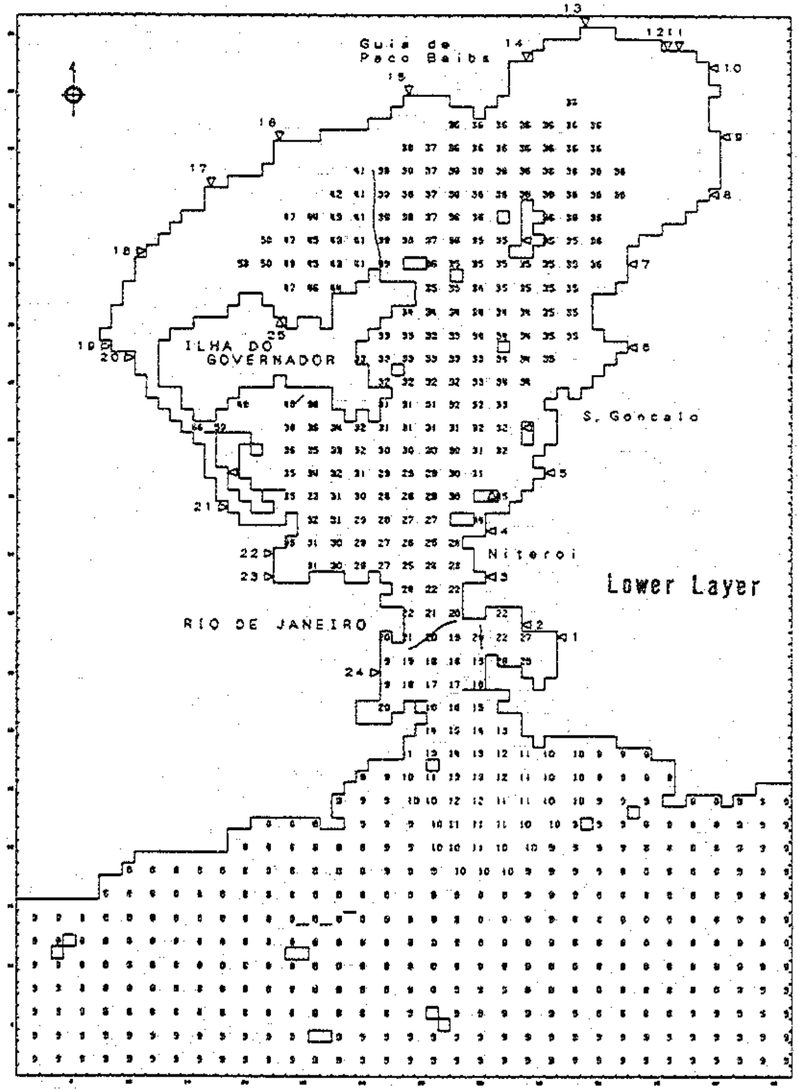
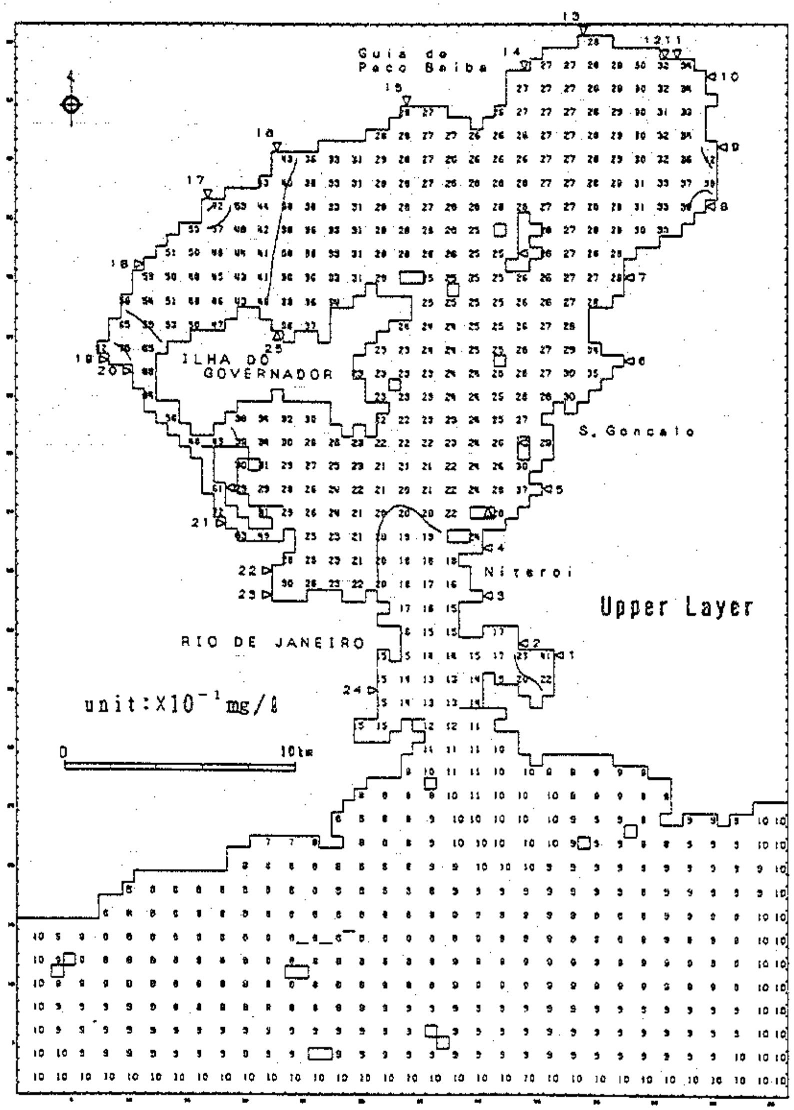


Fig.11.4-2(1) Calculated Water Quality Distribution in Rainy Season (BOD)



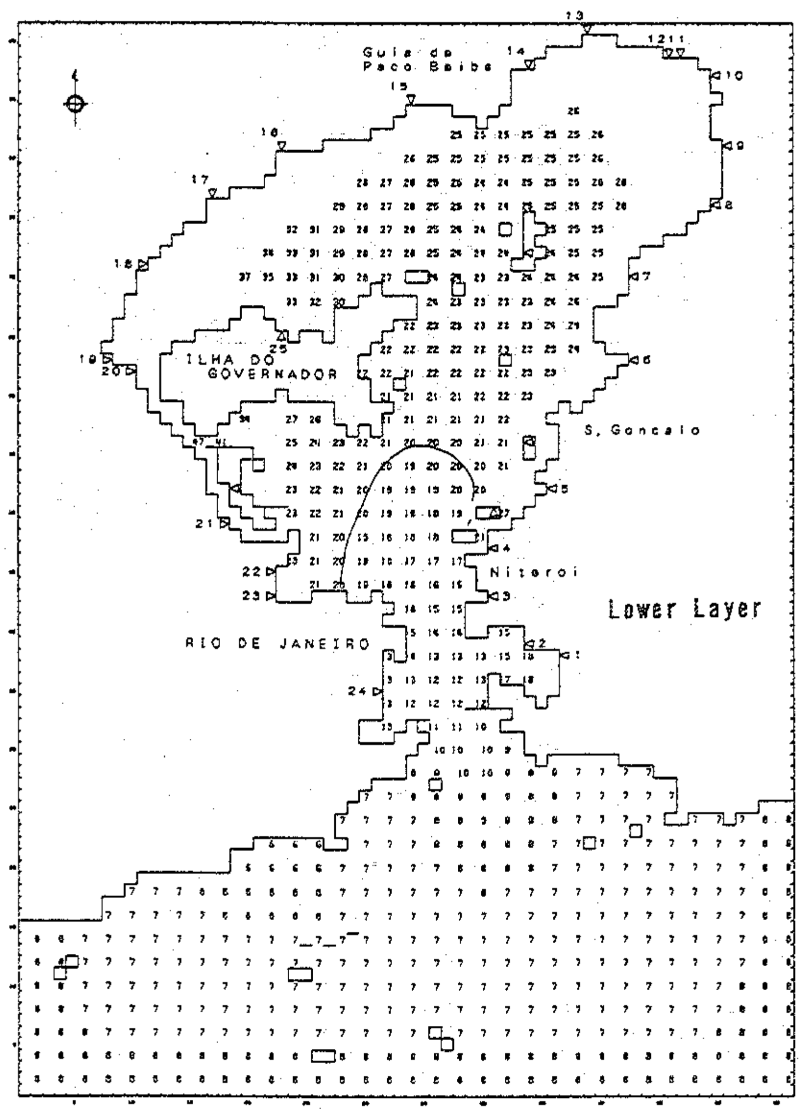
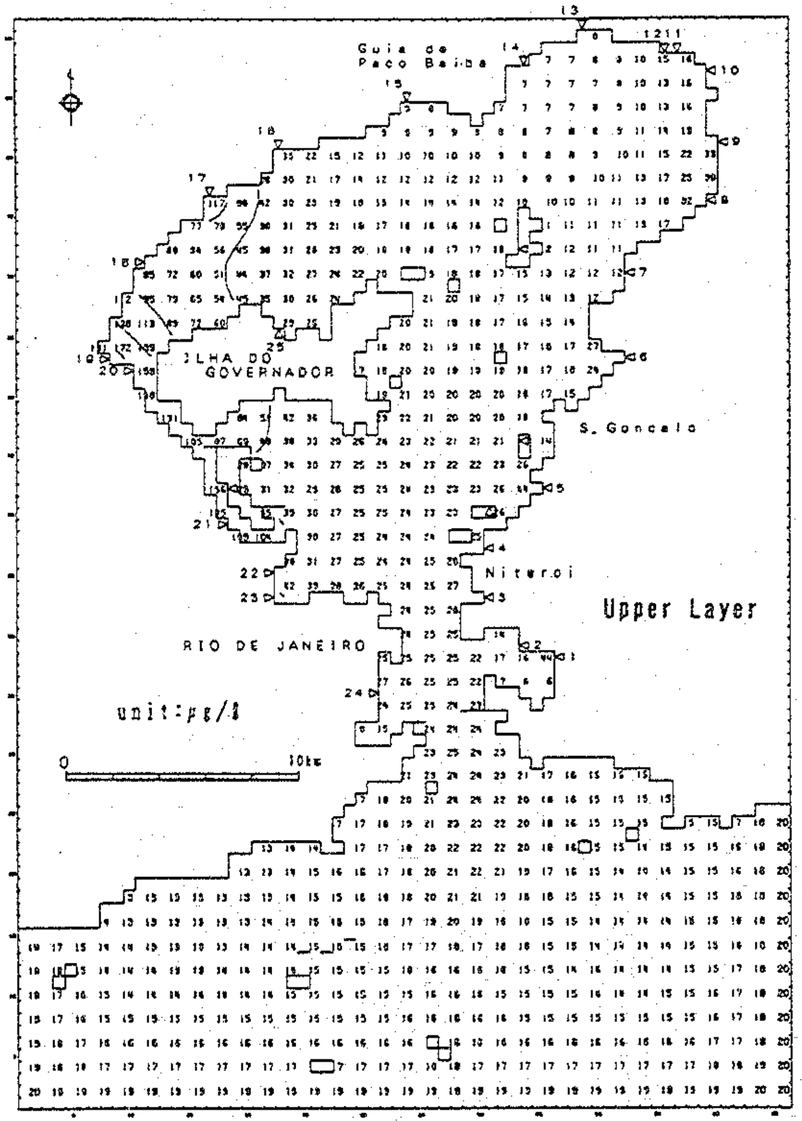


Fig.11.4-2(2) Calculated Water Quality Distribution in Rainy Season (COD)



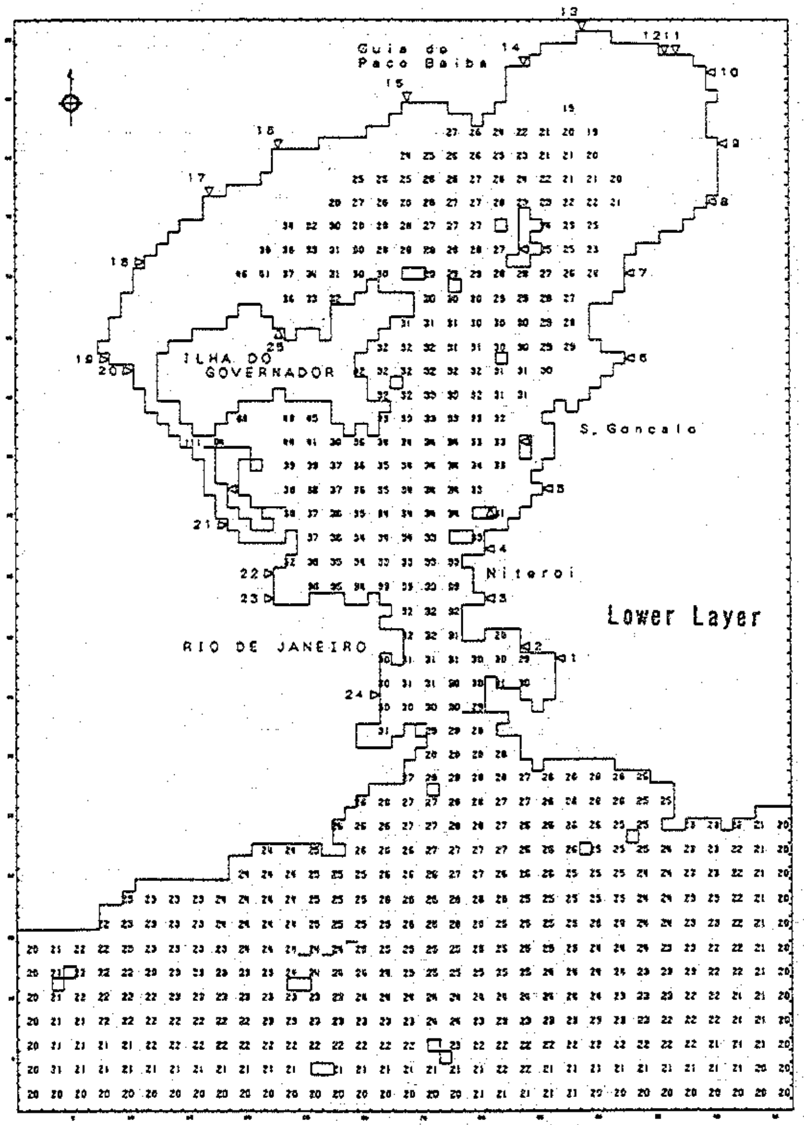


Fig.11.4-2(3) Calculated Water Quality Distribution in Rainy Season (PO_4-P)

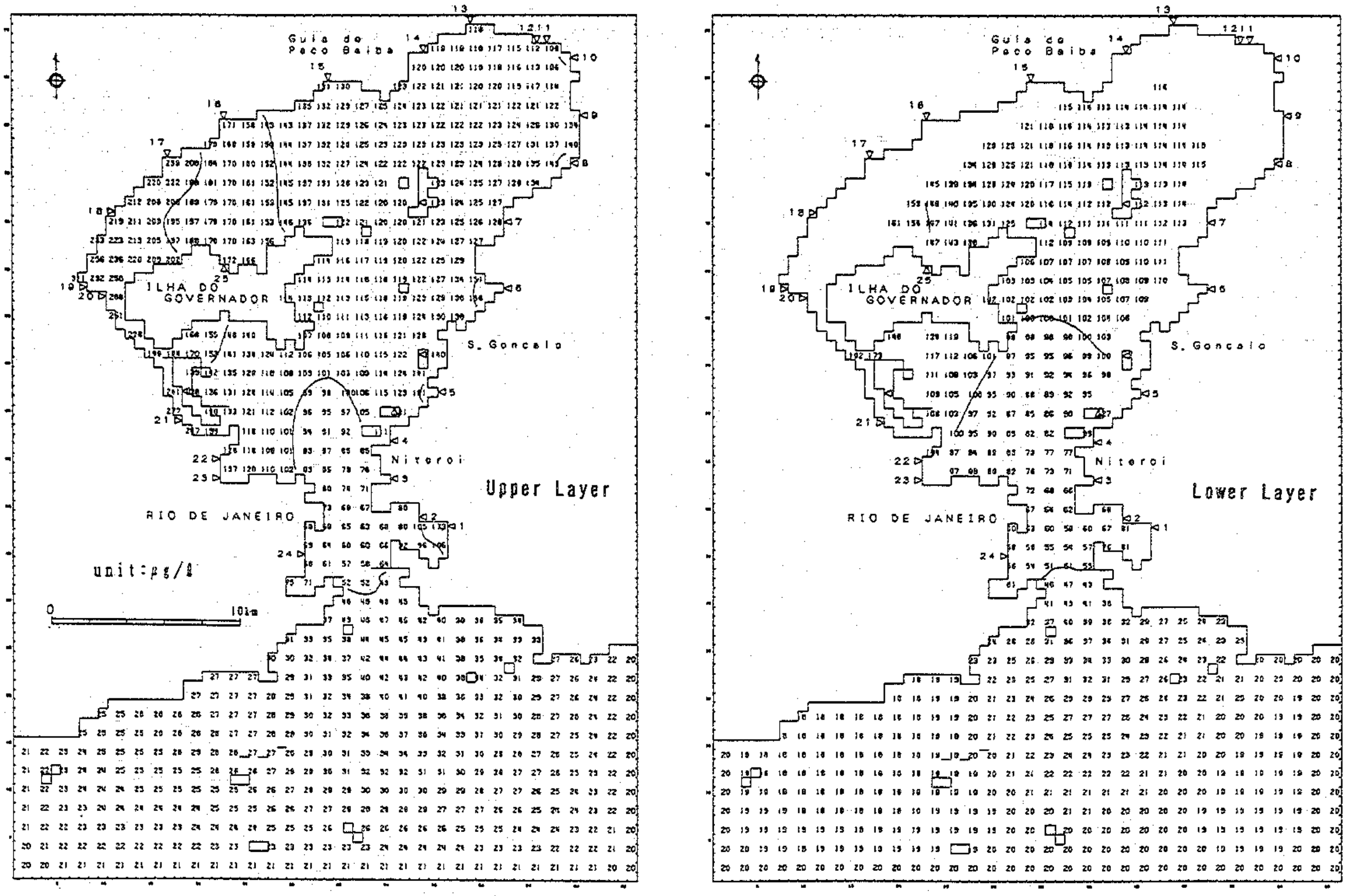


Fig.11.4-2(4) Calculated Water Quality Distribution in Rainy Season (O-P)

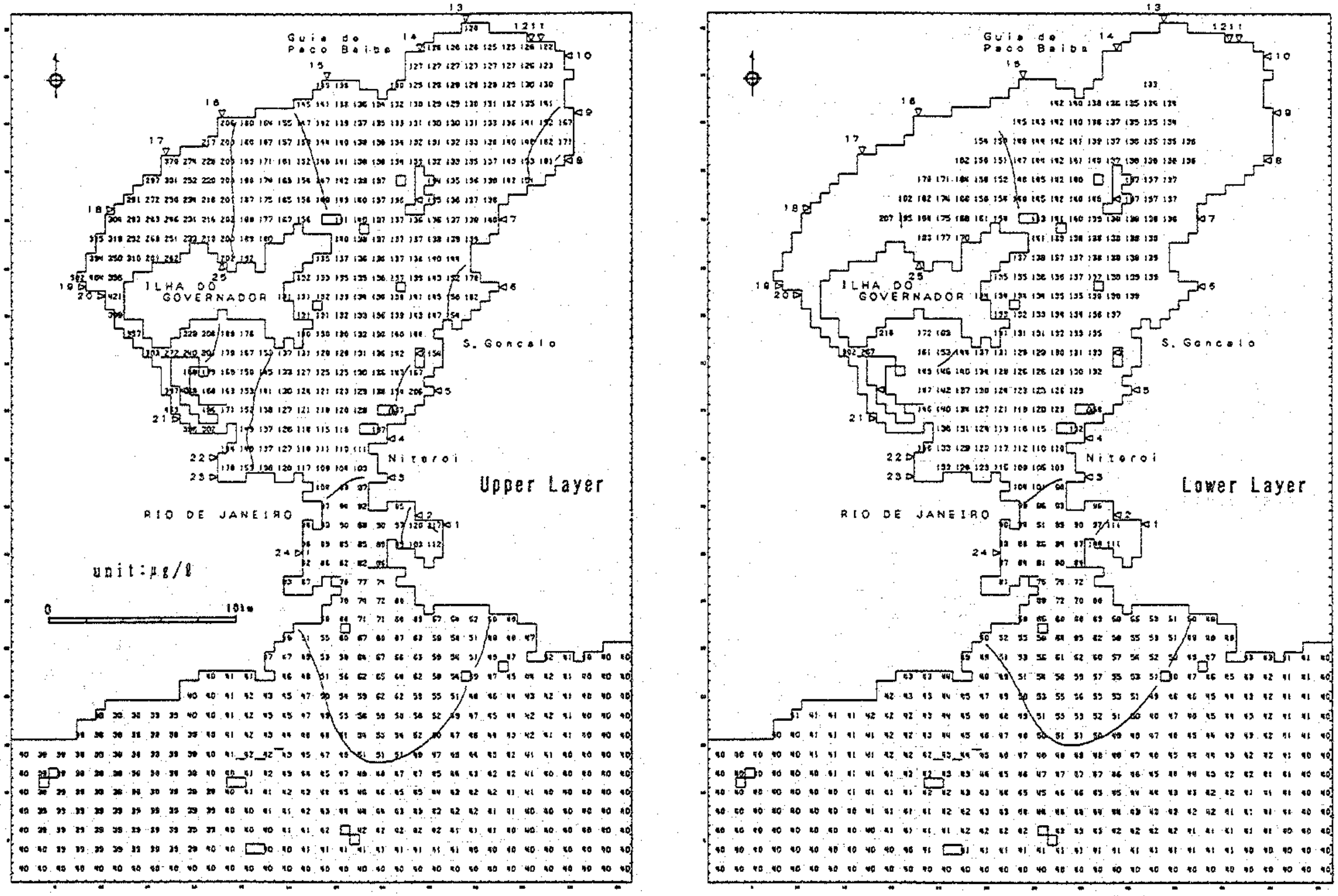
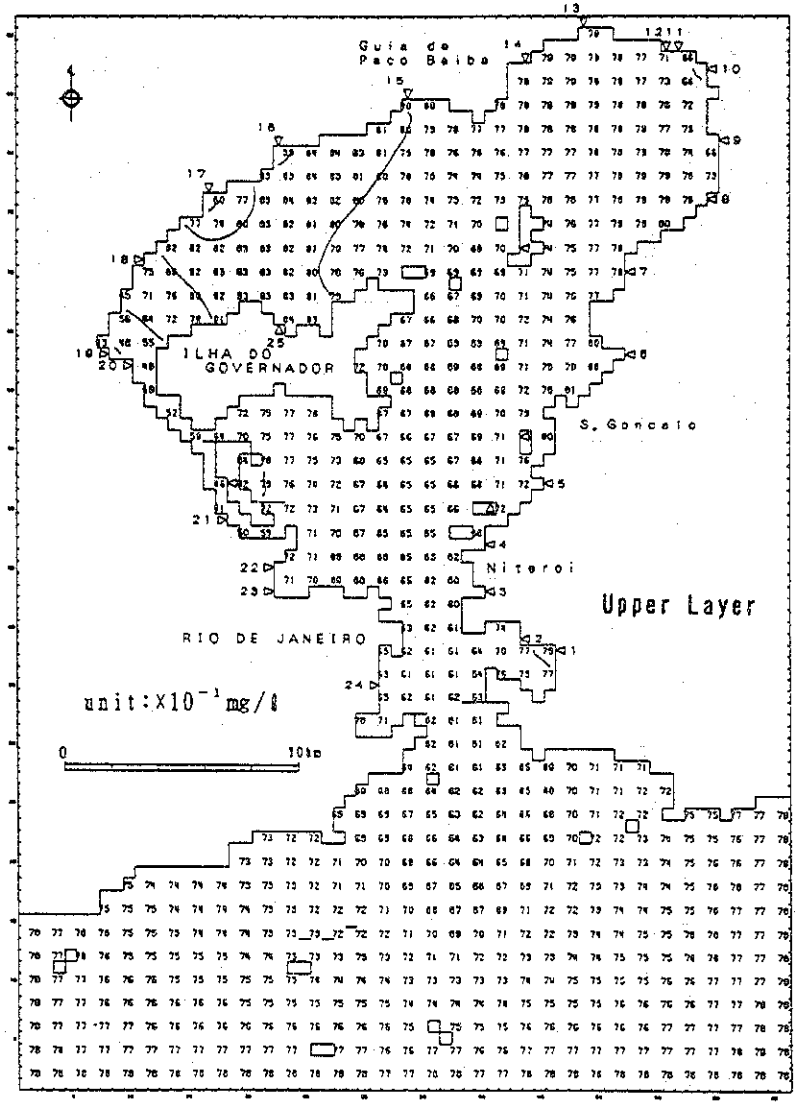


