CHAPTER 4

JUSTIFICATION AND COMPONENTS OF THE MASTER PLAN

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4.1 Present Environmental Conditions in the Patos and Mirim Lake Areas

Focusing on the results of the monitoring survey carried out along the longitudinal axis of Patos Lake, the deterioration in the water quality of the lake and the wetland ecosystem is outlined in **Table 4.1-1** along with the countermeasures that should be adopted. Based on this table, the JICA Study Team explains the present environmental conditions in the Patos and Mirim lake areas below.

(1) Contamination by Human Excreta (Contamination by Bacteria)

Since contamination by human excreta leads to water-borne diseases that are a direct threat to public health, especially children, recreation areas (beaches for swimming) and fish breeding grounds should be strictly monitored.

The level of coliform, an indicator of contamination by human excreta, is known to decline the farther away from the contamination source due to the effects of ultraviolet rays, among others. Survey results, however, show levels of log 1 to 3 MPN/100ml even in the offshore area more than 10km away from the lake coast. Based on this observation, the study assumes considerably high coliform levels in the lake coast that encompasses municipalities with inadequate sewage treatment facilities.

As a matter of fact, data provided by the Porto Alegre Municipality indicate remarkable contamination by coliform especially in the eastern coast of Guaiba Lake. FEPAM conducts coliform level measurements in certain points in summer to determine sanitary conditions in areas allowed for swimming. The coast of Pelotas (Laranjal), however, is especially high in fecal coliform groups. Some parts of the coast of Tapes were also found to have high fecal coliform levels. In consideration of the above mentioned circumstances, the treatment of domestic wastewater discharged from urban areas located near the lake should be done urgently.

Table4.1-1 Deterioration in the Water Quality and Wetland Ecosystem in the Mar de Dentro Area

Deterioration Level / Problems	Contamination Level in the Central Water Area of Patos Lake			Water Areas With Significant Pollutant Inflow & Sedimentation	Required Countermeasures
	Northern Area (P-1, P-2, P-3)	**Central Area (P-4, P-5)**	**Southern Area (P-6, P-7, P-8)**		
Contamination by Human Excreta (Contamination by Bacteria)	Coliform: log1~3MPN/100ml	Coliform: <log 1 MPN/100ml	Coliform: log 1~3 MPN/100ml	East Coast of Guaiba Lake Beaches of Laranjal, Tapes, and Sao Lourenco do Sul	Treatment of domestic wastewater in municipalities near the lake shore (construction of sewage treatment plant)
Eutrophication	Eutrophic	Mesotrophic	Mesotrophic ~ Eutrophic	Guaiba Lake Northern Area of Patos Lake Southern Area of Patos Lake	Countermeasures for non-point sources (entire Patos Lake Basin including Guaiba river basin) Treatment of domestic wastewater
Soil Runoff/Sedimentation	Clay silt ~ silt Distribute widely	Sand ~ clay (northern half area) Sand ~ clay silt (southern half area)	Sand distributes except in the ship route.	Guaiba Lake Lower Reaches of Rio Camaqua Mirim Lake	Countermeasures for non-point sources (entire Patos Lake Basin including Guaiba river basin)
Contamination by Organic Substances BOD COD (Mn)	Low 0.4 ~ 1.9mg/l 2.0 ~ 7.3mg/l	Low 0.5 ~ 1.4mg/l 2.2 ~ 10.4mg/l	Low 0.5 ~ 1.6mg/l 3.1 ~ 5.6mg/l	Guaiba Lake Saco deTapes Saco da Mangueira/RG Harbor	Improvement of water circulation Dredging of sludge
Contamination by Agricultural Chemicals	Levels of agricultural chemicals and their by-products in any water area are below the detectable limit. Organic chloride levels extracted from living organisms sampled from the 5 stations at the west coast of Patos Lake were lower than the detectable limit in almost all samples.			Unconfirmed	Unconfirmed
Contamination by Heavy Metals	Heavy metal concentration in any of the water areas is lower than the WHO standard. In sludge, however, Ni, Cu and Hg concentrations exceed environmental standard in the northern area.			Guaiba Lake Rio Camaqua Saco da Mangueira/RG Harbor	Unconfirmed
Contamination by Harmful Substances (CN, As, etc.)	CN levels in any of the water areas and the sludge were lower than the detectable limit. A small amount of As was detected in sludge extracted from the central area.			Unconfirmed	Unconfirmed
Saltwater Intrusion	None	Slight increase	Often	Southern area of Patos Lake	Changes in the form/structure of Rio Grande Channel
Wetland Ecosystem	Decrease in biodiversity	Decrease in biodiversity Decrease in wetland forest	Decrease in biodiversity Decrease in wetland forest		Removal of factors that cause deterioration (e.g. illegal drains) in areas adjacent to wetlands