Fig.11.4-2(5) Calculated Water Quality Distribution in Rainy Season (T-P)



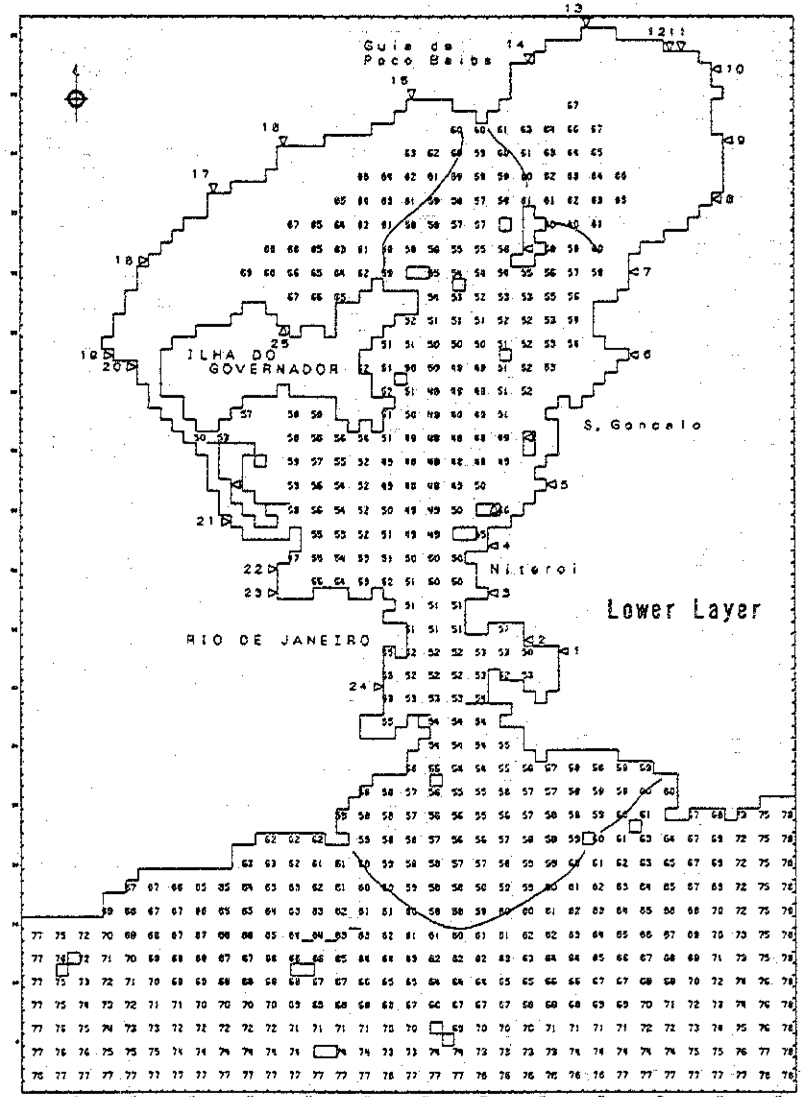


Fig.11.4-2(6) Calculated Water Quality Distribution in Rainy Season (DO)

11.4.2 Verification of Eutrophication Model

In order to evaluate the verification of the Eutrophication Model, we compared the observed concentrations and the calculated concentrations at each station for each index in both the dry and rainy seasons together with the mean values of both seasons (Fig. 11.4-3).

(1) Organic Matter (COD and BOD)

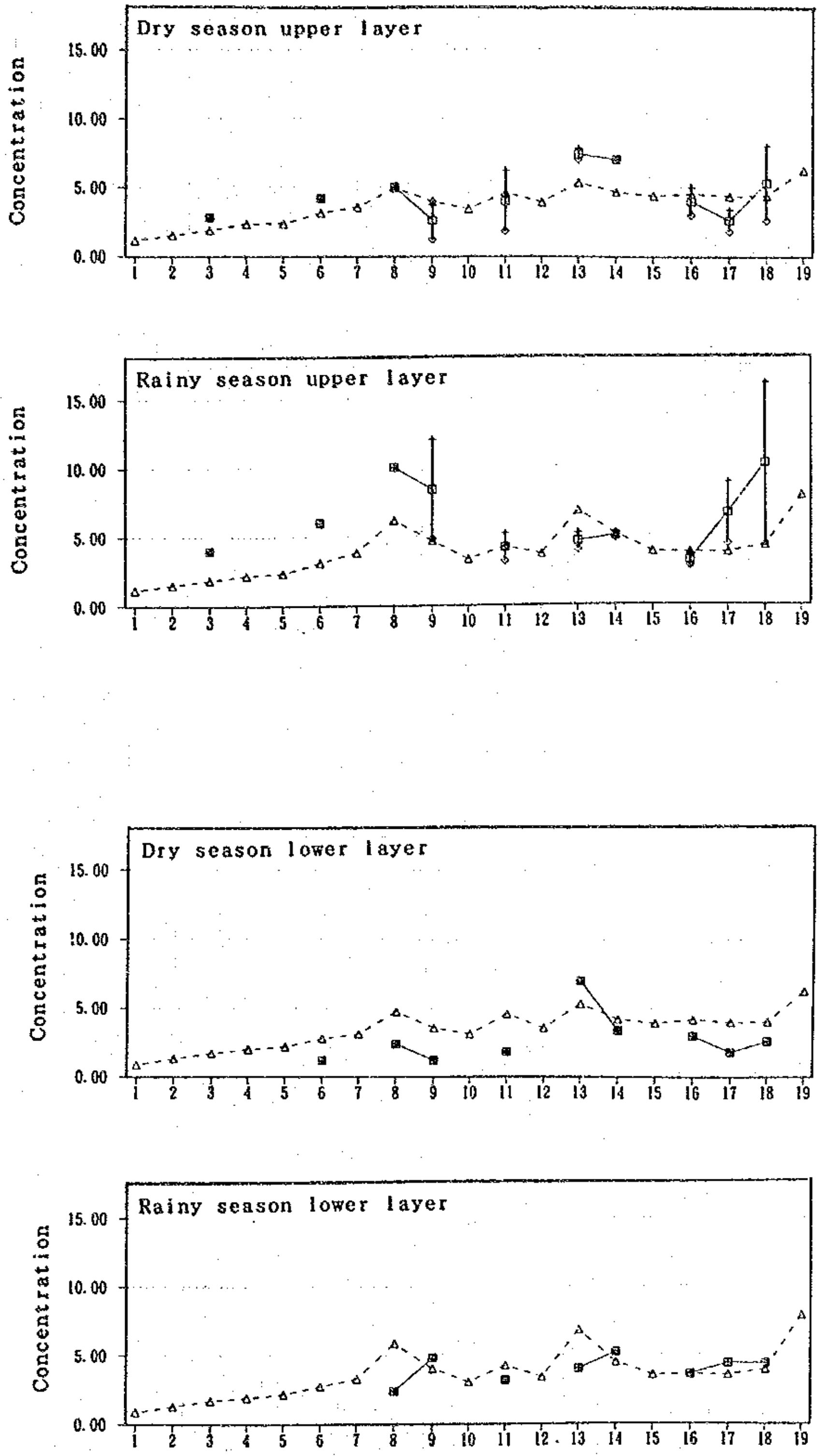
There are some differences at some points such as in the upper layer at St. 13 in the dry season and in the lower layer in the rainy season for COD, and the calculated values look lower as a whole for BOD. The calculated results, however, satisfactorily agree with the observed values.

(2) Nutrient Salts (PO_4-P, O-P and T-P)

Though the calculated values are larger than the observed ones in the upper layer in the dry season and in the lower layer in both seasons. It can be concluded, however, the calculation results satisfactorily agree with the observed values.

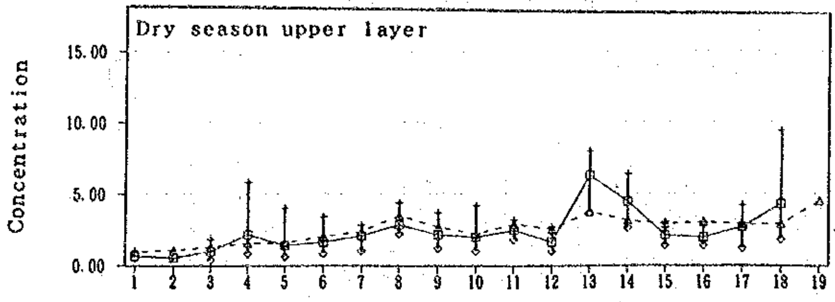
(3) Dissolved Oxygen (DO)

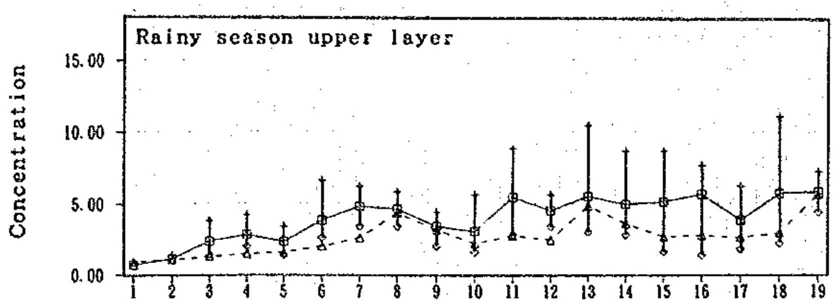
The calculated values at St. 7 to St. 9 are larger than the observed ones. It can be said, however, that the calculated results sufficiently agree with the observed values.

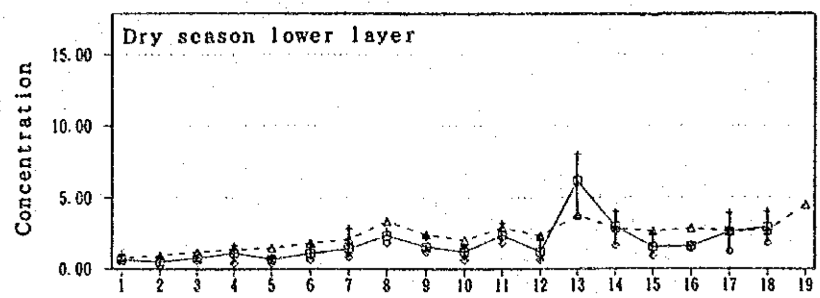


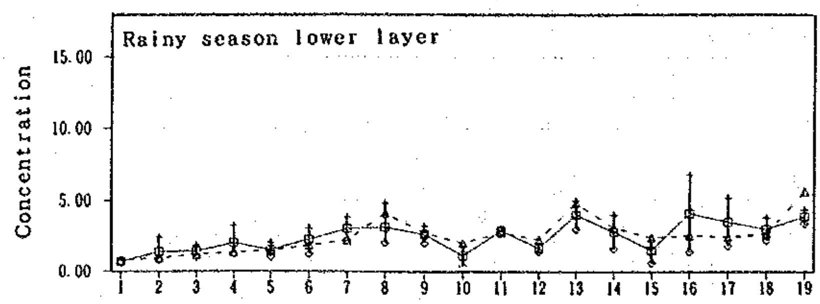
Station: Refer to Fig.11 3-2

Fig.11.4-3(1) Comparison of Observed and Calculated Water Quality (BOD)



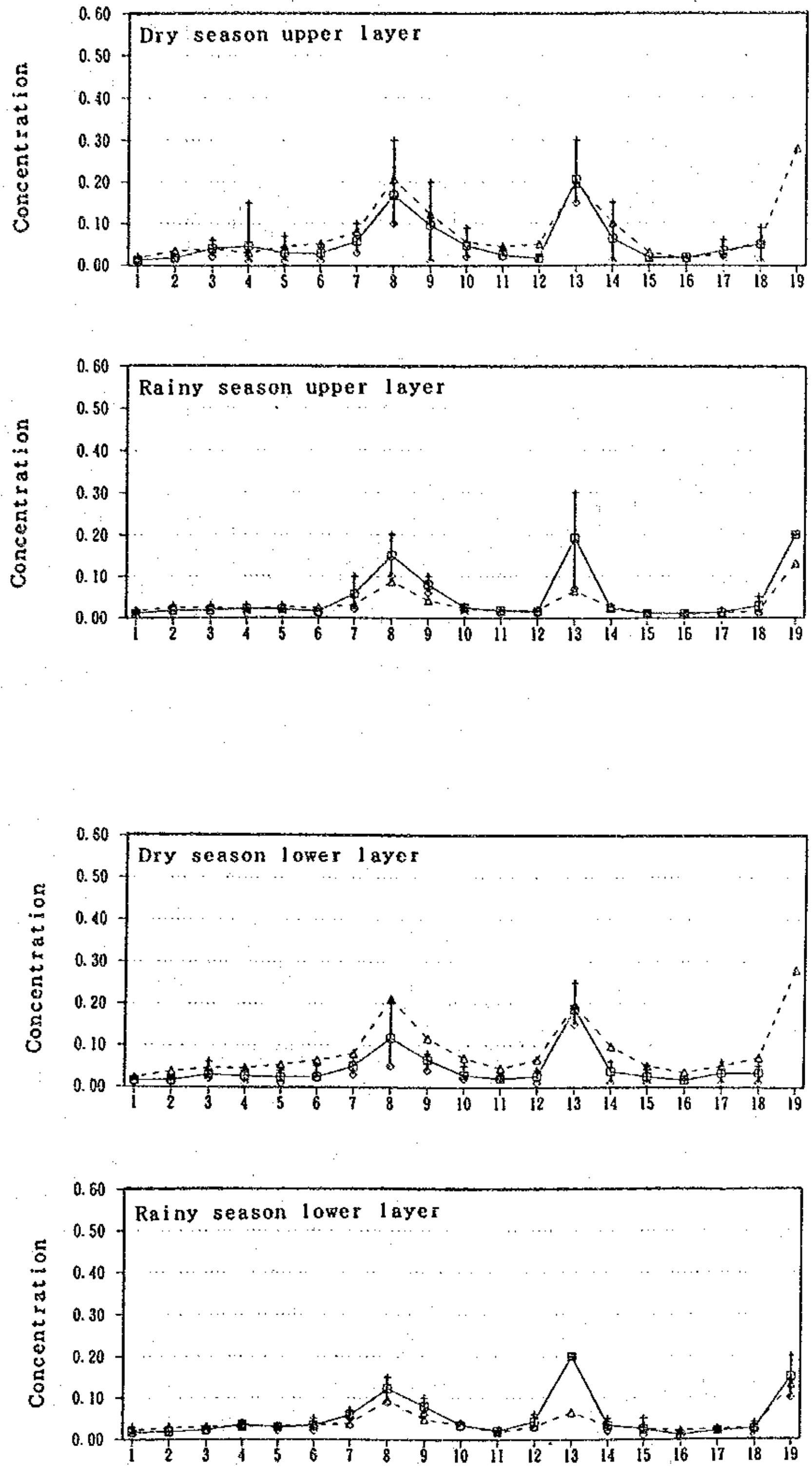






Station: Refer to Fig.11.3-2

Fig.11.4-3(2) Comparison of Observed and Calculated Water Quality (COD)



Station: Refer to Fig.11.3-2

Fig.11.4-3(3) Comparison of Observed and Calculated Water Quality (PO_4-P)

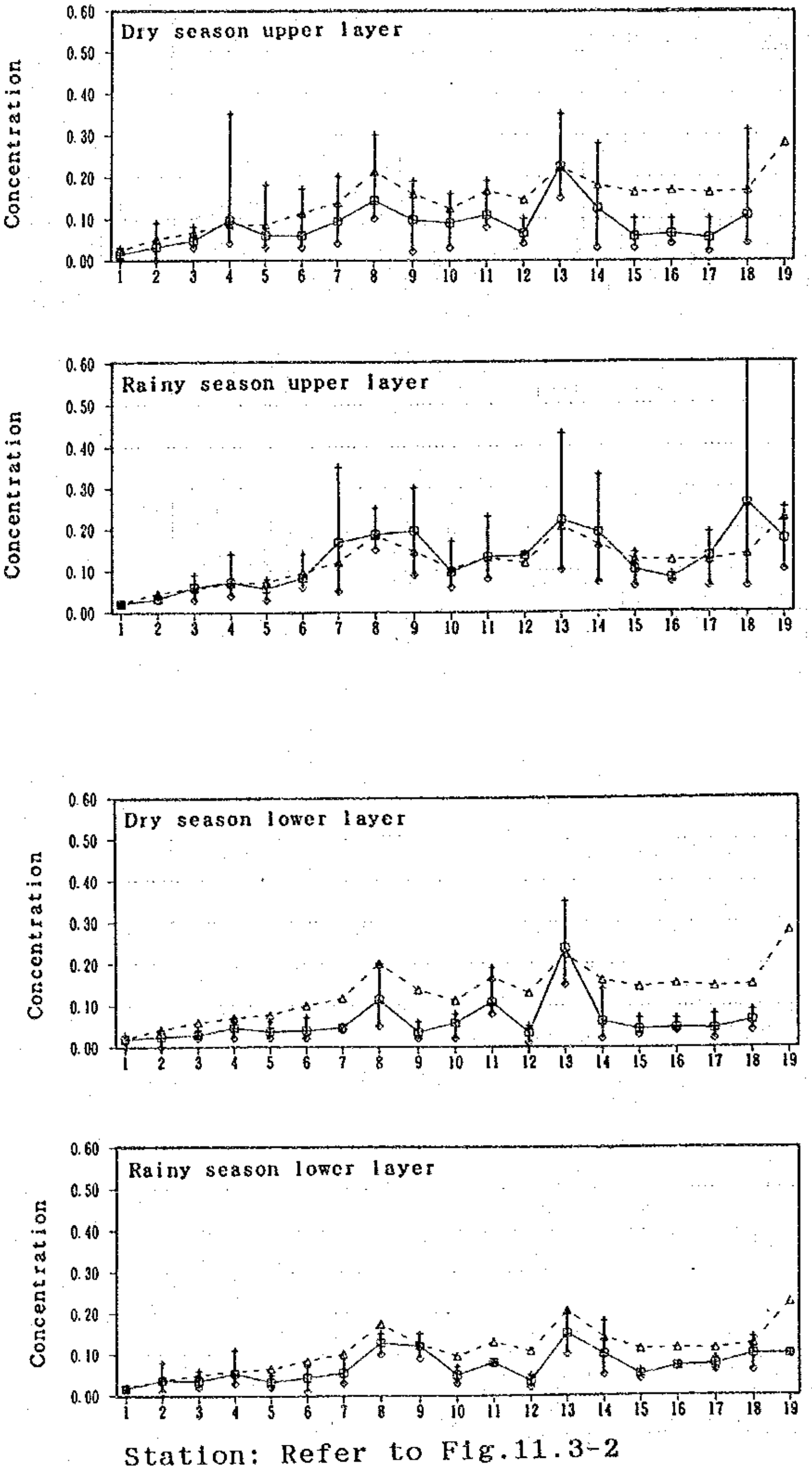
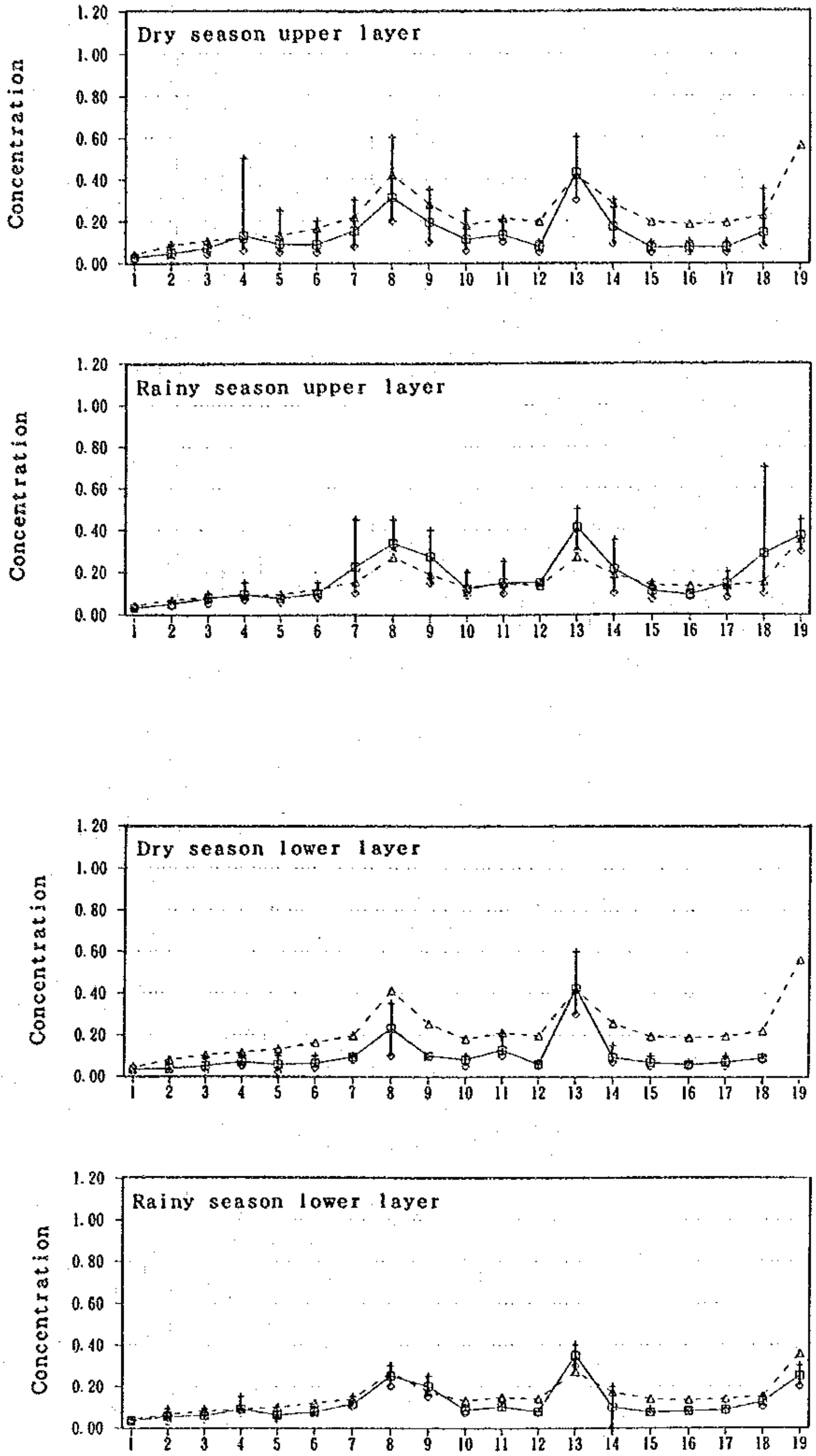
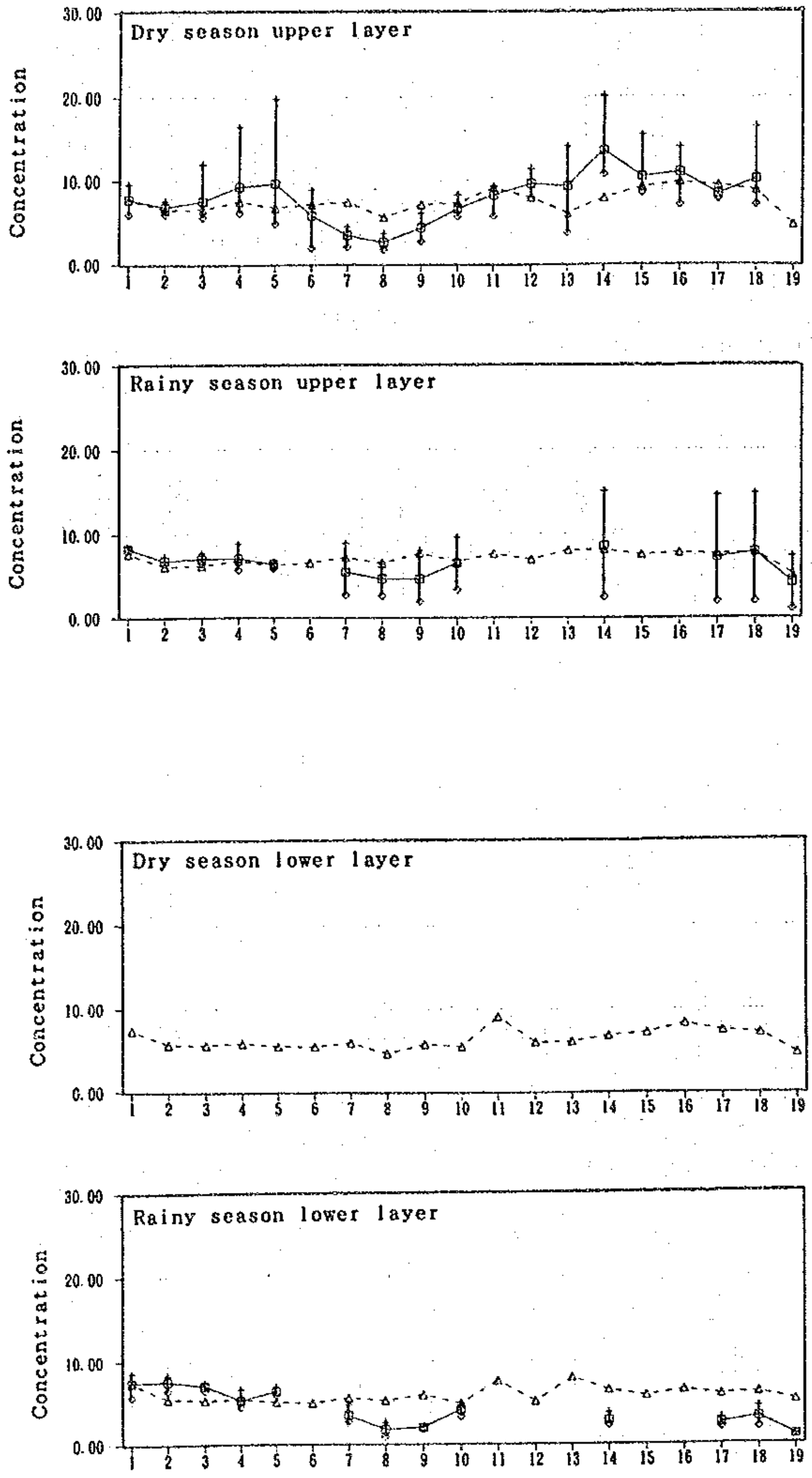


Fig.11.4-3(4) Comparison of Observed and Calculated Water Quality (O-P)



Station: Refer to Fig.11.3-2

Fig.11.4-3(5) Comparison of Observed and Calculated Water Quality (T-P)



Station: Refer to Fig.11.3-2

Fig.11.4-3(6) Comparison of Observed and Calculated Water Quality (DO)

11.5 Mass Balance of Nutrient Salts and Organic Matter

The balance (or income/expenditure) of nutrient salts (O-P, PO_4-P and T-P), organic matter (COD and BOD) and dissolved oxygen (DO) is summarized in **Table 11.5-1** for the dry season, rainy season and the annual mean value for the present state.

From this table, we can get an outline of the amount of primary production, decomposition, release etc., in other words, the sensitivity of the Eutrophication Model.

Table 11.5- 1 Mass Balance at Present in the Bay

Dry Season		O-P	PO_4-P	T-P	BOD	COD	DO
Standing stock	(t)	224.6	111.2	335.8	6091.1	4,327.2	11,605.4
Dispersion	(t/day)	-4.8	-3.7	-8.5	-100.6	-74.9	109.5
External load	(t/day)	13.3	8.9	22.1	277.1	214.9	0.0
Growth	(t/day)	36.4	-36.4	0.0	932.1	597.1	5,206.4
Decomposition	(t/day)	-25.3	25.3	0.0	-677.5	-446.0	-4,064.8
Settling	(t/day)	-19.6	0.0	-19.6	-517.1	-345.9	0.0
Release	(t/day)	0.0	6.0	6.0	85.9	54.8	-279.8
Exchange with air	(t/day)	0.0	0.0	0.0	0.0	0.0	-917.3
Rainy Season		O-P	PO_4-P	T-P	BOD	COD	DO
Standing stock	(t)	196.1	58.8	254.9	6,245.3	4,532.5	10,894.2
Dispersion	(t/day)	-4.7	-1.3	-6.1	-105.3	-80.6	117.2
External load	(t/day)	9.6	6.4	16.0	387.1	314.1	0.0
Growth	(t/day)	31.8	-31.8	0.0	814.0	521.5	4,546.9
Decomposition	(t/day)	-20.8	20.8	0.0	-666.2	-451.7	-3,997.0
Settling	(t/day)	-15.9	0.0	-15.9	-515.5	-358.0	0.0
Release	(t/day)	0.0	6.0	6.0	85.9	54.8	-279.8
Exchange with air	(t/day)	0.0	0.0	0.0	0.0	0.0	-387.3
Annual Mean		O-P	PO_4-P	T-P	BOD	COD	DO
Standing stock	(t)	210.3	78.0	288.3	6,214.2	4,515.2	11,272.9
Dispersion	(t/day)	-4.9	-2.1	-7.0	-105.2	-79.2	117.5
External load	(t/day)	11.4	7.6	19.0	332.1	264.5	0.0
Growth	(t/day)	34.9	-34.9	0.0	892.9	572.0	4,987.8
Decomposition	(t/day)	-23.5	23.5	0.0	-683.0	-456.0	-4,097.8
Settling	(t/day)	-18.0	0.0	-18.0	-522.7	-356.1	0.0
Release	(t/day)	0.0	6.0	6.0	85.9	54.8	-279.8
Exchange with air	(t/day)	0.0	0.0	0.0	0.0	0.0	-727.7

PART VI

FUTURE DEVELOPMENT

AND

FUTURE WATER QUALITY

WITHOUT MEASURE

CHAPTER 12

FUTURE SOCIOECONOMIC FRAMEWORK OF THE GUANABARA BAY BASIN

CHAPTER 12

FUTURE SOCIOECONOMIC FRAMEWORK OF THE GUANABARA BAY BASIN

In order to come up with a comprehensive measure against future water pollution in the bay, we should first predict future water quality of the bay. This task needs the future picture of the factors which govern the water quality. To this end, we need to prepare future development scenarios which take into account economy, population, basic urban services and regional development plans.

With these in mind, we tried to come up with future development scenarios, taking into account the four factors above. Because of the uncertainties and to make the scenarios more flexible, we prepared two scenarios, one is pessimistic and the other optimistic. Both scenarios are for the year 2000 and 2010 which correspond to the target year of the countermeasures.

12.1 Regional Development Plans

State and municipal development master plans, or zoning and related laws in the absence of such plans, were reviewed to analyze their contents. It can be said that they all contain provisions on environmental protection, but do not contain sufficient concrete details on development activities and on the coverage of basic services. Therefore, these development master plans are not specific enough to serve as a basis for estimating future socioeconomic conditions in the Guanabara Bay basin.

Ironically, Cachoeiras de Macacu, which is a municipality without a development plan and without zoning and related laws, has taken the initiative in establishing an Industrial District, and to directly negotiate with BID for financing the expansion of sewer services. Sewer infrastructure works usually require large investments, whereby municipalities usually rely on other government institutions for the provision of these services.

Every municipality can be said to have basic legal provisions for environmental protection. Likewise, every municipality purports to protect the environment and to pursue the type of economic development which is compatible with the rational utilization of natural resources, in order to avoid irreversible damage to the environment. In this regard, even in the promotion of manufacturing industries, the emphasis is on "environmentally friendly" or "non-polluting" industries.

The parts that need to be strengthened consist of the application or enforcement of the existing laws, and the lack of specific details on types, scales and time frames of industries and other activities to be promoted as basis for socioeconomic development. Therefore, these two weaknesses need to be dealt with by the relevant state and federal institutions.

Concerning the enforcement of environmental legislation, encouragement can be gained from the Rio de Janeiro State Development Plan, which deals with the establishment of an "environmental crime prevention force". The implementation of this idea, if coupled with necessary financial, technical and institutional support, could turn out to be a major contributing factor towards instilling life into the numerous environmental laws, which currently are not effectively enforced.

In reference to the promotion of "non-polluting" industries, the role of FEEMA is critical, as one of its functions is to monitor and control industrial effluents according to established water quality standards. If the monitoring and control are effectively implemented, then manufacturing industries could indeed be "non-polluting" and "environmentally friendly".

12.2 Future Socioeconomic Scenarios

Formulation of a pollution control master plan implies the need to envisage the socioeconomic situation that is likely to prevail some time in the future. This will be the result of changes in population, presence or lack of a diversity of measures that the government usually implements, leading ultimately to a particular way of life and living standards. The future socioeconomic situation defines changes in discharge of pollutants, and influences the choice of pollution control measures to be applied. The reverse is also true, that is, pollution control measures have definite effects on the future socioeconomic conditions.

12.2.1 Bases for Future Scenarios

The present master plan has two target years: 2000 and 2010. Socioeconomic scenarios for the two target years are to be defined in terms of (1) population, (2) coverage of basic services: water supply, sewerage and solid wastes disposal, and (3) economic activities, including changes that are bound to occur in the land area under cultivation, and the sector-specific growth rates.

(1) Population

Population projection usually falls under the jurisdiction of official institutions, because they have access to all the necessary background data and information which is frequently unavailable to outsiders. However, the two relevant official Brazilian institutions in charge of census and statistics, IBGE at the national level and CIDE at the Rio de Janeiro State level, have no population projections.

Under this situation, the alternatives are either to use the population projection of the IDB financed Basic Sanitation Program, or use past population growth trends to estimate municipality-specific growth rates. Using the population projection of the Basic Sanitation Program has the advantage of providing consistency to the population data for plans relating to the Guanabara Bay basin, but the drawbacks are the partial coverage of the basin and the lack of breakdown by municipality.

(2) Coverage of Basic Services

Concerning the coverage of basic services (water supply, sewerage and solid wastes disposal), the source for future socioeconomic scenarios should normally be the regional development plans. However, the reviewed state and municipal development plans contain broad policy objectives without sector-specific quantitative goals. In addition, the planning horizon of these development plans is usually five years, shorter than the target years for the pollution control master plan.

Consequently, the IDB financed Basic Sanitation Program for the Guanabara Bay basin contains the only concrete data that can be taken into consideration in the estimation of future coverage of solid wastes disposal services in some municipalities.

(3) Economic Activity

Estimation of types and the scale of future economic activity is the most difficult proposition, especially in view of the abnormal Brazilian economy during the past decade. The hope of relying on development plans, both at the state and municipal levels, turned out to be impractical, because such plans generally lack sector-specific quantitative goals. Encouraging , however, is the emphasis placed on promoting "environmentally friendly" or "non-polluting" industries. This opens the possibility for estimating future pollutant discharge at lower than present levels, instead of basing on the types and scales of future industrial activities.

An alternative is to estimate future economic activity on the basis of existing data, namely, various censuses (1960, 1970, 1980 and 1985) for agriculture, industry and services. The future is to be estimated by economic sector, from base figures of selected sector-specific indicators and assumed rates of growth. The growth rates of these selected indicators should keep a balance between the expanding "Brazilian miracle" economy of the 1970s and the foreign-debt ladden sluggish economy of the 1980s.

Selected Indicators

Primary Sector:	Area of land under cultivation, by Municipality in 1985
Secondary Sector:	Number of employees by industry type, in metropolitan Rio de Janeiro in 1985
Tertiary Sector:	Number of employees in the food and lodging services, by municipality in 1985

Another conceptually possible procedure in estimating future economic activity is to start from the population projections. Then, the economically active population can be estimated and proportionately distributed among economic sectors.

12.2.2 Assumptions for Future Scenarios

(1) Case 1 - Expected Scenario

Population growth	:	slowing and stabilizing
Basic Services	:	expanding as per IDB Program
Economy	:	"clean" industries and services

a) Population Growth

Population growth is assumed to slow down and stabilize around the year 2005. This is the theory of the World Bank, whereby the Brazilian population growth rate will equal the replacement rate, or zero population growth (ZPG), in the year 2005. As the overall population growth rate in Brazil between 1980 and 1991 was 1.89% per year, the natural population growth rate is assumed to be a moderate 2%.

For purposes of population projection, the municipalities of the Guanabara Bay basin were divided into four groups on the basis of past population growth trends. Then, future population growth rates were estimated by municipality and by time span. The assumed population growth rates will get smaller the farther into the future. This reflects increasing difficulties in predicting the distant future, and can be defended on grounds of the future expansion of opportunities for women's education, which is widely recognized as the most significant factor for effective family planning.

The assumed growth rates by municipality and by time span in the four groups are shown in **Table 12.2-1**. The four groups are the following.

"Grown" (Rio de Janeiro, Niteroi, Nilopolis, Sao Joao de Meriti)

"Grown" municipalities consist of those fully urbanized, with very high population densities. Very low population growth rates were observed in the recent past and are presumed to occur in the near future in these municipalities. Further, a very slow population growth (0.5%-0.75%) is assumed up to the year 2005, when the population is assumed to stabilize.

The assumed population growth rates are as follows:

1992-2000: 0.5%-0.75%
2001-2005: 0.5%
2006-2010: 0.0%

"Growing" (Sao Goncalo, Itaborai, Rio Bonito)

"Growing" municipalities consist of those presently growing or are likely to grow in the near future. This is based on the observation of on-going housing developments in Sao Goncalo and the expansive economy of Itaborai. These effects are likely to spill over onto Rio Bonito, which presently serves as the commercial center bridging metropolitan Rio de Janeiro and the surrounding rural areas. The growth expected in "growing" municipalities is induced by the saturation of "grown" municipalities.

The assumed population growth rates are as follows:

1992-2000: 2.0%-4.0%
2001-2005: 2.5%
2006-2010: 0.5%-1.0%

"Next-to-grow" (Mage, Cachoeiras de Macacu)

"Next-to-grow" municipalities consist of those likely to grow slightly later than the "growing" municipalities, even though chances are that they will grow at about the same time. Mage is slowly changing from an area of weekend houses and private recreation facilities to an area with houses where people normally live and from which they commute to work. Cachoeiras de Macacu, although too far for daily commuting to metropolitan Rio de Janeiro, the establishment of an industrial park with the cooperation of CODIN, plus efforts to begin installation of sewer works by the municipal government, are likely to induce population inflows.

The assumed population growth rates are as follows:

1992-2000: 2.0%
2001-2005: 3.0%
2006-2010: 1.0%

"Possible Growth" (Duque de Caxias, Nova Iguacu)

"Possible Growth" municipalities consist of those relatively large communities (over half a million), practically fully urbanized, but with insufficient service infrastructure. These municipalities are assumed to have a moderate natural growth rate.

Table 12.2-1 Population Growth Rate

Municipalities	Calculated				Estimated		
	60-70	70-80	92- 80-91	2000	1-5	Sc.1 6-10	Sc.2 6-10
<u>Grown</u>							
Nilópolis	3.02	1.70	0.37	0.5	0.5	0.0	0.0
Niteroi	2.92	1.84	0.43	0.75	0.5	0.0	0.5
Rio de Janeiro	2.62	1.66	0.43	0.75	0.5	0.0	0.5
S.J.de Meriti	4.73	2.79	0.58	0.5	0.5	0.0	0.0
<u>Growing</u>							
Sao Goncalo	5.81	3.63	1.79	3.0	2.5	0.5	0.5
Itaborai	4.78	5.62	3.16	4.0	2.5	1.0	1.0
Rio Bonito	2.32	1.27	1.09	2.0	2.5	1.0	1.0
<u>Next-to-Grow</u>							
Magé	6.83	3.93	1.27	2.0	3.0	1.0	1.0
Cacho. de Macacu	2.39	0.67	1.04	2.0	3.0	1.0	1.0
<u>Possible Grwoth</u>							
Duque de Caxias	5.99	2.89	1.31	2.0	2.5	0.0	1.0
Nova Igucacu	7.38	4.17	1.48	2.0	2.5	0.0	1.0

Source: Calculated from Census data

Both the World Bank and the IDB have targeted this area to improve living conditions through provision of flood control infrastructure, water supply, sewer and solid wastes disposal services. Given the convenient location of these municipalities to metropolitan Rio de Janeiro, if living conditions improve as a result of the World Bank and IDB projects, population inflow is likely to occur from the saturated "grown" municipalities into these "possible growth" municipalities. However, this population inflow is considered to be short lasting, quickly reaching the zero population growth stage.

The assumed population growth rates are as follows:

1992-2000: 2.0%
2001-2005: 2.5%
2006-2010: 0.0%

b) Basic Services

Service coverage of water supply, sewerage and solid wastes disposal is assumed in reference to the IDB financed Basic Sanitation Program. In general, the following coverage is assumed.

* Municipalities with IDB Projects

2000: 90%-100%
2010: 100%

* Rio de Janeiro and Niteroi

2000: 100%
2010: 100%

* Other Municipalities

2000: 70%
2010: 90%

Detailed growth rates by municipality and by time span are shown in Table 3.2-2, 3.2-3 and 3.2-4 of Supporting Report I.

c) Economy

An attempt was made to reflect the regional development plans,which appear to promote the service sector. Accordingly, the tertiary sector is to grow at the fastest rate. The manufacturing sector is to grow relatively slowly, as incentives are mainly focused on those industries without adverse environmental effects. Since manufacturing grows relatively slowly, farming, in addition to the service sector, is to grow at a faster rate.

Primary Sector

The future of the primary sector is to be estimated as a functionof the land area under cultivation by municipality in 1985, which is the year with the latest available census data.

Growth rates of land area under farming were estimated by municipality for the periods 1986-2000 and 2001-2010, as shown in Table 3.2-5 of Supporting Report I.

Secondary Sector

The future of the secondary sector is to be assumed as a functionof the number of employees by industry type in metropolitan Rio de Janeiro in 1985, which is the year with the latest available census data. Because manufacturing activities are concentrated in metropolitan Rio de Janeiro, it was deemed appropriate to use this data for the Guanabara Bay basin rather than the municipality-specific data. In addition, the selected industry types accounted for more than 80% of employment in the secondary sector in 1985.

Following a similar procedure as in the primary sector, growthrates of the number of employees by industry typewere estimated for metropolitan Rio de Janeiro for theperiods 1986-2000 and 2001-2010, as shown in Table 3.2-6 of Supporting Report I.

Tertiary Sector

The future of the tertiary sector is to be assumed as a function of the number of employees in the lodging and food services industry by municipality in 1985, which is the year with the latest available census data. Following a similar procedure as in the primary and secondary sectors, growth rates of the number of employees in the lodging and food services industry were estimated by municipality for the two periods 1986-2000 and 2001-2010, as shown in Table 3.2-7 of Supporting Report I.

(2) Case 2 - Pessimistic Scenario

Population growth: increasing even after 2005

Services: lower coverage than the IDB Program

Economy: "dirty" industries keep growing

a) Population Growth

The World Bank assumption of zero population growth from the year 2005 is assumed to materialize only in the municipalities of Nilopolis and Sao Joao de Meriti, which at present have the highest population densities. Population growth is assumed to continue into the future, albeit at a slower rate. However, for the 1992-2000 period, population growth rates are assumed to be the same as in Case 1, as shown in **Table 12.2-1** and summarized below.

"Grown" Municipalities

1992-2000: 0.5%-0.75%
2001-2005: 0.5%
2006-2010: 0.0%-0.5%

"Growing" Municipalities

1992-2000: 2.0%-4.0%
2001-2005: 2.5%
2006-2010: 0.5%-1.0%

"Next-to-Grow" Municipalities

1992-2000: 2.0%
2001-2005: 3.0%
2006-2010: 1.0%

"Possible Growth" Municipalities

1992-2000: 2.0%
2001-2005: 2.5%
2006-2010: 1.0%

b) Basic Services

Service coverage of water supply, sewerage and solid wastes disposal is assumed to be lower than the targeted by the IDB financed Basic Sanitation Program. The assumed coverage rates are shown in Tables 3.2-2 to 3.2-4 of Supporting Report I and are summarized as follows.

* Municipalities with IDB Projects

  2000: 70% - 90%
  2010: 80% - 100%

* Rio de Janeiro and Niteroi (same as Case 1)

  2000: 100%
  2010: 100%

* Other Municipalities

  2000: 50% - 70%
  2010: 70% - 90%

c) Economy

The difference in assumptions from Case 1 concerning economic activities refers mostly to the secondary sector. Here, the manufacturing sector, including "polluting" industries, are assumed to keep growing at a faster rate than the primary and the tertiary sectors. Accordingly, the growth rates are to be relatively slower in farming and the service sectors. The assumed growth rates are shown in Table 13.2-5 to 3.2-7 of Supporting Report I.

12.3 Socioeconomic Framework in the Target Years

The socioeconomic scenarios described in Section 12.2 served as a basis for estimating the socioeconomic framework for the Guanabara Bay basin in the two target years 2000 and 2010. The Population is shown in **Table 12.3-1**, and the other items are summarized in **Table 12.3-2**.

Table 12.3-1 Population : 1991 Census and Projections

Municipalities	Present (1991)	Scenario 1 2000	Scenario 1 2010	Scenario 2 2000	Scenario 2 2010
Cacho de Macacu	40,195	48,037	58,529	48,037	58,529
Duque de Caxias	664,643	794,310	898,689	794,310	944,532
Itaborai	161,274	259,544	272,956	229,544	272,956
Magè	191,359	228,692	278,641	228,692	278,641
Nilopolis	157,819	165,065	169,233	165,065	169,233
Niteroi	416,123	445,069	456,308	445,069	467,831
Nova Iguacu	1,286,337	1,537,292	1,739,305	1,537,292	1,828,027
Rio Bonito	45,093	53,891	64,084	53,891	64,084
Rio de Janeiro	5,336,179	5,707,368	5,851,487	5,707,368	5,999,245
Sao Goncalo	747,891	975,829	1,131,940	975,829	1,131,940
S. J. de Meriti	425,038	444,552	455,778	444,552	455,778
G. B. Basin	9,471,951	10,629,649	11,376,950	10,629,649	11,670,796

Table 12.3 -2 Future Socioeconomic Framework of the Guanabara Bay Basin

Item	Unit	Present	Scenario 1		Scenario 2	
			2000	2010	2000	2010
Population	Person	9,471,951	10,629,649	11,376,950	10,629,649	11,670,796
Growth Rates	%/yr					
1992-2001		-	1.29	-	1.29	-
2001-2010		-	-	0.68	-	0.94
Basic Services						
Pop. w/solid Wastes Disp. Coverage	Person (%)	7,115,316 (75.1)	9,831,045 (92.5)	11,163,463 (98.1)	8,962,932 (84.3)	10,649,977 (91.3)
Pop. w/water supply Coverage	Person (%)	7,390,509 (78.0)	10,176,766 (95.7)	11,336,825 (99.6)	9,558,759 (89.9)	11,132,674 (95.4)
Pop. w/Sewerage Coverage	Person (%)	5,272,870 (55.7)	10,069,896 (94.7)	11,309,529 (99.4)	8,531,207 (80.3)	10,874,346 (93.2)
Economy						
Sector Growth Rates	%/yr					
Primary						
1986-2000		-	0.87	-	0.20	-
2001-2010		-	-	0.43	-	0.20
Secondary						
1986-2001		-	1.09	-	2.27	-
2001-2010		-	-	1.28	-	1.83
Tertiary						
1986-2001		-	3.01	-	2.04	-
2001-2010		-	-	2.36	-	1.09

12.3.1 Population

The 1991 population census data for the municipalities in the Guanabara Bay basin were projected to the target years with the assumed growth rates, as shown in the summary below. Scenario 1 represents a slowing population growth, stabilizing around the year 2005 according to the World Bank, while Scenario 2 assumes that the population in most municipalities keeps growing after 2005.

1991 Census	9,471,951
Scenario 1	
2000	10,629,649
2010	11,376,950
Growth rates	
1992-2000	1.29%/yr.
2001-2010	0.68%/yr.
Scenario 2	
2000	11,629,649
2010	11,670,796
Growth rates	
1992-2000	1.29%/yr.
2001-2010	0.94%/yr.

12.3.2 Coverage of Basic Services

The coverage of basic services in the Guanabara Bay basin, at present and the projections for the two scenarios, is presented below. The figure in parentheses refers to the percentage of the serviced population relative to total population. Scenario 1 represents achievements of coverage goals consistent with the BID Basic Sanitation Program, while Scenario 2 assumes lower coverage.

(1) Solid Wastes Disposal

Present	7,115,316 (75.1%)
Scenario 1	
2000	9,831,045 (92.5%)
2010	11,163,463 (98.1%)

Scenario 2	
2000	8,962,932 (84.3%)
2010	10,649,977 (91.3%)

(2) Water Supply

Present	7,390,507 (78.0%)
Scenario 1	
2000	10,176,766 (95.7%)
2010	11,336,825 (99.6%)
Scenario 2	
2000	9,558,759 (89.9%)
2010	11,132,674 (95.4%)

(3) Sewerage

Present	5,272,870 (55.7%)
Scenario 1	
2000	10,069,896 (94.7%)
2010	11,309,529 (99.4%)
Scenario 2	
2000	8,531,207 (80.3%)
2010	10,874,346 (93.2%)

12.3.3 Economy

The economic framework in the Guanabara Bay basin is described in reference to the sectional growth rates. Scenario 1 represents a relatively slow growth rate in the manufacturing sector, due to the emphasis in the service sector and "clean" industries. Consequently, the relatively strong primary sector growth reflects absorption of some labor displaced from the manufacturing sector. Accordingly, there is an increase in the cultivated land area.
On the contrary, Scenario 2 represents a less than expected growth rate in the service sector, which coupled with the continued growth of "dirty" industries, provides employment opportunities in the secondary sector. Accordingly, the primary sector grows relatively less and the cultivated land area is smaller.

(1) Primary Sector

Cultivated land area (ha)

Present (1985)	118,488
Scenario 1	
2000	134,916
2010	140,811
Scenario 2	
2000	122,117
2010	124,630

Primary sector growth rates (%/yr.)

Present	
1980-1985	0.56
Scenario 1	
1986-2000	0.87
2001-2010	0.43
Scenario 2	
1986-2000	0.20
2001-2010	0.20

(2) Secondary Sector

Employment in 12 selected industries

Present (1985)	346,625
Scenario 1	
2000	407,766
2010	463,193
Scenario 2	
2000	485,064
2010	581,617

Secondary sector growth rates (%/yr.)

Present		
	1980-1985	-2.29
Scenario 1		
	1986-2000	1.09
	2001-2010	1.28
Scenario 2		
	1986-2000	2.27
	2001-2010	1.83

(3) Tertiary Sector

Employment in lodging and food service

Present		
	1985	100,849
Scenario 1		
	2000	157,456
	2010	208,776
Scenario 2		
	2000	136,624
	2010	152,251

Tertiary sector growth rates (%/yr.)

Present		
	1980-1985	2.03
Scenario 1		
	1986-2000	3.01
	2001-2010	2.86
Scenario 2		
	1986-2000	2.04
	2001-2010	1.09

CHAPTER 13

ESTIMATE
OF FUTURE WATER QUALITY
IN THE BAY
WITHOUT MEASURE

CHAPTER 13

ESTIMATE OF FUTURE WATER QUALITY IN THE BAY WITHOUT MEASURE

Based on the future scenario formulated in Chapter 12, we estimated future water quality (without measure) in the Bay using numerical simulation model estabilished in this study (see Chapter 10). Before running the model, we calculated future runoff load in terms of BOD and Total Phosphorous using the estimation method developed in this study (see Chapter 9), for the year 2000 and 2010, respectively.

13.1 Future Runoff Load from the Basin

The expected scenarios of social conditions in the basins in future were stated in Chapter 12. Here, the runoff loads from all basins that correspond to the scenarios is calculated.

Firstly, the future population per scenario was calculated for each basin based on the population per administrative unit capita by using the weighed mean method. Calculated populations and population densities are shown in **Table 13.1-1.**

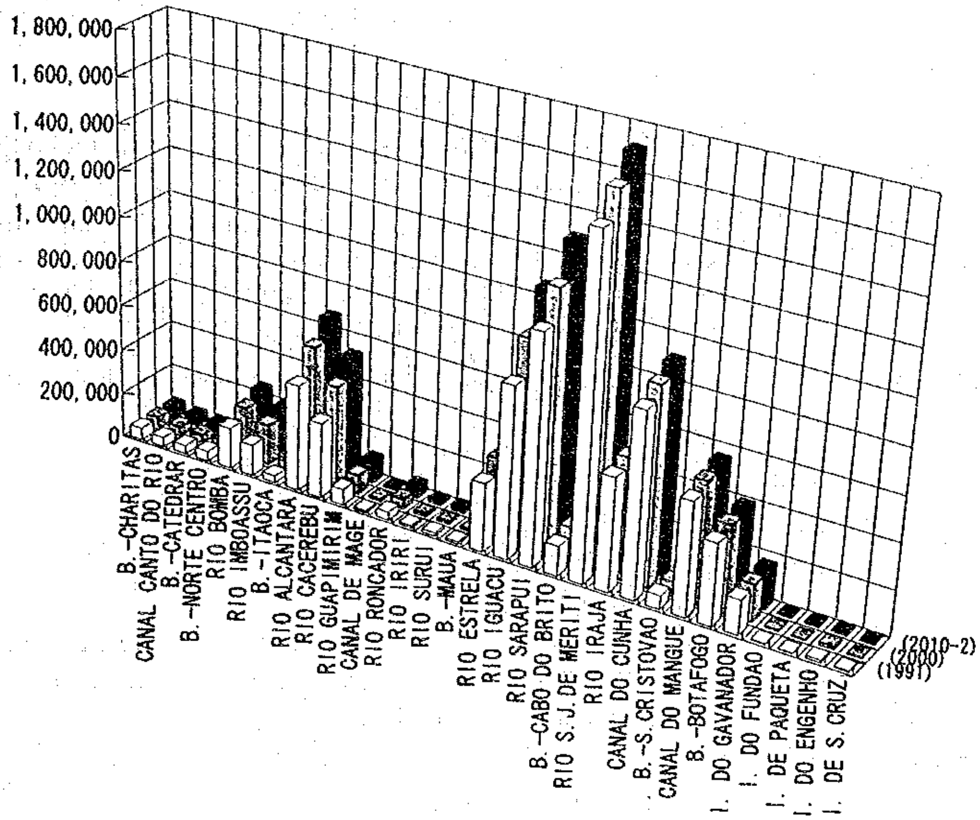
Future runoff loads from the basins were obtained by entering the population density into the potential model of pollutant runoff load proposed in Chapter 9.3, on the assumption that the current relation between pollutant load per unit activity of source and the estimate model of precipitation/discharge will not changed in the future.

The results of future runoff loads for 1991, 2000 and 2010 are shown in **Table 13.1-1** and **Fig.13.1-1** for BOD and T-P in each basin.

Table 13.1-1 Estimation of Future Runoff Load without Measure (Annual Mean Value)

Basin No.		NAME	Basin Area (km2)	Population (persons)			Population Density (10^3/km2)			BOD. Load (t/d)			T-P. Load (t/d)		
				(1991)	(2000)	(2010-2)	(1991)	(2000)	(2010-2)	(1991)	(2000)	(2010-2)	(1991)	(2000)	(2010-2)
Eastern Basin	1	B. -CHARITAS	9.40	53.310	57.042	59.707	5.67	6.07	6.35	2.35	2.51	2.63	0.15	0.16	0.17
	2	CANAL CANTO DO RIO	7.40	41.745	44.667	46.754	5.64	6.04	6.32	1.84	1.97	2.07	0.12	0.13	0.14
	3	B. -CATEDRAR	7.80	37.458	40.080	41.953	4.80	5.14	5.38	1.65	1.77	1.85	0.11	0.11	0.12
	4	B. -NORTE CENTRO	7.90	43.607	46.659	48.840	5.52	5.91	6.18	1.92	2.06	2.16	0.12	0.13	0.14
	5	RIO BOMBA	26.20	183.099	227.043	258.170	6.99	8.67	9.85	8.00	9.96	11.34	0.51	0.64	0.74
	6	RIO IMBOASSU	30.80	138.636	180.227	209.340	4.50	5.85	6.80	6.02	7.85	9.13	0.38	0.50	0.58
Eastern sub total			89.50	497.855	595.718	664.764	5.56	6.66	7.43	21.78	26.12	29.18	1.39	1.67	1.89
Northeastern Basin	7	B. -ITAOCA	6.40	31.925	41.503	48.207	4.99	6.48	7.53	1.41	1.84	2.14	0.09	0.12	0.14
	8	RIO ALCANTARA	144.60	470.420	592.729	677.405	3.25	4.10	4.68	20.07	25.33	28.99	1.20	1.53	1.76
	9	RIO CACEREBU	846.70	336.193	450.499	534.547	0.40	0.53	0.63	14.80	19.46	22.90	0.80	1.05	1.25
	10	RIO GUAPIMIRIM	1253.10	69.853	83.824	102.684	0.06	0.07	0.08	4.67	5.22	5.97	0.26	0.29	0.33
	11	CANAL DE MAGE	18.30	8.458	10.150	12.349	0.46	0.55	0.67	0.38	0.45	0.55	0.02	0.03	0.03
	12	RIO RONCADOR	111.40	36.370	43.644	53.100	0.33	0.39	0.48	1.66	1.96	2.35	0.09	0.11	0.13
	13	RIO IRIRI	27.80	10.684	12.821	15.599	0.38	0.46	0.56	0.49	0.58	0.69	0.03	0.03	0.04
	14	RIO SURUI	68.80	12.910	15.492	18.849	0.19	0.23	0.27	0.63	0.74	0.88	0.04	0.04	0.05
Northeastern sub total			2477.10	976.813	1.250.662	1.462.740	0.39	0.50	0.59	44.11	55.58	64.47	2.53	3.20	3.73
Northwestern Basin	15	B. -MAUA	28.90	8.541	10.249	12.470	0.30	0.35	0.43	0.40	0.47	0.56	0.02	0.03	0.03
	16	RIO ESTRELA	342.50	302.495	362.994	435.593	0.88	1.06	1.27	12.92	15.44	18.47	0.72	0.87	1.05
	17.1-5	RIO IGUACU	562.80	758.010	909.612	1.076.374	1.35	1.62	1.91	31.97	38.30	45.29	1.80	2.17	2.58
	17.6	RIO SARAPUI	165.50	1.012.275	1.153.994	1.305.835	6.12	6.97	7.89	43.40	49.56	56.17	2.66	3.05	3.48
	18	B. -CABO DO BRITO	27.00	132.091	158.509	187.569	4.89	5.87	6.95	5.75	6.91	8.20	0.36	0.44	0.52
Northwestern sub total			1126.70	2.213.412	2.595.358	3.017.841	1.96	2.30	2.68	94.44	110.68	128.69	5.56	6.56	7.66
Western Basin	19	RIO S. J. DE MERITI	164.50	1.492.458	1.611.855	1.716.327	9.07	9.80	10.43	64.33	69.56	74.14	4.01	4.35	4.65
	20	RIO IRAJA	35.70	500.276	535.295	560.309	14.01	14.99	15.69	22.04	23.61	24.73	1.44	1.55	1.63
	21	CANAL DO CUNHA	63.60	815.389	872.466	913.236	12.82	13.72	14.36	35.66	38.20	40.02	2.30	2.47	2.59
	22	B. -S. CRISTOVAO	6.60	60.011	64.212	67.212	9.09	9.73	10.18	2.67	2.86	2.99	0.18	0.19	0.20
	23	CANAL DO MANGUE	42.80	500.876	535.937	560.981	11.70	12.52	13.11	21.96	23.52	24.64	1.42	1.53	1.60
	24	B. -BOTAFOGO	26.00	358.622	383.726	401.657	13.79	14.76	15.45	15.84	16.97	17.78	1.04	1.12	1.18
Western sub total			339.20	3.727.632	4.003.491	4.219.722	10.99	11.80	12.44	162.50	174.72	184.30	10.39	11.21	11.85
Island	25	I. DO GAVANADOR	38.20	153.903	164.676	172.371	4.03	4.31	4.51	6.66	7.13	7.47	0.41	0.44	0.47
	26	I. DO FUNDAO	5.40	5.277	5.646	5.910	0.98	1.05	1.09	0.23	0.25	0.26	0.01	0.02	0.02
	27	I. DE PAQUETA	1.70	3.254	3.482	3.644	1.91	2.05	2.14	0.14	0.15	0.16	0.01	0.01	0.01
	28	I. DO ENGENHO	1.30	11.034	11.806	12.358	8.49	9.08	9.51	0.50	0.53	0.56	0.03	0.04	0.04
	29	I. DE S. CRUZ	1.40	4.851	5.191	5.433	3.47	3.71	3.88	0.22	0.23	0.24	0.01	0.02	0.02
Island sub total			48.00	178.319	190.801	199.716	3.71	3.98	4.16	7.75	8.29	8.69	0.47	0.53	0.56
Total			4080.50	7.594.031	8.636.030	9.564.783	1.86	2.12	2.34	330.58	375.39	415.33	20.34	23.17	25.69

population(persons)



BOD Load(t/d)

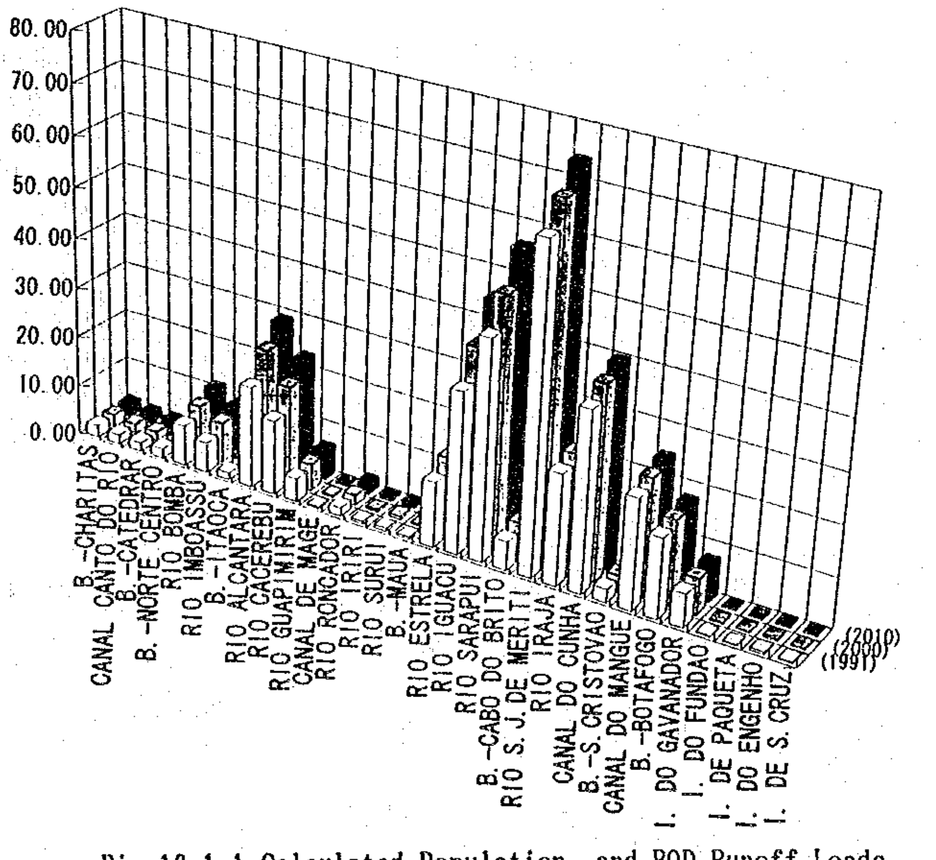


Fig.13.1-1 Calculated Population and BOD Runoff Loads

13.2 Future Water Quality in the Bay Estimated by Numerical Simulation

13.2.1 Calculation Case

The future runoff loads entering into the bay will certainly increase with the increase in population, development of production activities etc. We estimated the future water quality in the bay, for the case when measures for the improvement of water quality are left as they are.

We carried out the calculation by a numerical simulation for the following cases;

(1) Present Case : 1991
(2) Future Case : 2000
(3) Future Case : 2010 (Scenario 2)

As a trial calculation, we used annual mean values for each year shown in **Table 13.2-1** as runoff loads from rivers, and used present loads as direct loads into the bay and also the release loads from sediment.

As stated in Chapter 10 and 11, we considered PO_4-P and O-P as nutrient salts in the numerical simulation model for the estimation of water quality in the bay.

Therefore, we estimated PO_4-P and O-P loads from the results of T-P shown in **Table 13.2-1**. For the estimation of PO_4-P load, we assumed the relation of PO_4-P/T-P = 0.40 which was obtained empirically. The O-P load was calculated as the difference between T-P and PO_4-P. The results for each year are shown in **Table 13.2-2** and **13.2-3**.

The effluent loads from each basin are summarized in **Table 13.2-4**. It is estimated that the total load of all basins will increase by 12.6 % by 2000 and 23.9 % by 2010 compared to the present (1991). For each basin, the increase is high for the Northeastern Basin, Eastern Basin and Northwestern Basin.

We also used the same coefficients for future cases as were used in the present case (**Table 11.1-3**) for the Eutrophication Model.

Table 13.2-1 External Load at Present (Annual Mean)

RIVER INFLOW — Annual Mean value in 1991

NO	NAME	I	J	Discharge (m3/s)	BOD (t/day)	COD (t/day)	PO4-P (t/day)	O-P (t/day)
River load								
1	B.-CHARITAS	46	38	1.17	2.35	1.89	0.060	0.090
2	CANAL CANTO DO RIO	43	39	0.92	1.84	1.49	0.048	0.072
3	B.-CATEDRAR	40	43	0.86	1.65	1.33	0.044	0.066
4	B.-NORTE CENTRO	40	47	0.96	1.92	1.55	0.048	0.072
5	RIO BOMBA	45	52	3.75	8.00	6.33	0.204	0.306
6	RIO IMBOASSU	52	63	3.14	6.02	4.81	0.152	0.228
Eastern Sub Total				10.80	21.78	17.40	0.556	0.834
7	B.-ITAOCA	52	70	0.73	1.41	1.14	0.036	0.054
8	RIO ALCANTARA	59	76	11.48	20.07	16.01	0.480	0.720
9	RIO CACEREBU	60	81	27.67	14.80	17.28	0.320	0.480
10	RIO GUAPIMIRIM	59	87	32.36	4.67	12.97	0.104	0.156
11	CANAL DE MAGE	57	88	0.67	0.38	0.44	0.008	0.012
12	RIO RONCADOR	56	88	3.65	1.66	2.11	0.036	0.054
13	RIO IRIRI	49	90	0.97	0.49	0.59	0.012	0.018
14	RIO SURUI	44	87	2.09	0.63	1.02	0.016	0.024
Northeastern Sub Total				79.62	44.11	51.56	1.012	1.518
15	B.-MAUA	34	84	0.96	0.40	0.53	0.008	0.012
16	RIO ESTRELA	23	80	14.10	12.92	12.09	0.288	0.432
171	RIO IGUACU	17	76	27.01	31.97	27.58	0.720	1.080
172	RIO SARAPUI	17	76	20.61	43.40	33.72	1.064	1.596
18	B.-CABO DO BRITO	12	71	2.93	5.75	4.58	0.144	0.216
Northwestern Sub Total				65.61	94.44	78.50	2.224	3.336
19	RIO S.J.DE MERITI	9	63	28.27	64.33	49.68	1.604	2.406
20	RIO IRAJA	11	62	9.25	22.04	17.30	0.576	0.864
21	CANAL DO CUNHA	19	49	15.04	35.66	27.80	0.920	1.380
22	B.-S.CRISTOVAO	23	45	1.21	2.67	2.14	0.072	0.108
23	CANAL DO MANGUE	23	43	9.40	21.96	17.20	0.568	0.852
24	B.-BOTAFOGO	32	35	6.68	15.84	12.48	0.416	0.624
Western Sub Total				69.85	162.50	126.60	4.156	6.234
25	I.DO GAVANADOR	23	66	3.59	6.66	5.33	0.164	0.246
26	I.DO FUNDAO	18	52	0.25	0.23	0.22	0.004	0.006
27	I.DE PAQUETA	43	72	0.11	0.14	0.13	0.004	0.006
28	I.DO ENGENHO	43	56	0.23	0.50	0.41	0.012	0.018
29	I.DE S.CRUZ	41	51	0.13	0.22	0.18	0.004	0.006
Islands Sub Total				4.31	7.75	6.27	0.188	0.282
River load Total				230.19	330.58	280.33	8.136	12.204
Direct Load								
007		43	36	-	2.13	-	-	-
001		46	55	-	6.70	-	-	-
004		46	56	-	2.40	-	-	-
008		44	51	-	2.10	-	-	-
009		40	47	-	1.94	-	-	-
027		45	52	-	0.80	-	-	-
034		46	57	-	0.66	-	-	-
044		46	57	-	0.51	-	-	-
047		46	57	-	0.48	-	-	-
062		48	59	-	0.38	-	-	-
113		51	62	-	0.22	-	-	-
Eastern Sub Total				-	18.32	-	-	-
015		17	76	-	1.32	-	-	-
018		17	76	-	1.20	-	-	-
075		17	76	-	0.33	-	-	-
029		17	76	-	0.79	-	-	-
086		17	76	-	0.31	-	-	-
137		10	68	-	0.16	-	-	-
Northwestern Sub Total				-	4.11	-	-	-
030		11	62	-	0.72	-	-	-
042		11	62	-	0.52	-	-	-
051		32	36	-	0.45	-	-	-
Western Sub Total				-	1.69	-	-	-
Direct Load Sub Total				-	24.11	-	-	-
Total				230.19	354.69	280.33	8.136	12.204

Table 13.2-2 External Load in 2000

NO	NAME	I	J	Discharge (m3/s)	BOD (t/day)	PO4-P (t/day)	O-P (t/day)
River load							
1	B.-CHARITAS	46	38	1.23	2.51	0.064	0.096
2	CANAL CANTO DO RIO	43	39	0.97	1.97	0.052	0.078
3	B.-CATEDRAR	40	43	0.90	1.77	0.044	0.066
4	B.-NORTE CENTRO	40	47	1.01	2.06	0.052	0.078
5	RIO BOMBA	45	52	4.48	9.96	0.256	0.384
6	RIO IMBOASSU	52	63	3.82	7.85	0.200	0.300
Eastern Sub Total				12.41	26.12	0.668	1.002
7	B.-ITAOCA	52	70	0.89	1.84	0.048	0.072
8	RIO ALCANTARA	59	76	13.41	25.33	0.612	0.918
9	RIO CACEREBU	60	81	29.54	19.46	0.420	0.630
10	RIO GUAPIMIRIM	59	87	32.76	5.22	0.116	0.174
11	CANAL DE MAGE	57	88	0.70	0.45	0.012	0.018
12	RIO RONCADOR	56	88	3.78	1.96	0.044	0.066
13	RIO IRIRI	49	90	1.00	0.58	0.012	0.018
14	RIO SURUI	44	87	2.15	0.74	0.016	0.024
Northeastern Sub Total				84.23	55.58	1.280	1.920
15	B.-MAUA	34	84	0.99	0.47	0.012	0.018
16	RIO ESTRELA	23	80	15.05	15.44	0.348	0.522
171	RIO IGUACU	17	76	29.35	38.30	0.868	1.302
172	RIO SARAPUI	17	76	22.87	49.56	1.220	1.830
18	B.-CABO DO BRITO	12	71	3.37	6.91	0.176	0.264
Northwestern Sub Total				71.63	110.68	2.624	3.936
19	RIO S.J.DE MERITI	9	63	30.19	69.56	1.740	2.610
20	RIO IRAJA	11	62	9.83	23.61	0.620	0.930
21	CANAL DO CUNHA	19	49	15.99	38.20	0.988	1.482
22	B.-S.CRISTOVAO	23	45	1.28	2.86	0.076	0.114
23	CANAL DO MANGUE	23	43	9.99	23.52	0.612	0.918
24	B.-BOTAFOGO	32	35	7.10	16.97	0.448	0.672
Western Sub Total				74.38	174.72	4.484	6.726
25	I.DO GAVANADOR	23	66	3.76	7.13	0.176	0.264
26	I.DO FUNDAO	18	52	0.26	0.25	0.008	0.012
27	I.DE PAQUETA	43	72	0.11	0.15	0.004	0.006
28	I.DO ENGENHO	43	56	0.25	0.53	0.016	0.024
29	I.DE S.CRUZ	41	51	0.13	0.23	0.008	0.012
Islands Sub Total				4.51	8.29	0.212	0.318
River load Total				247.16	375.39	9.268	13.902
Direct Load							
007		43	36	-	2.13	-	-
001		46	55	-	6.70	-	-
004		46	56	-	2.40	-	-
008		44	51	-	2.10	-	-
009		40	47	-	1.94	-	-
027		45	52	-	0.80	-	-
034		46	57	-	0.66	-	-
044		46	57	-	0.51	-	-
047		46	57	-	0.48	-	-
062		48	59	-	0.38	-	-
113		51	62	-	0.22	-	-
Eastern Sub Total				-	18.32	-	-
015		17	76	-	1.32	-	-
018		17	76	-	1.20	-	-
075		17	76	-	0.33	-	-
029		17	76	-	0.79	-	-
086		17	76	-	0.31	-	-
137		10	68	-	0.16	-	-
Northwestern Sub Total				-	4.11	-	-
030		11	62	-	0.72	-	-
042		11	62	-	0.52	-	-
051		32	36	-	0.45	-	-
Western Sub Total				-	1.69	-	-
Direct Load Sub Total				-	24.11	-	-
Total				247.16	399.50	9.268	13.902

Table 13.2-3 External Load in 2010 (Scenario-2)

NO	NAME	I	J	Discharge (m3/s)	BOD (t/day)	PO4-P (t/day)	O-P (t/day)
River load							
1	B.-CHARITAS	46	38	1.27	2.63	0.068	0.102
2	CANAL CANTO DO RIO	43	39	1.00	2.07	0.056	0.084
3	B.-CATEDRAR	40	43	0.93	1.85	0.048	0.072
4	B.-NORTE CENTRO	40	47	1.05	2.16	0.056	0.084
5	RIO BOMBA	45	52	5.00	11.34	0.296	0.444
6	RIO IMBOASSU	52	63	4.30	9.13	0.232	0.348
Eastern Sub Total				13.55	29.18	0.756	1.134
7	B.-ITAOCA	52	70	1.00	2.14	0.056	0.084
8	RIO ALCANTARA	59	76	14.75	28.99	0.704	1.056
9	RIO CACEREBU	60	81	30.89	22.90	0.500	0.751
10	RIO GUAPIMIRIM	59	87	33.25	5.97	0.132	0.198
11	CANAL DE MAGE	57	88	0.73	0.55	0.012	0.018
12	RIO RONCADOR	56	88	3.94	2.35	0.052	0.078
13	RIO IRIRI	49	90	1.05	0.69	0.016	0.024
14	RIO SURUI	44	87	2.21	0.88	0.020	0.031
Northeastern Sub Total				87.82	64.47	1.493	2.239
15	B.-MAUA	34	84	1.03	0.56	0.012	0.018
16	RIO ESTRELA	23	80	16.19	18.47	0.420	0.631
171	RIO IGUACU	17	76	31.93	45.29	1.032	1.548
172	RIO SARAPUI	17	76	25.30	56.17	1.392	2.088
18	B.-CABO DO BRITO	12	71	3.85	8.20	0.208	0.312
Northwestern Sub Total				78.30	128.69	3.064	4.597
19	RIO S.J.DE MERITI	9	63	31.88	74.14	1.860	2.791
20	RIO IRAJA	11	62	10.25	24.73	0.652	0.978
21	CANAL DO CUNHA	19	49	16.66	40.02	1.036	1.554
22	B.-S.CRISTOVAO	23	45	1.33	2.99	0.080	0.120
23	CANAL DO MANGUE	23	43	10.40	24.64	0.640	0.960
24	B.-BOTAFOGO	32	35	7.40	17.78	0.472	0.708
Western Sub Total				77.92	184.30	4.740	7.111
25	I.DO GAVANADOR	23	66	3.89	7.47	0.188	0.282
26	I.DO FUNDAO	18	52	0.26	0.26	0.008	0.012
27	I.DE PAQUETA	43	72	0.11	0.16	0.004	0.006
28	I.DO ENGENHO	43	56	0.25	0.56	0.016	0.024
29	I.DE S.CRUZ	41	51	0.14	0.24	0.008	0.012
Islands Sub Total				4.65	8.69	0.224	0.336
River load Total				262.24	415.33	10.278	15.416
Direct Load							
007		43	36	-	2.13	-	-
001		46	55	-	6.70	-	-
004		46	56	-	2.40	-	-
008		44	51	-	2.10	-	-
009		40	47	-	1.94	-	-
027		45	52	-	0.80	-	-
034		46	57	-	0.66	-	-
044		46	57	-	0.51	-	-
047		46	57	-	0.48	-	-
062		48	59	-	0.38	-	-
113		51	62	-	0.22	-	-
Eastern Sub Total				-	18.32	-	-
015		17	76	-	1.32	-	-
018		17	76	-	1.20	-	-
075		17	76	-	0.33	-	-
029		17	76	-	0.79	-	-
086		17	76	-	0.31	-	-
137		10	68	-	0.16	-	-
Northwestern Sub Total				-	4.11	-	-
030		11	62	-	0.72	-	-
042		11	62	-	0.52	-	-
051		32	36	-	0.45	-	-
Western Sub Total				-	1.69	-	-
Direct Load Sub Total				-	24.11	-	-
Total				262.24	439.44	10.278	15.416

Table 13.2-4 Future Runoff Load for BOD without Measures

Basin	1991	2000	2010
Eastern Basin	40.1 ton/day	44.4 ton/day (+10.8%)	47.5 ton/day (+18.5%)
Northeastern Basin	44.1 ton/day	55.6 ton/day (+26.0%)	64.5 ton/day (+46.2%)
Northwestern Basin	94.6 ton/day	114.8 ton/day (+16.5%)	132.8 ton/day (+34.8%)
Western Basin	164.2 ton/day	176.4 ton/day (+ 7.4%)	186.0 ton/day (+13.3%)
Islands	7.8 ton/day	8.3 ton/day (+ 7.0%)	8.7 ton/day (+12.1%)
Total	354.7 ton/day	399.5 ton/day (+12.6%)	439.5 ton/day (+23.9%)

13.2.2 Results

The results are shown in **Fig.13.2-1** for 2000 and in **Fig.13.2-2** for 2010, for when no measures are taken, for the upper and lower layers for the distribution of BOD, T-P and DO concentrations with the annual mean value.

It is obvious that areas with high concentrations of organic matter and nutrient salts expand with the increase of effluent loads.

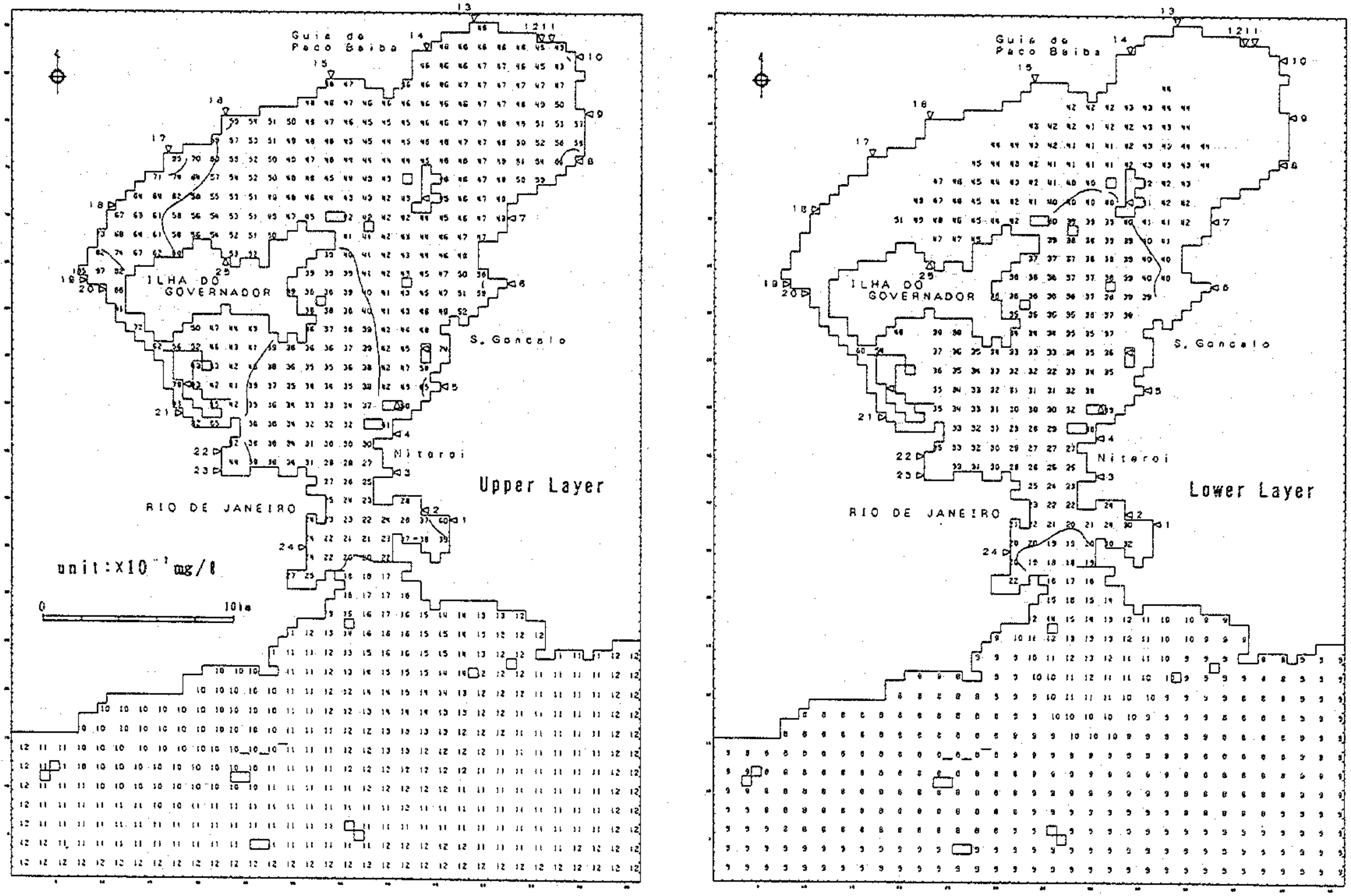
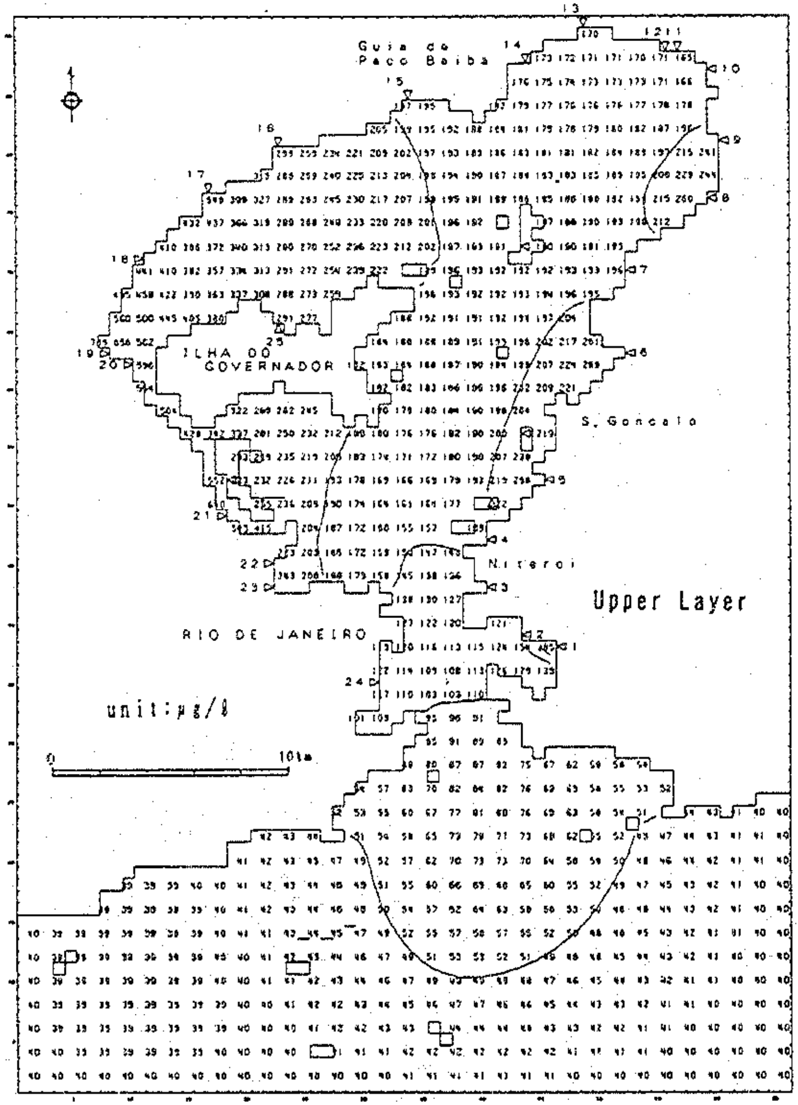


Fig.13.2-1(1) Calculated Water Quality in 2000 without Measure (BOD)



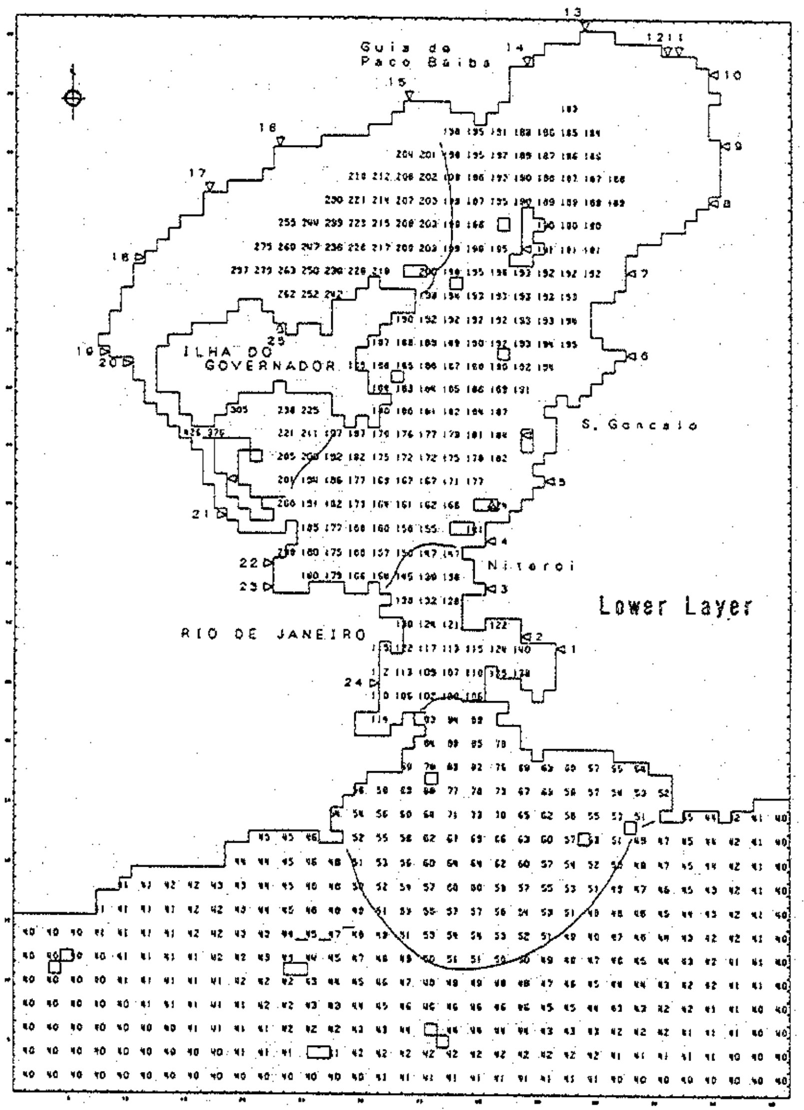
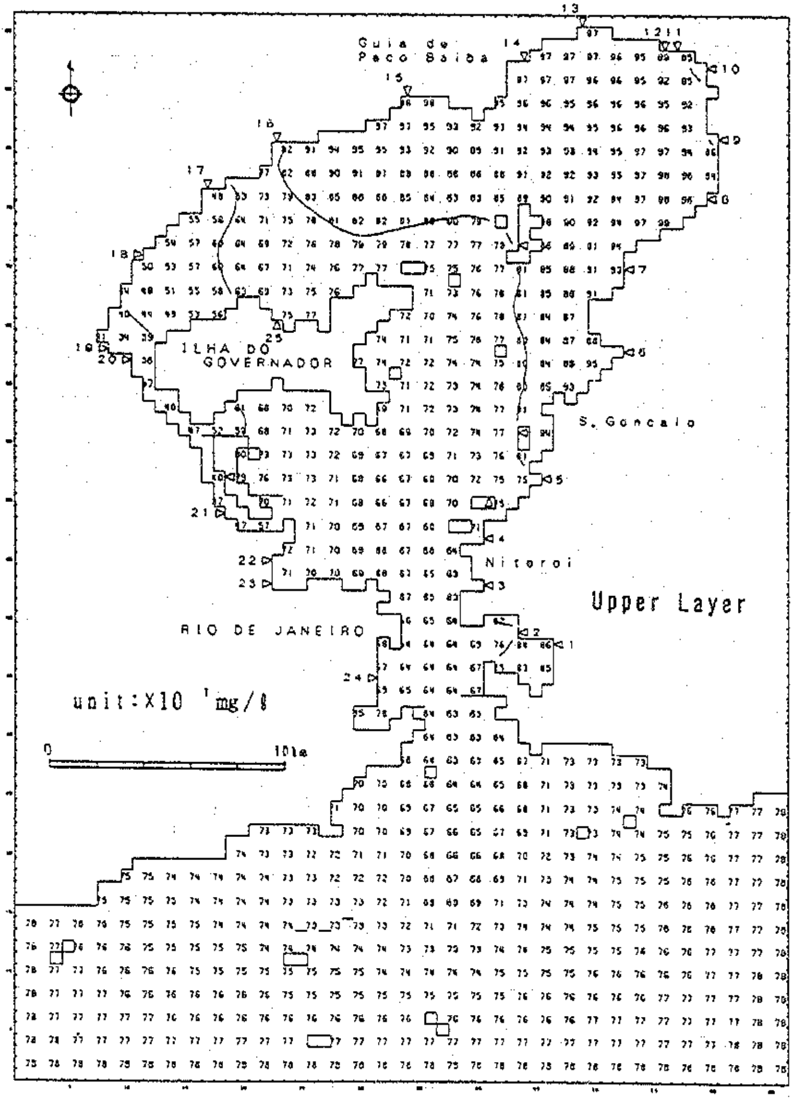


Fig.13.2-1(2) Calculated Water Quality in 2000 without Measure (T-P)



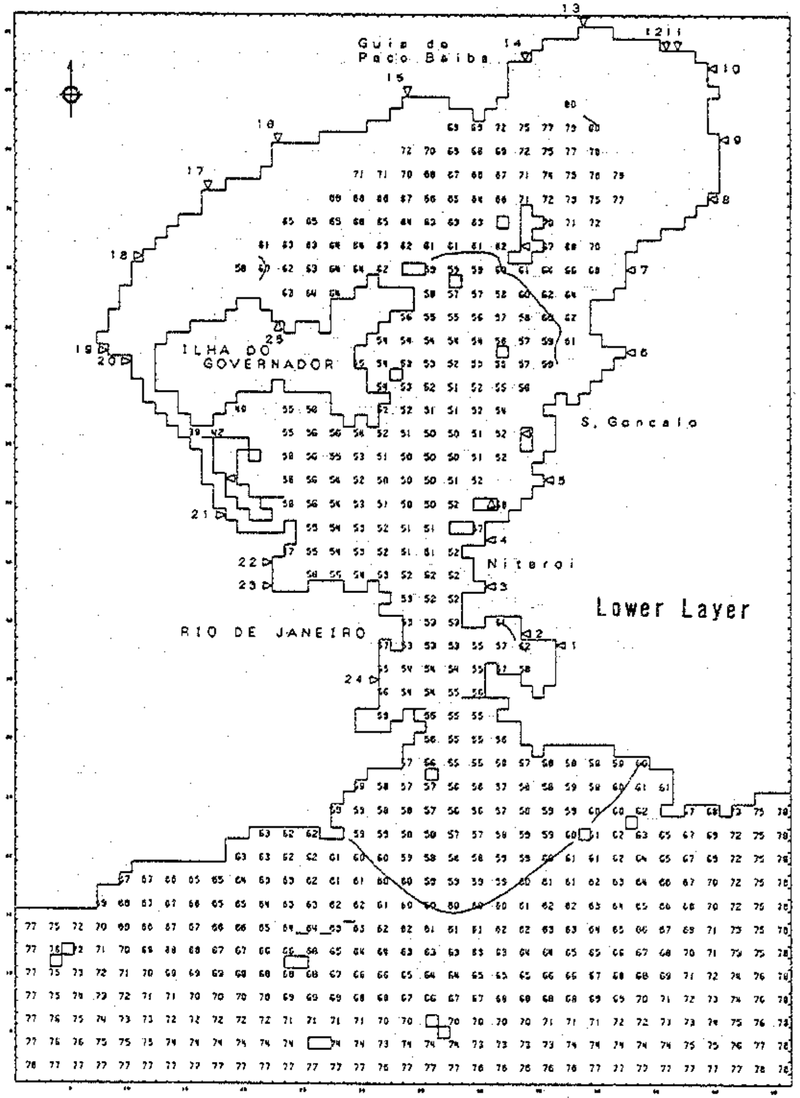
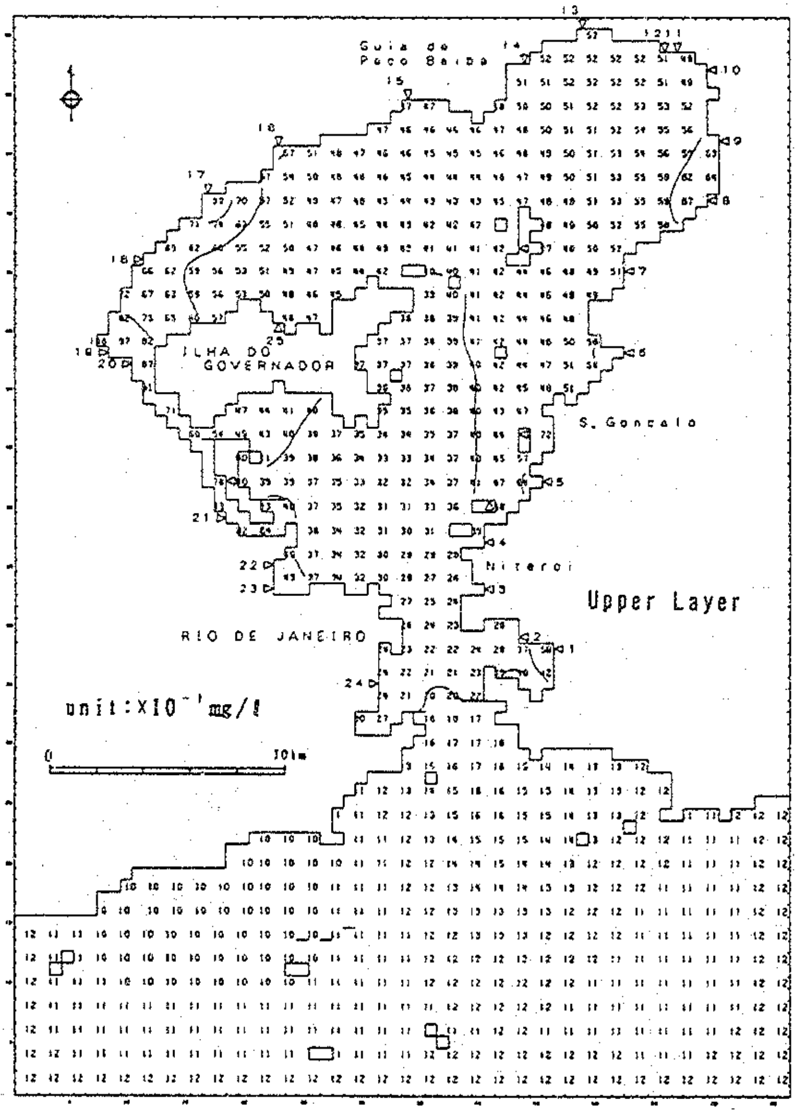


Fig.13.2-1(3) Calculated Water Quality in 2000 without Measure (DO)



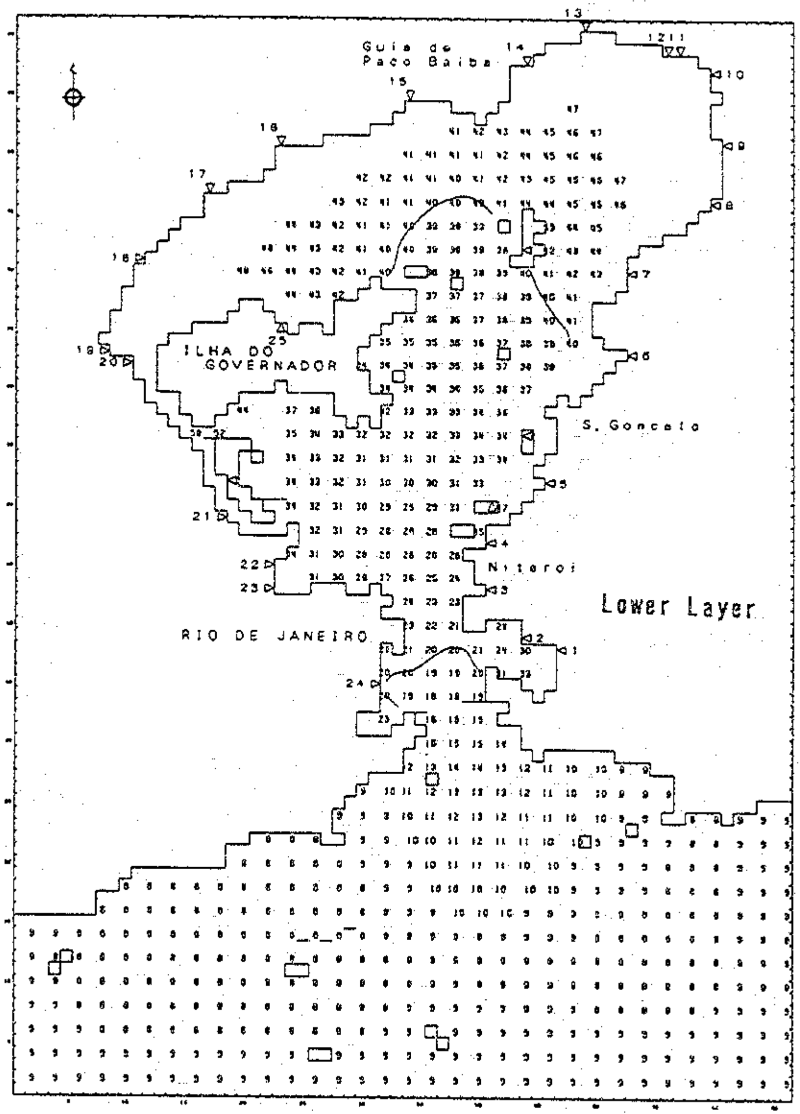


Fig.13.2-2(1) Calculated Water Quality in 2010 without Measure (sinario-2) (BOD)

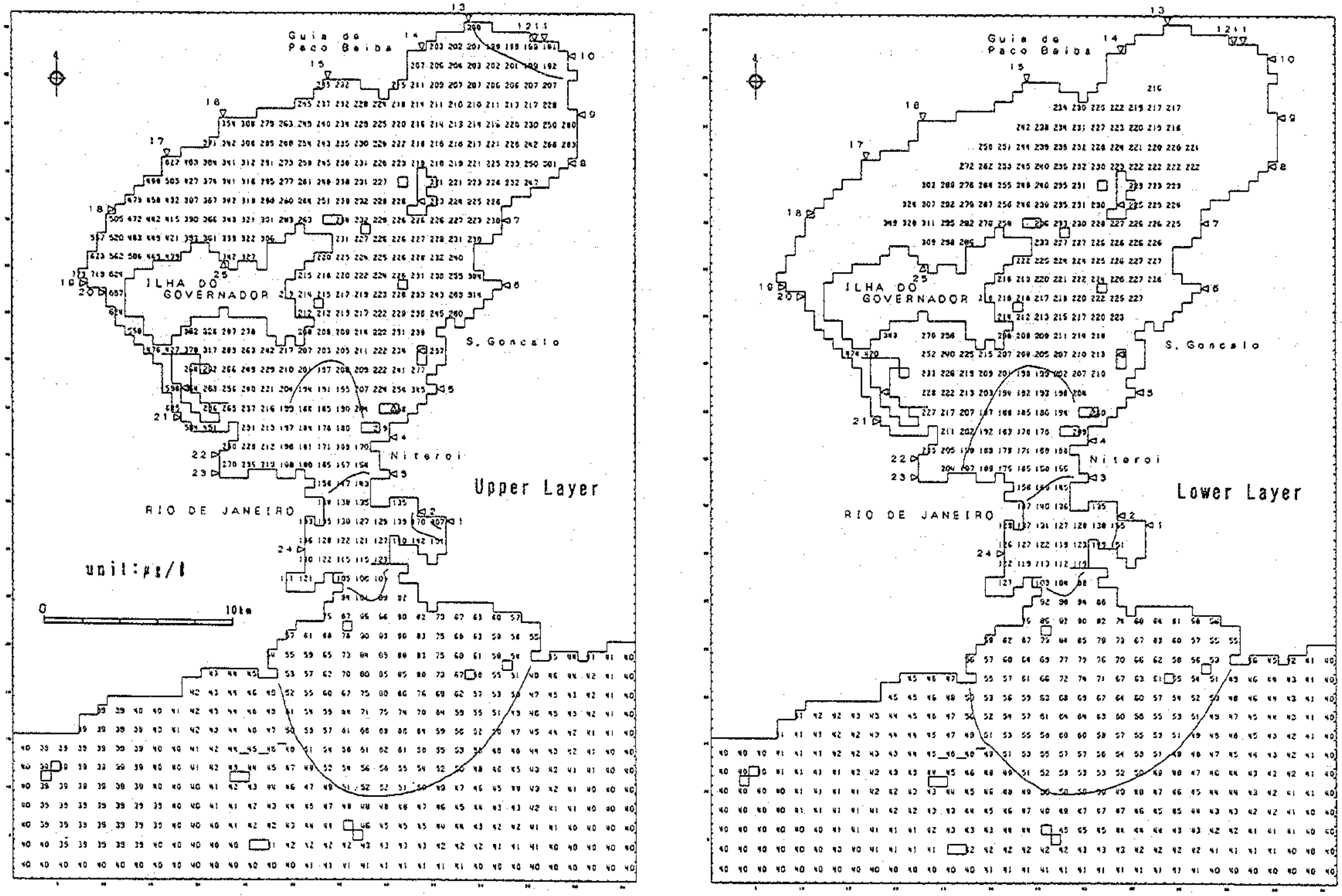
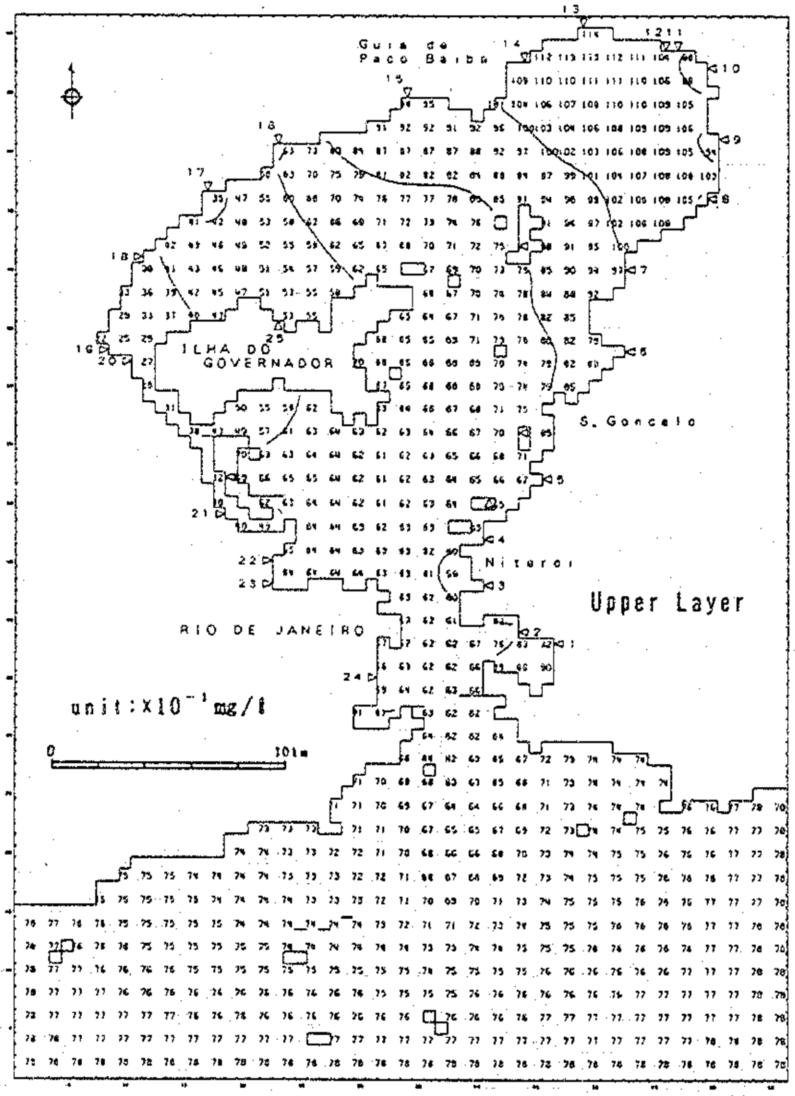


Fig.13.2-2(2) Calculated Water Quality in 2010 without Measure (sinario-2) (T-P)



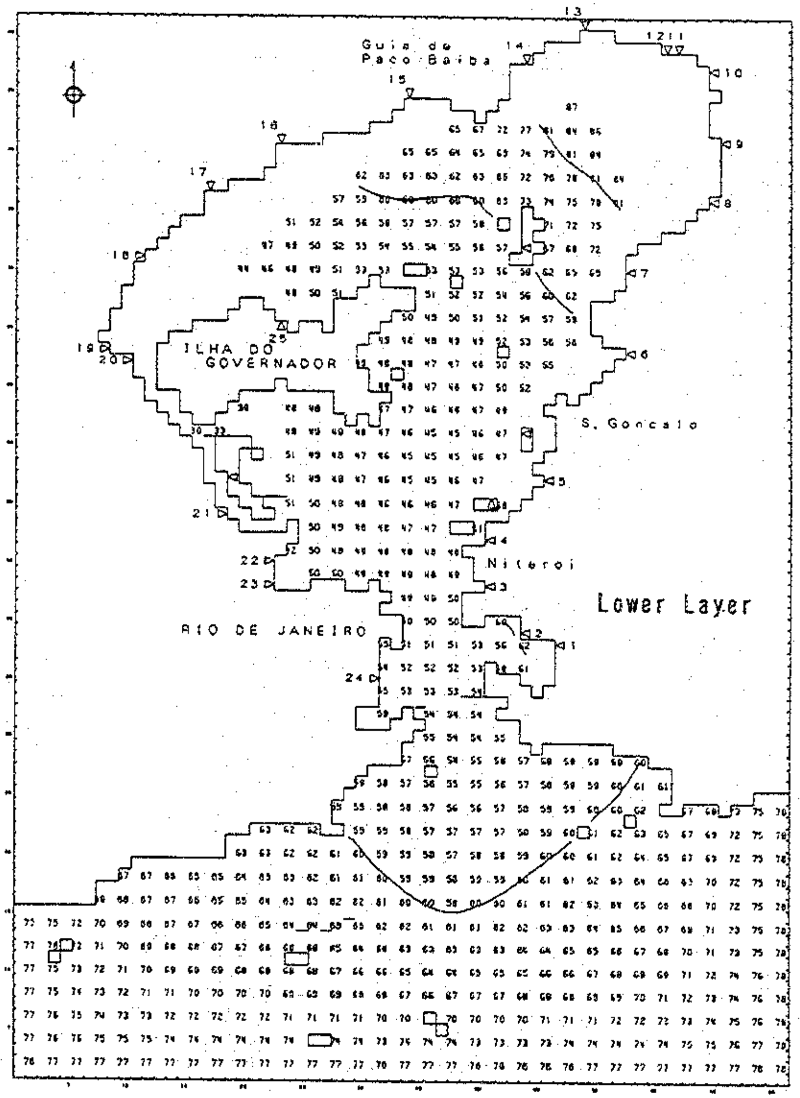


Fig.13.2-2(3) Calculated Water Quality in 2010 without Measure (sinario-2) (DO)

13.2.3 Evaluation of the Calculation Result

Fig.13.2-3 and **Fig. 13.2-4** show the differences of the BOD and T-P concentrations at each lattice point between the year 2000 and 1991, and 2010 and 1991.

We calculated the average BOD and T-P concentrations in each block and the increase of BOD and T-P concentrations compared to the present concentration in each block. The results are shown in **Fig.13.2-5**and **Fig.13.2-6**.

These figures show that BOD concentrations increase 6.2% (0.25 mg/l) by 2000, on average for all the bay. By regional groups, high increases are seen in the northeastern area of the bay at 0.80 mg/l in Block F by 2010, with the highest increase being 19.7 %.

Regarding T-P, high increases of values occur in the whole bay area, 39 % increase from 0.18 mg/l (1991) to 0.25 mg/l (2010) for the average concentration in the bay.

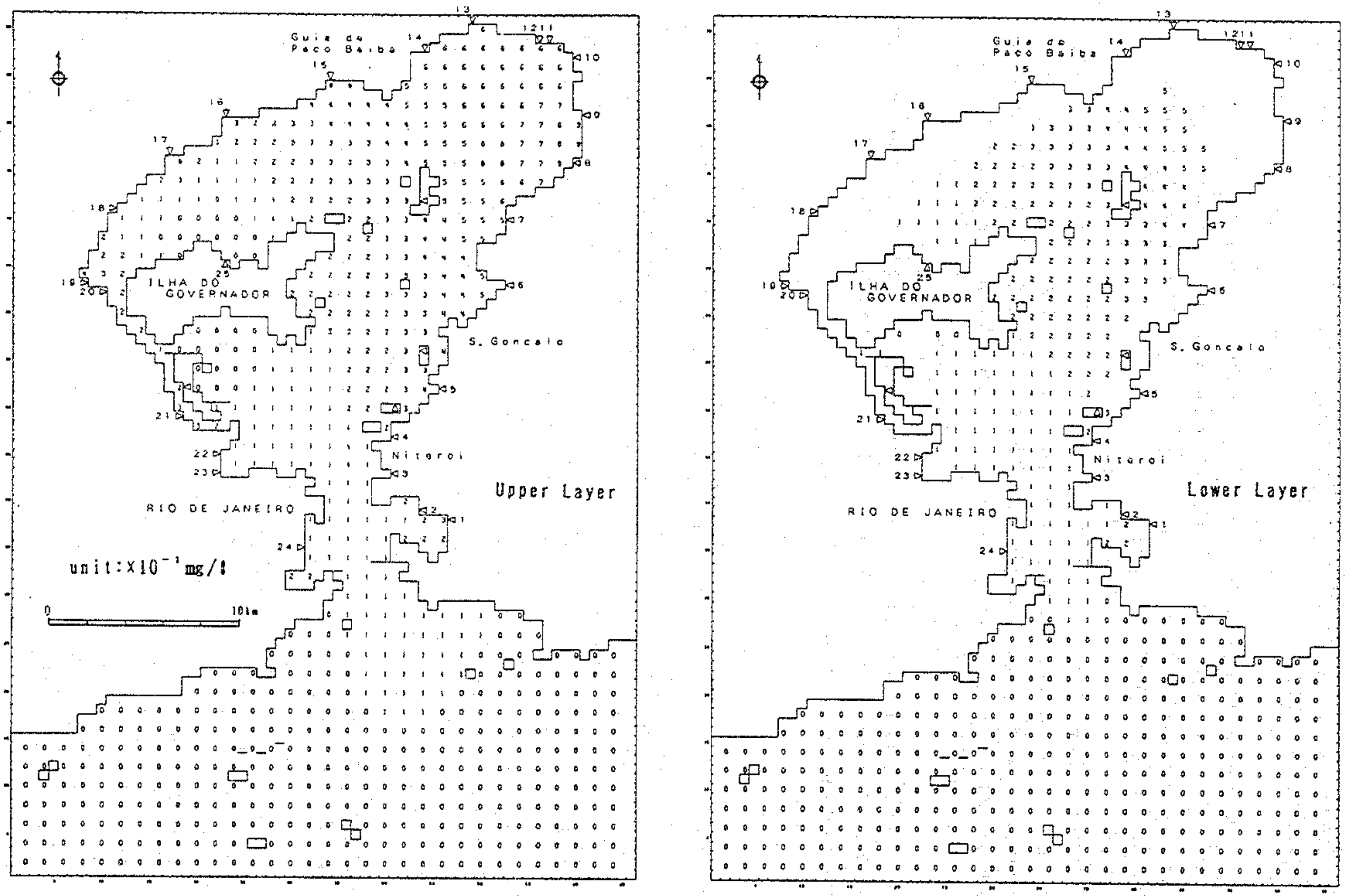
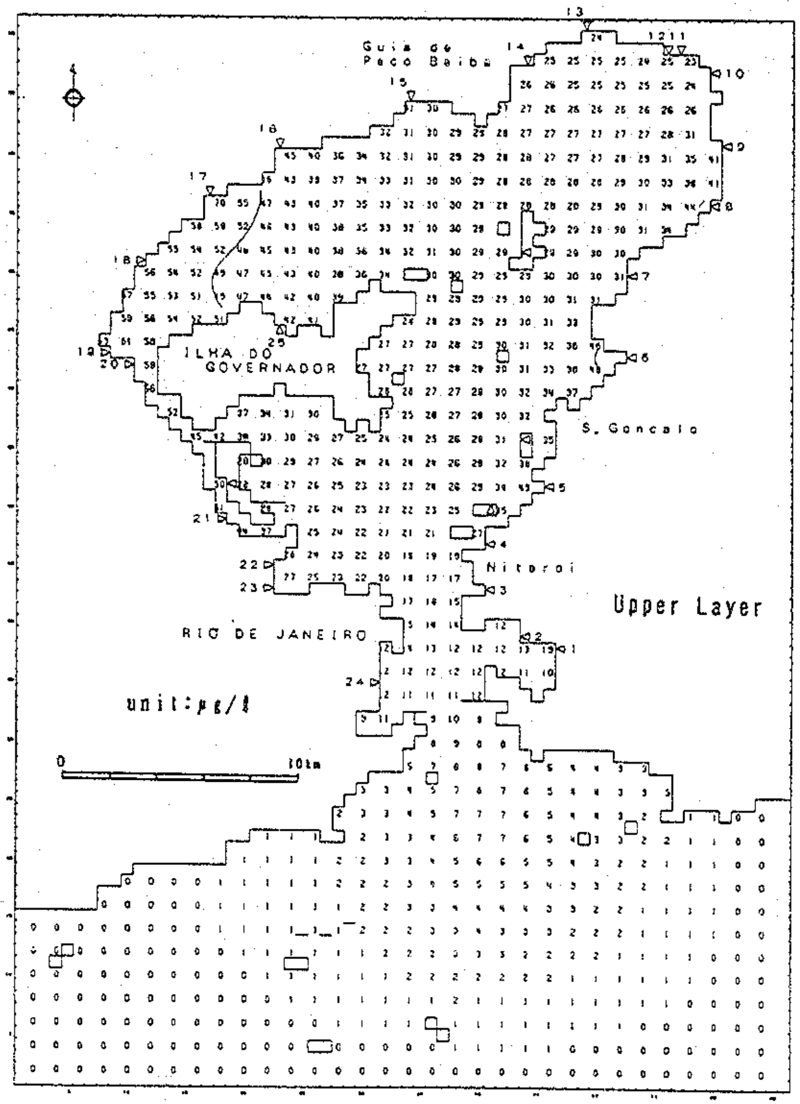


Fig.13.2-3(1) Water Quality Variation from 1991 to 2000 without Measure
(BOD)



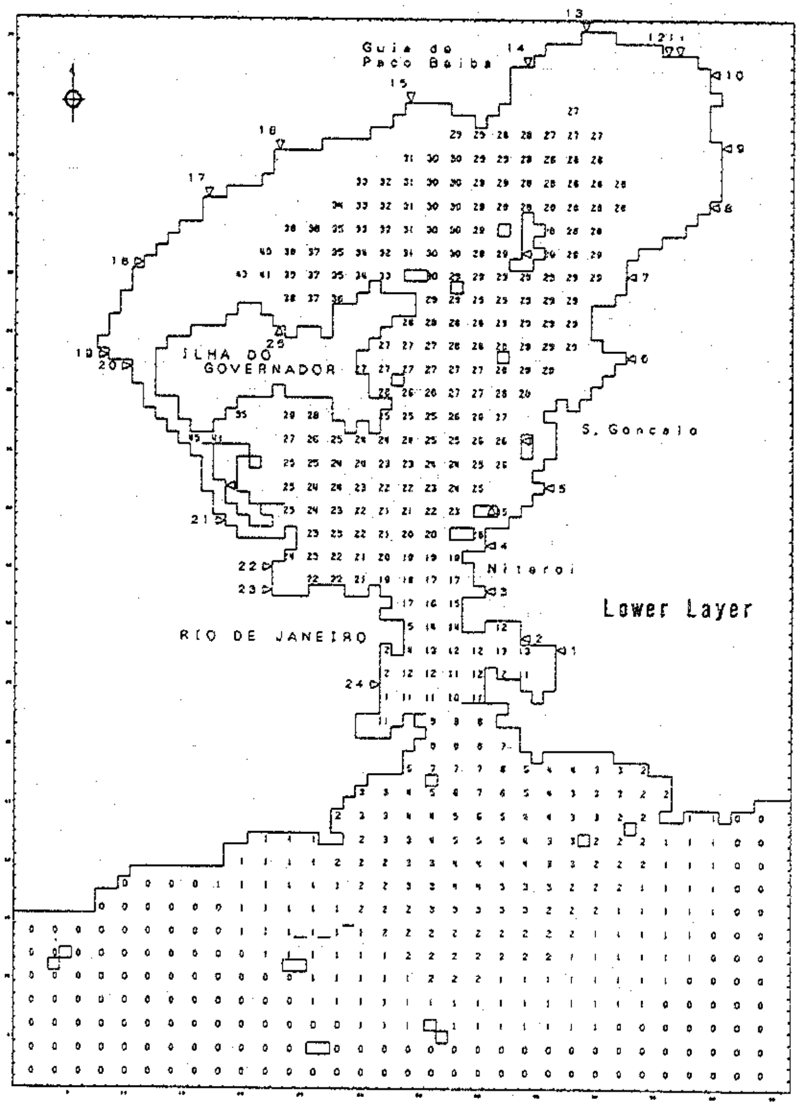


Fig.13.2-3(2) Water Quality Variation from 1991 to 2000 without Measure

(T-P)

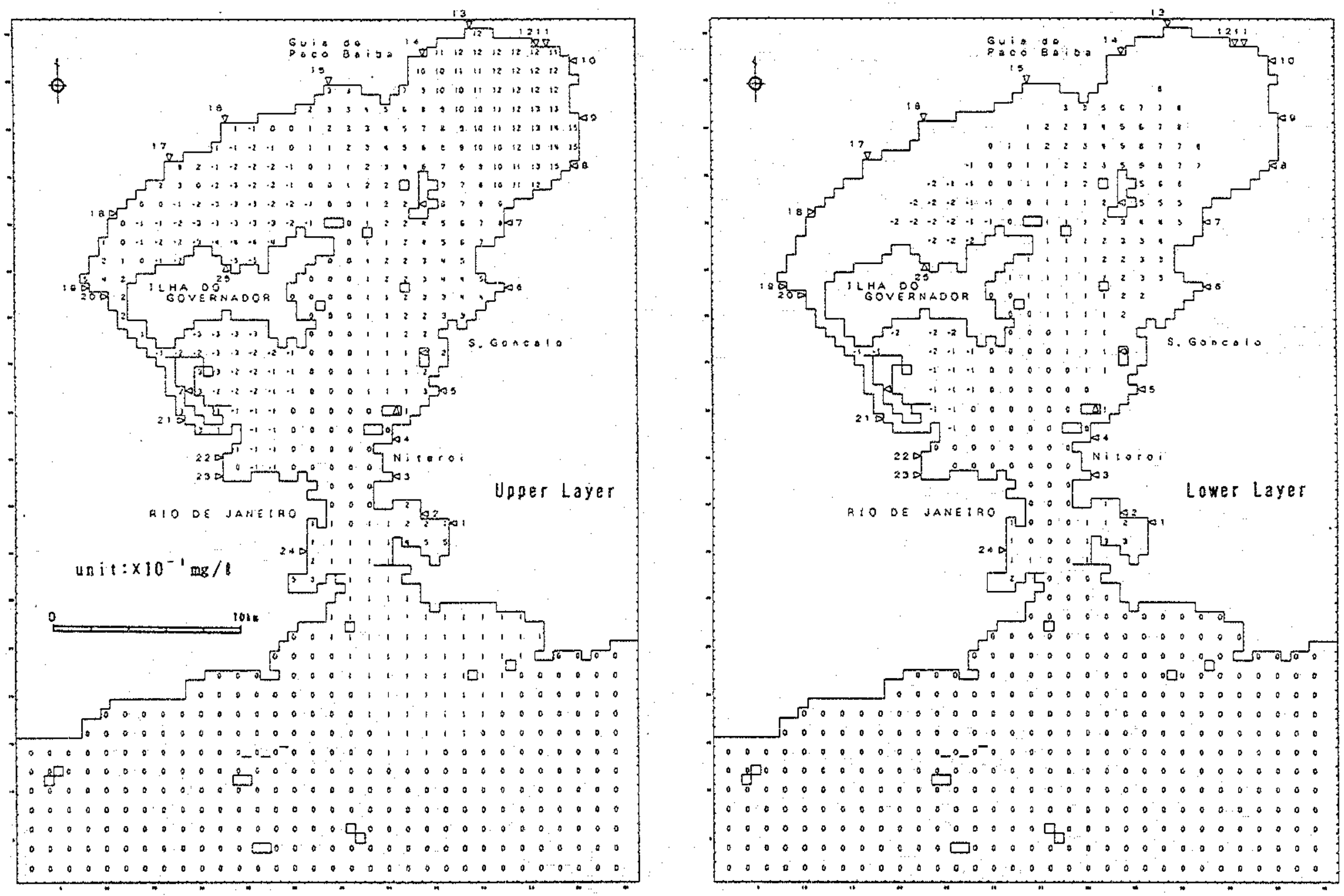


Fig.13.2-4(1) Water Quality Variation from 1991 to 2010(scenario-2) without Measure (BOD)

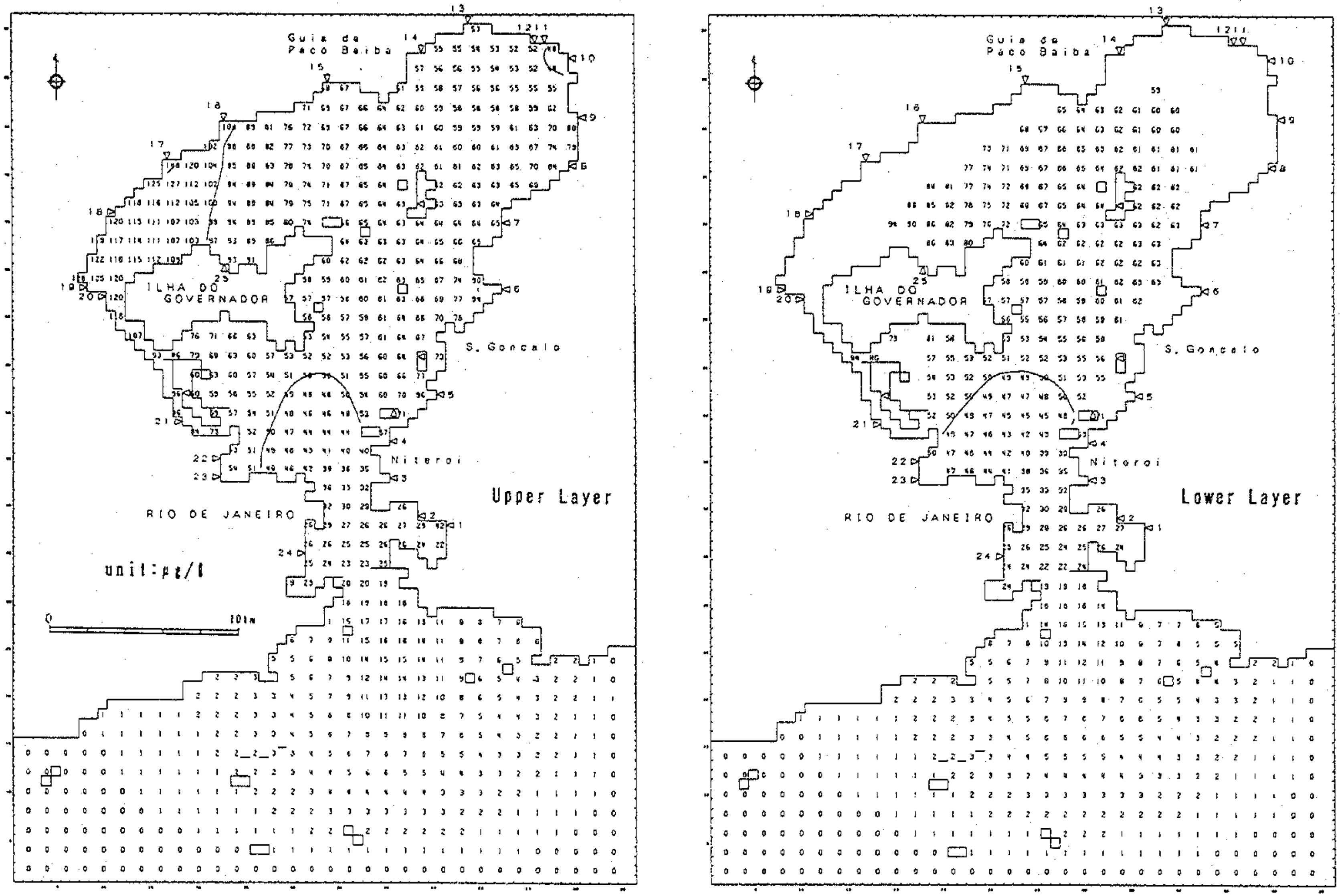


Fig.13.2-4(2) Water Quality Variation from 1991 to 2010(scenario-2) without Measure (T-P)

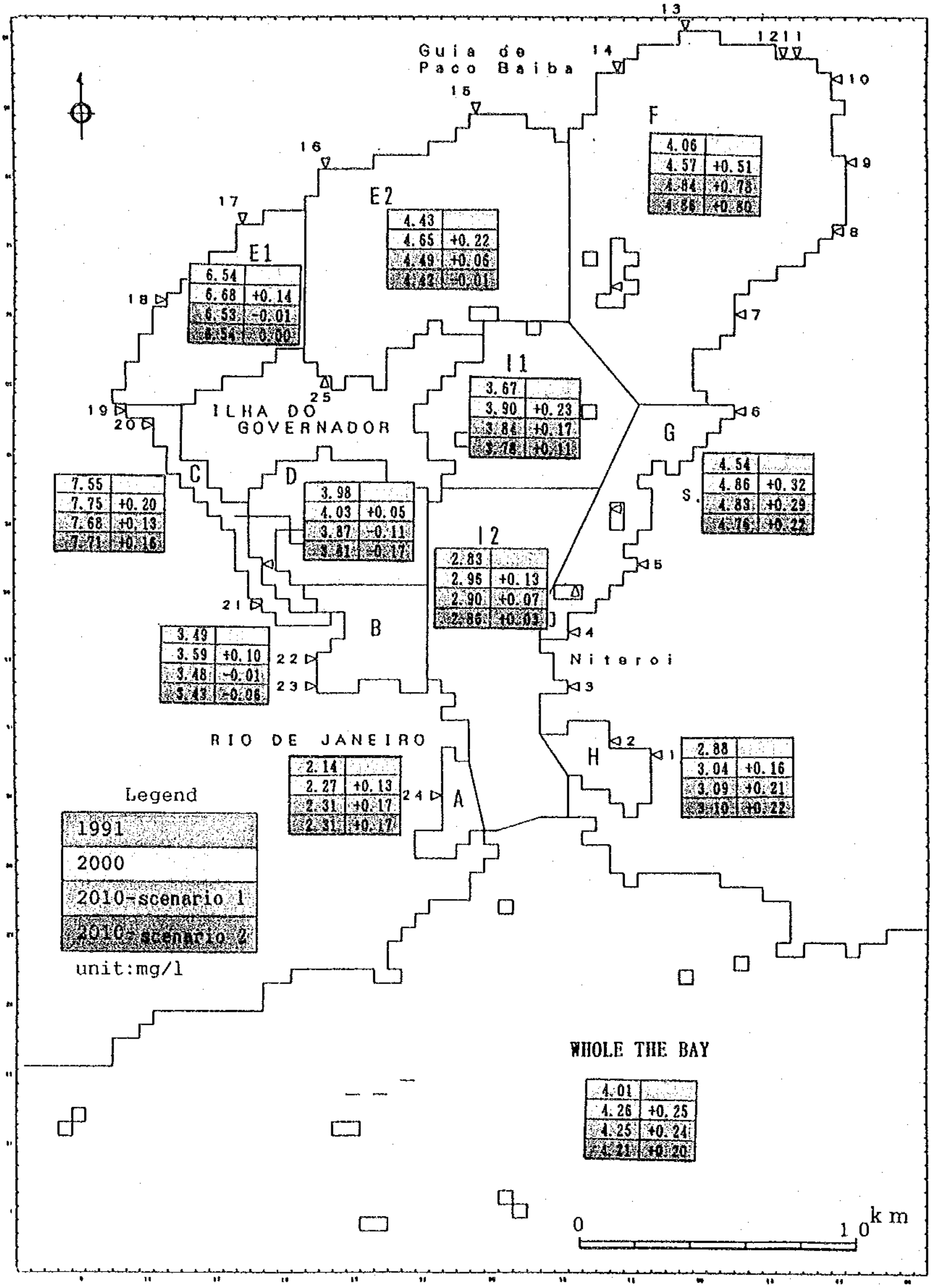


Fig. 13.2-5 Distribution of BOD Concentration without Measure

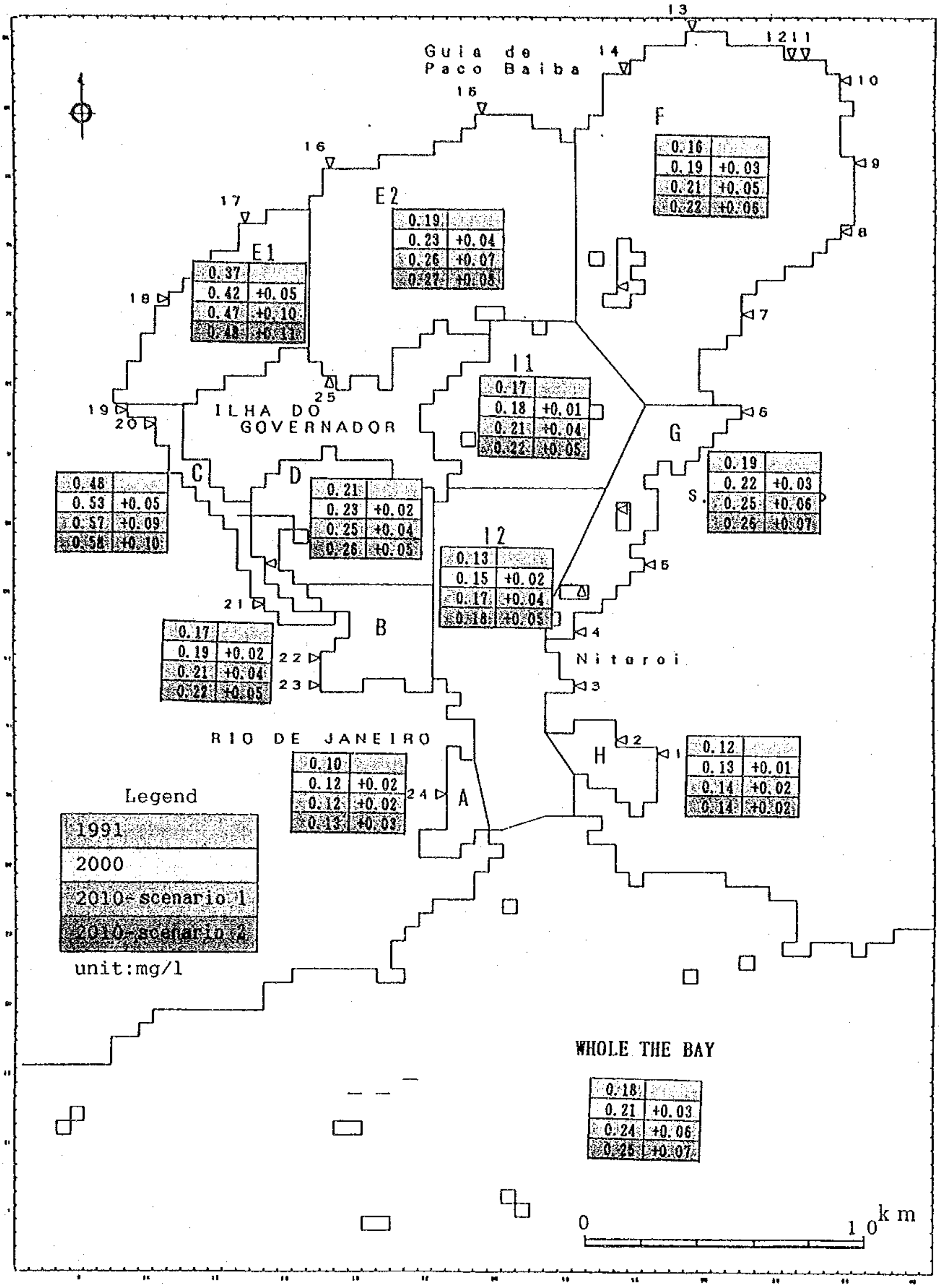


Fig. 13.2-6 Distribution of T-P Concentration without Measure

PART VII

MEASURES TO RECUPERATE THE GUANABARA BAY ECOSYSTEM

CHAPTER 14

EXISTING FACTORS

AND

ISSUES OF

SOFTWARE-TYPE MEASURES

CHAPTER 14

EXISTING FACTORS AND ISSUES OF SOFTWARE-TYPE MEASURES

Administrative systems, legislative systems, financial systems and education systems (we call these systems "software-type measure") are of great importance to solve water pollution. Wastewater treatment technologies which are called "hardware-type measures" in this study are of another importance.

Question is a coordination between the two. Without firm backing of software-type measures, hardware-type measures could not meet the objective in an effective manner. In this chapter, several software-type measures in the state of Rio de Janeiro were reviewed and current issues were analyzed.

14.1 Components of the Software-type Measures

It is necessary to keep a balance between economic activities, the preservation of nature and the living conditions of residents to maintain the environment in an assimilative capacity. This is the reason why administrative intervention is necessary to preserve the environment, including the water quality.

The principal components of the social system for the water quality improvement are summarized in **Table 14.1-1.**

These components are more important than the techniques for the improvement of the river and/or sea water.

14.2 Administrative System

14.2.1 Administrative Organizations

It should be emphasized that the water quality improvement project is linked to many administrative organizations, whose cooperation is indispensable in attaining the objectives of the project.

Table 14.1- 1 Components of the Software-Type Measures

Component of Measures	Details of Each Component
(1) Administrative System	Administrative organization to carry out environmental policy. Role of a research institute attached to the administrative agency.
(2) Legislative System	Regulation of water quality standards. Regulation of effluents from individual pollution sources. Regulation of land uses. Environment impact assessment system.
(3) Agreement & Approval System	Agreement system between the local government and the owners of firms. Permission and approval system for the authorities concerned.
(4) Economic System	Demand controlling water charge system. Effluent charge system. Product charge system. Marketable certificate of right to pollute. Subsidy system. Treasury investment and loan system. Tax reduction system.
(5) Financial System	Financing from taxes. Financing from incomes of government works. Fund raising system through fining polluters. Fund raising system through beneficiaries. Credit financing system.
(6) Resident Participation System	Participation system on explanation meetings or public hearings etc. Public movement through environmental groups. (so-called NGO)
(7) Education System	Education system by the state. Education system by municipalities.

In regard to the recuperation of the ecosystem in Guanabara Bay, the following administrative organizations have important roles;

[Federal Level]

SEMA : Environment Secretariat
CONAMA : National Council of Environment

[State Level]

CODEG : Coordinate Commission for Program of Depollution in the Guanabara Bay
SEMAMPE : State Secretariat of the Environment and Special Projects
CECA : State Commission for Environment Control
FECAM : Special Fund for Environment Control
FEEMA : State Foundation for Environmental Engineering
SERLA : State Institute for Rivers and Lagoons
IEF : State Institute for Forest Preservation
SOSP : Secretariat of Public Works
CEDAE : State Company of Water and Sewage

[Municipality Level]

COMLURB : Municipal Company of Urban Cleaning

Within the organizations described above, those in the State of Rio de Janeiro, such and CODEG, SEMAMPE, CECA, and three organizations of FEEMA, SERLA and IEF which are under SEMAMPE have relatively important roles in the improvement and control of the water quality in the Bay.

14.2.2 Role of Administrative Organizations

The role and activities of the main organizations are as follows;

CODEG : To coordinate and follow special projects related to the improvement of the inhabitants quality of life and environmental conditions of the Guanabara Bay basin.

To assist the Rio de Janeiro State and the Rio de Janeiro Municipality together with financing agencies during the implementation phase of projects.

SEMAMPE: To promote, supervise, coordinate and execute programs, projects and official activities related to environment.

To exert the power of environmental legislation through licensing and control of potential polluting activities, as well as through the application of penalties when the legislation is not followed.

To establish environmental norms and standards for the State of Rio de Janeiro.

To cooperate with the federal and municipal authorities as well as with authorities from other states in order to execute measures related to pollution control and natural resource preservation.

To implant and administer the organs of nature conservation instituted by the State.

To execute drainage works in order to recuperate the fluvial and lake basins in relation to flood control, erosion and to regulate the fluvial regime.

To manage the state's resources.

CECA : To approve and propose to SEMAMPE the necessary measures for pollution control and environmental protection recommended by FEEMA.

To exert police power related to pollution control and environmental protection.

To give permission for the operation of potential-pollution activities.

FEEMA : To research and to control the environment, and to establish norms and standards, to train and serve personnel for the rational utilization of the environment.

To give technical support to CECA.

To suggest the necessary measures for pollution control and environment protection to CECA.

To deal with the fiscal issues concerning environmental protection standards in the State of Rio de Janeiro in the name of CECA, including also the federal standards.

SERLA : To maintain river basins and lakes controlling the effects of floods and erosion, and to regulate the fluvial regime in rivers, channels and estuaries.

To execute macrodrainage, microdrainage and underground drainage works for the recuperation of dense urban areas.

To inspect the following things related to marginal areas of water bodies under state jurisdiction;

. Protection of lagoons and natural water bodies against the interference of rural and urban processes.

. Control of erosion and solid transportation in rivers, lagoons, estuaries and coastal areas.

. Conservations of rivers, channels, lakes, lagoons and their estuaries.

IEF : To attend the necessity of flora and fauna conservation.

To promote reforestation.

To execute the forest policy, promoting the compatibility of the socioeconomic development with the environmental conservation in the State of Rio de Janeiro.

14.2.3 Current Issues of the Administrative System

At present the most important thing to do for the recuperation of the ecosystem in Gunabara Bay is to activate the above mentioned administrative organizations of the State of Rio de Janeiro related to water quality improvement under the strong leadership of SEMAMPE cooperating with CODEG.

SEMAMPE should render competent administrative and economic assistance to FEEMA, SERLA and IEF. These organizations have many able engineers of which effective activation seems not to be too difficult.

Recently, FEEMA stopped monitoring the water quality in the Bay, which had been carried out for more than two decades. The monitoring for effluents from industry also looks like being restricted. Financial problems are the reason why FEEMA can not continue the monitoring as it did. This example suggests that the state government is not so interested in environmental policies.

From an environmental protection point of view, CECA, which is the commission for environmental control under SEMAMPE, has a lot of power and a responsibility for the preservation and control of water quality in the Bay. Therefore, it is desired that this commission acts more energetically and exerts its power over pollution control and environmental protection issues.

The money from fines collected from pollution and environmental protection offenders is put into a fund by FECAM and it is used for pollution control and environmental protection projects through FEEMA, SERLA and IEF. This system looks to work well and should be continued.

As a result, existing administrative groups in the State of Rio de Janeiro relating to the preservation and control of water quality look sufficiently organized in themselves. However, it might be said that the government of the State of Rio de Janeiro carry forward the environmental policies more strongly backed by finances.

14.3 Legislative System

14.3.1 Water Quality Standards

In Guanabara Bay, the water area is classified into thirty six (36) segments based on a mathematical model produced by FEEMA in 1977, and the most beneficial use of each segment is decided by CONAMA. The water quality standards for each segment with regard to its use are also established by CONAMA.

The same procedure was also applied to the major rivers flowing into the Bay.

The water quality standards established by CONAMA are shown in **Table 14.3-1** for fresh water, salt water and brackish water. The standards for salt water are applied to Guanabara Bay.

The water area classification in the Guanabara Bay basin is shown in **Fig. 14.3-1** for the rivers and in **Fig. 14.3-2** for the Bay, respectively. In the rivers, Class 2 is applied to the water areas of rivers flowing into the inner part of the Bay, and Class 4 to the water area of rivers situated near the entrance of the Bay. In the Bay, Class 5 is applied to all the Bay area excluding the five (5) segments No. 21, 22, 23, 27, 30, to which Class 6 is applied.

14.3.2 Effluent Standards

The establishment of regulations on effluent pollutants is the most direct measure to conserve the environment, and its effect is immediate if its enforcement is strong. This system is imposed on effluent discharging actions directly causing water pollution.

In the State of Rio de Janeiro, effluent standards by CONAMA in terms of many parameters as a concentration of pollutants shown in **Table 14.3-2** keep the direct and indirect effluent discharge condition into the water resources in a minimum.

Thereafter, a new deliberation "Guideline for Organic Amount Control in Industrial Liquid Effluents" was established by FEEMA as effluent standards for each type of industries, which is more strict than the existing effluent standards.

Recently, FEEMA proposed the new guidelines "Taxation for the Control of Water and Air Pollution (TCPHA)" to the commission for the preservation of the environment. This proposal aims to introduce the total pollutant load system.

Table 14.3- 1 Water Quality Standard for Each Class of Water Area (CONAMA No. 20)

Fresh Water

Class	Item / Purpose of Water Use	Standard Values: pH	BOD	TDS	DO	No. of Coliform Groups	Turbidity
Special	-Public water supply without previous or with simple desinfection -Natural balance protection of aquatic life	-	-	-	-	Zero for Total Coliforms	-
Class 1	- Public water supply after simplified treatment -Aquatic life protection -Primary contact recreation -Irrigation of green vegetables eaten in raw form and fruits consumed with peel -Natural or/and intensive growing of species for human feeding	6.0 | 9.0	3 mg/l or less	500 mg/l or less	6 mg/l or more	(Recreation) not good when 80 % of samples 1000 MPN/100 ml or less F.C. or 5000 MPN/100 ml or less T.C. (Irrigation) zero coliform (Other Uses) 80% of samples 200 MPN/100 ml or less F.C. or 1000 MPN/100 ml or less T.C.	40 NTU
Class 2	-Public water supply after conventional treatment -Aquatic life protection -Primary contact recreation -Irrigation of green vegetables and fruit trees -Natural or/and intensive growing of species for human feeding	6.0 | 9.0	5 mg/l or less	500 mg/l or less	5 mg/l or more	(Recreation) equal to Class 1 (Other Uses) 80 % of samples 1000 MPN/100 ml or less F.C. 5000 MPN/100 ml or less T.C.	100 NTU
Class 3	-Public water supply after conventional treatment -Irrigation of several culture -Animal growing	6.0 | 9.0	10mg/l or less	500 mg/l or less	4 mg/l or more	80 % of samples 4000 MPN/100 ml or less F.C. or 20000 MPN/100 ml or less T.C.	100 NTU
Class 4	-Navigation -Aesthetic -Other uses	6.0 | 9.0	-	-	2 mg/l or more	-	-

(Note) F.C. : Fecal Coliforms
T.C. : Total Coliforms

Salt Water

Class	Item / Purpose of Water Use	Standard Values			
		pH	BOD	DO	No. of Coliform Groups
Class 5	-Primary contact recreation -Aquatic life protection -Natural or/and intensive growing of species for human feeding	6.5 | 8.5 pH≤ 2	5 mg/l or less	6 mg/l or more	(Recreation) equal to Class 1 (Growing of Species for Human Feeding) mean ≤ 14 MPN/100 ml F.C. and 10 % of samples ≤ 43 MPN/100 ml F.C. (Other Uses) 80% of samples : 1000 MPN/100 ml or less F.C.
Class 6	-Commercial navigation -Aesthetic -Secondary contact recreation	6.5 | 8.5 pH≤ 2	10mg/l or less	4 mg/l or more	80 % of samples 4000 MPN/100 ml or less F.C. or 2000 MPN/100 ml or less T.C.

Brackish Water

Class	Item / Purpose of Water Use	Standard Values			
		pH	BOD	DO	No. of Coliform Groups
Class 7	-Primary contact recreation -Aquatic life -Natural or/and intensive growing of species for human feeding	6.5 | 8.5	5 mg/l or less	5 mg/l or more	(Recreation) equal to Class 1 (Growing of Species for Human Feeding) mean ≤ 14 MPN/100 ml F.C. and 10 % of samples ≤ 43 MPN/100 ml F.C. (Other Uses) 80 % of samples : 1000 MPN/100 ml or less F.C. or 5000 MPN/100 ml or less T.C.
Class 8	-Commercial navigation -Aesthetic -Secondary contact recreation	5.0 | 9.0	-	3 mg/l or more	20 % of samples : 4000 MPN/100 ml or less F.C. or 20000 MPN/100 ml or less T.C.

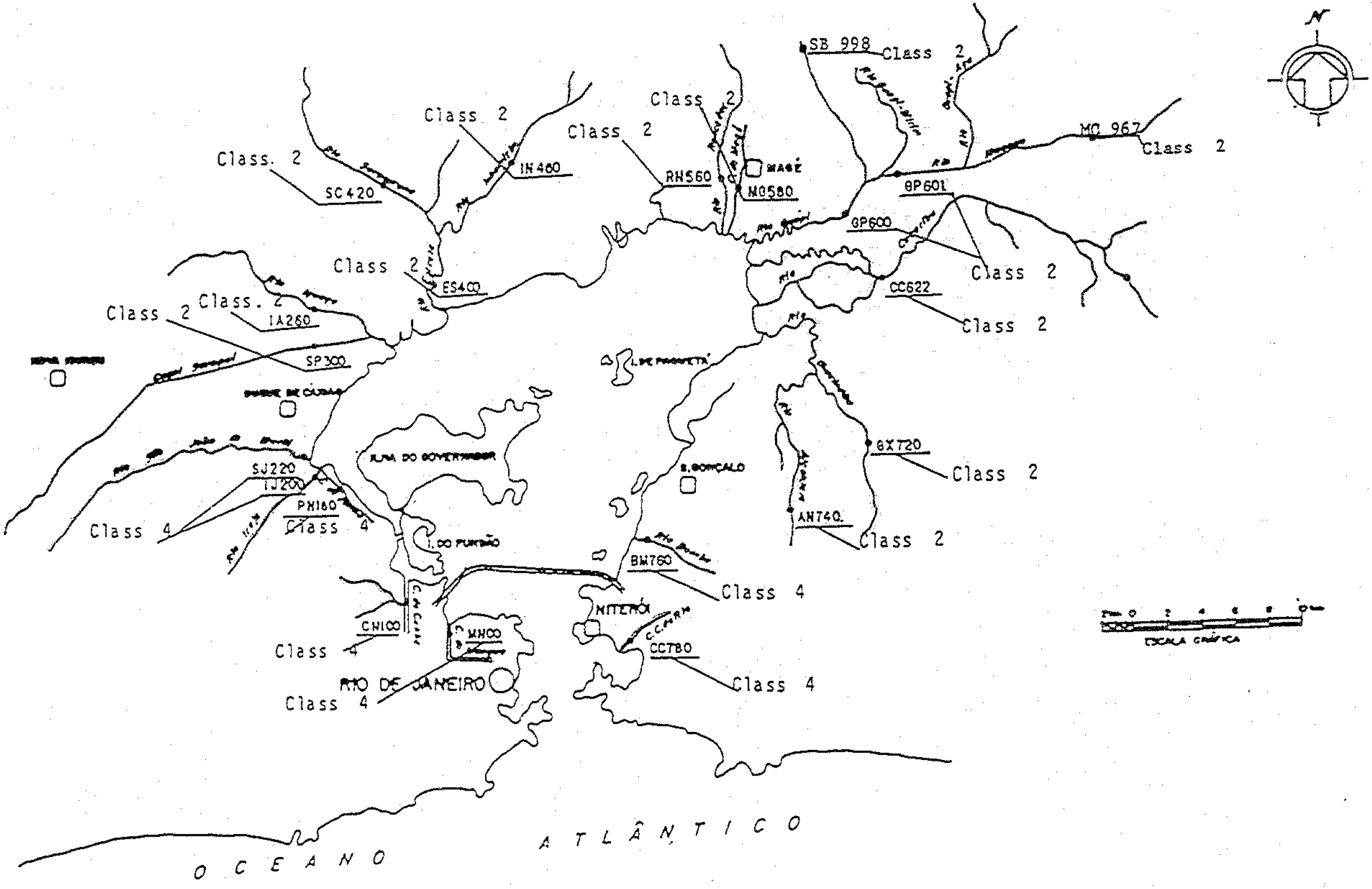


Fig. 14.3- 1 Water Area Classification of the Rivers in the Guanabara Bay Basin

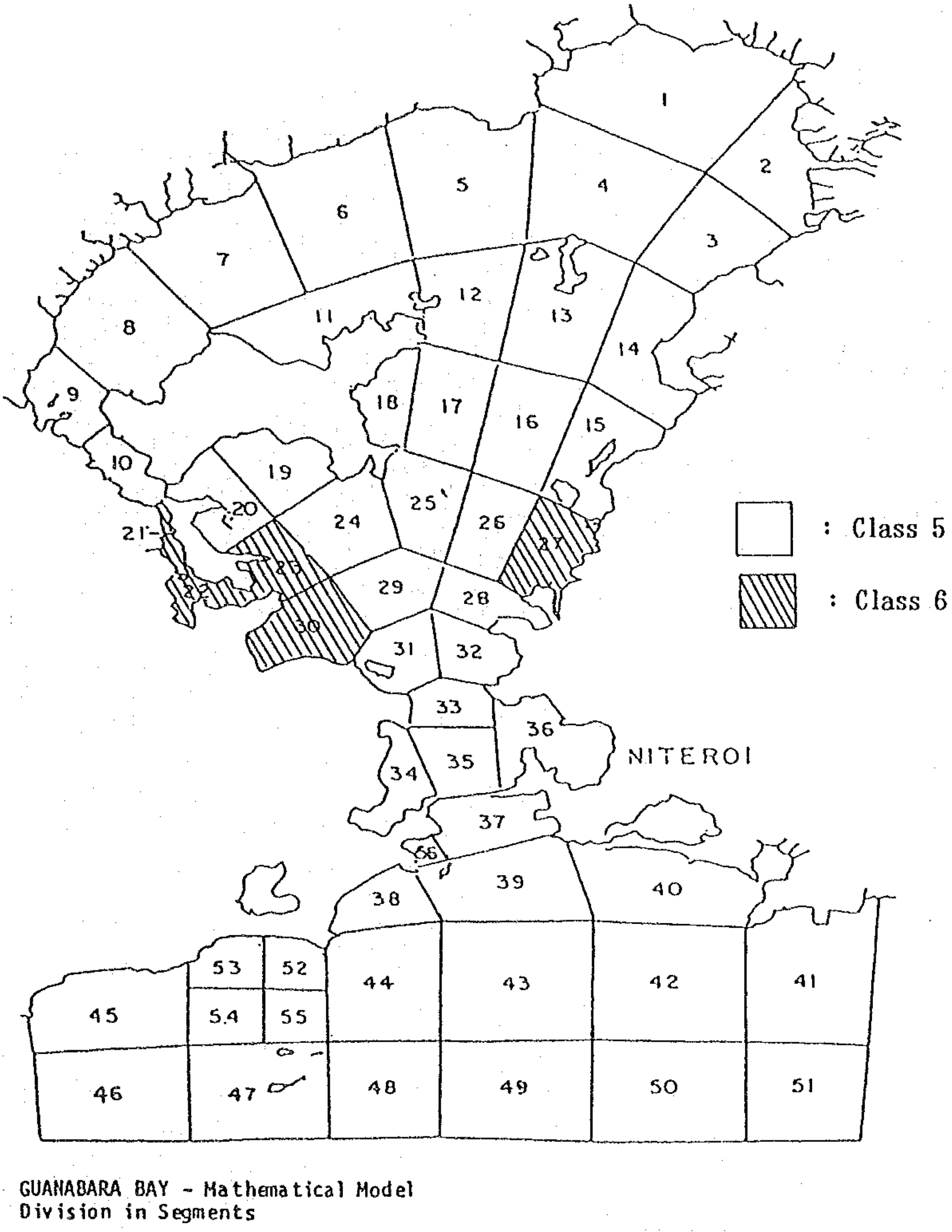


Fig. 14.3- 2 Water Area Classification of Guanabara Bay

Table 14.3- 2 Effluent Standards (CONAMA No. 20)

Parameter	Standard Values	Parameter	Standard Values
pH	5 - 9	Florides(F)	10 mg/l
Temperature	40°C	Soluble Manganese(Mn)	1.0 mg/l
Settleable Solids	1 ml/l (1 hour in in Inholl Cone)	Mercury(Hg)	0.01 mg/l
Mineral Oils	20 mg/l	Nickel(Ni)	2.0 mg/l
Vegetable oils or Animal Fats	50 mg/l	Silver(Ag)	0.1 mg/l
		Selenium(Se)	0.05 mg/l
Ammonia(N)	5.0 mg/l	Sulfides(S)	1.0 mg/l
Total Arsenic(As)	0.5 mg/l	Sulfites(SO_3)	1.0 mg/l
Barium(Ba)	5.0 mg/l	Zinc(Zn)	5.0 mg/l
Boron(B)	5.0 mg/l	Organophosphate Compounds and Total Carbanates	1.0 mg/l in terms of paration
Cadmium(Cd)	0.2 mg/l		
Cyanides(CN)	0.2 mg/l		
Lead(Pb)	0.5 mg/l	Carbon Sulfide	1.0 mg/l
Copper(Cu)	1.0 mg/l	Trichloroethylene	1.0 mg/l
		Carbon Tetrachloride	1.0 mg/l
Hexavalent Chromium(Cr^{+6})	0.5 mg/l	Dichloroethylene	1.0 mg/l
Trivalent Chromium(Cr^{+3})	2.0 mg/l	Other Organophosphate Compounds (Pesticides, Solvents)	0.05 mg/l
Tin(Sn)	4.0 mg/l		
Phenols(C^6H^5OH)	0.5 mg/l		
Soluble Iron(Fe)	15 mg/l		

[Note] Standard Values are less than or lower than the above-mentioned values

14.3.3 Land Use

Environmental problems are closely related to land use. Therefore, adequate administrative intervention is necessary to restrict the use of the land when it badly affects the surrounding environment.

In Brazil, planning in the urban area is controlled by municipalities and in the agricultural area it is controlled by the federal government. The state government, through FEEMA in the case of the State of Rio de Janeiro, however, can intervene in projects in urban areas through the EIA (Environment Impact Assessment), when a project is likely to damage the surrounding environment.

Permanently protected areas or APP (Area de Protecao Permanente) are designated by the respective municipality, the state or the federal government for areas to have a high value as an environmental area. If circumstances require, the owner of an area designated as APP can be exempted from paying taxes or in some cases the area maybe expropriated.

The APP does not have to be a clearly defined area. Areas can be designated in general terms, e.g. mangrove area. The area around the mouth of the Rio Guapimirim is designated as an APP.

CODIN (Companhia Distrito Industriais) is an organization that relocates factories situated in the center of the city to the suburbs for environmental protection.

Moreover, FEEMA carries out a scheme for the management of the coastal areas of the State Rio de Janeiro together with the municipalities. This scheme is a macro-zoning of the coastal area which is divided into four areas: the south-west part, the east part, the north part of the state and the Guanabara Bay basin. In these areas, the zoning of the east part have already been completed and the zoning of the Guanabara Bay basin will start in 1993. The main land use categories of this macro-zoning are as follows;

(1) Environmental Protection Zone
(2) Floral Zone
(3) Federal Protection Zone
(4) Urban Zone
(5) Development Zone on Urban Planning

(6) Recreation Zone
(7) Industrial Zone
(8) Agricultural Zone
(9) Port and Harbor Zone

14.3.4 Environment Impact Assessment System

The environment impact assessment (EIA) system was conceived to implement appropriate countermeasures prior to the implementation of large scale developments which might influence the peripheral surrounding environment.

FEEMA is the responsible authority for the evaluation of the resolutions stipulated in the EIA report, or as it is called in Brazil the RIMA (Relatorio de Impacts Ambiental). For the final stage of the RIMA a public hearing must be held and this should be preceded by advertisements in the three main newspapers.

14.3.5 Current Issues of Legislative System

As the beneficial uses of the area have changed, reflecting the present water quality in the Bay and simulation techniques used to predict the future water quality have advanced, it may be better that the existing water area classification and water quality standards in Guanabara Bay are restudied in detail taking into account of the results of this study.

The legistation concerning Effluent standards to pollutant discharging actions and the EIA system has no serious problems. However, it should be said that there are some problems in putting the legislations in practice.

MARPOL-73 is an international agreement relating to the prevention of marine pollution. The Brazilian government has not signed Annex 4 : Treatment of sewage discharged from vessels, and Annex 5 : Disposal of garbage from vessels. Early signing of Annex 4 and Annex 5 by the Barzilian government is highly desired.

As for land use, the adequate intervention by the state government together with municipalities is desired to prevent undesirable use of land by means of a taxation system, a land expropriation system and so on with the aim at preserving the environment under an overall management plan for the Guanabara Bay basin.