(2) Eutrophication

When nutrient salts exceed a certain level, (e.g. eutrophic level defined by Vollenweier (1984)), an abnormal proliferation of algae often occurs resulting in various constraints to water use. More than half the nitrogen and phosphorous (67% and 56%, respectively) flowing out from the Patos Lake basin originate from the Guaiba River basin in the northern side of the lake. Consequently, eutrophication in the northern area of Patos Lake is remarkable. Further, blue algae is generated sometimes in the southern lake area as a result of the inflow of nitrogen and phosphorous from the Sao Goncalo channel and the sewage from Pelotas and Rio Grande. In consideration of the above mentioned circumstances, countermeasures should be taken as soon as possible for the northern and southern areas if the sustainable use of water resources and Patos Lake is required.

(3) Soil Runoff and Sedimentation

Soil runoff caused by riverbed erosion, unsuitable land use practices, etc., not only lowers land productivity but also significantly affects the ecosystem as it decreases water depth and causes turbidity. In the Patos and Mirim lake basins, the nautical route between Santa Vitoria do Palmar and Pelotas has been closed due to a decline in the water depth in this section. In addition, a large amount of money is being spent every year to maintain the nautical route between Rio Grande and Porto Alegre. In this study, areas prone to soil erosion were classified based on the natural conditions (e.g. rainfall, topography, and vegetation) in every sub-basins. An environmentally-oriented agricultural system effective in the prevention of soil runoff should be introduced to the Cangucu area where agricultural activities are prosperous and the risk of soil runoff is high. Further, soil runoff prevention measures, mainly afforestation, should be implemented in the basin of the water resource where agricultural activities are difficult to carry out and the risk of soil runoff is high.

(4) Organic Contamination

Organic contamination decreases the dissolved oxygen concentration in the water. It causes bottom mud putrefaction and adversely affects aquatic and wetland ecosystems to a significant degree. As Patos Lake is generally shallow, the supply of oxygen is easy, about half of the organic load flows into Guaiba Lake which acts as a natural oxidation pond, and the BOD and COD levels are low even in the northern water section. However, existing data indicate that organic contamination is progressive in enclosed water bodies such as Saco de Tapes, Saco da Mangueira/Rio Grande harbor, where the sewage treatment facilities of municipalities in the hinterland are inadequate.

Existing data reveal bottom mud contamination in the above mentioned areas. In consideration of the above circumstances, water circulation improvement or bottom sediment dredging should be done especially in inlets where the demand for water use is high.

(5) Contamination by Agricultural Chemicals

Agricultural chemicals are detrimental to predatory animals of the high order through the food chain. The results of the monitoring survey indicate that agricultural chemical levels (analysis of the 7 types of agricultural chemicals widely used in the study area and their by-products) in the central axis of Patos Lake are below the detectable limit. Except for a few of the samples, agricultural chemical levels (analysis was limited to organic chlorine compounds) in benthos and fish species collected from 5 stations at the west coast of Patos Lake were also below the detectable limit. Although contamination by agricultural chemicals was not evidenced at this point, a detailed survey of agricultural chemical levels in living organisms, predatory animals of the high order included, is recommended in consideration of the large amount of agricultural chemicals used in the paddies and fields in the study area.

(6) Contamination by Heavy Metals

Heavy metals are accumulated in bottom mud and are detrimental to living organisms through the benthos. The monitoring survey results indicate that heavy metal concentration in the water at the central axis of Patos Lake is lower than the WHO standard, although Ni, Cu, Hg, among others within the bottom mud exceeded a certain level: levels tend to increase in the northern and southern area. Some existing data report that the bottom mud in the neighboring areas of Saco da Manguiera/RG harbor considerably contain some kind of heavy metal. However, because all generation sources have not been determined, the impacts of heavy metals on the ecosystem cannot be fully ascertained. Accordingly, studies and research on heavy metals in bottom mud and organisms should be continued at this point, along with the generation source (including mines) inventory survey.

(7) Contamination by Other Harmful Substances (CN, As, etc.)

Harmful substances such as cyanide, arsenic, etc., are discharged mainly by gilding and metallurgical factories. Contamination by these substances normally occur due to the lack of facilities for treatment, illegal dumping, as well as accidents during transport. The results of the monitoring survey indicate CN levels in the water and bottom mud lower than the detectable limit. In addition, As levels detected in the central area and bottom mud were too small to cause any problems. Nonetheless, the possibility of the improper operation of treatment facilities, illegal dumping, and accidents during the transport of harmful substances makes the generation source inventory survey absolutely necessary.

(8) Salt Water Intrusion

Seawater is exchanged between Patos Lake and the ocean through the Rio Grande channel. Saltwater intrudes into the central area of the lake when river discharge and wind conditions are favorable. Although particularly detrimental to the use of the lake water for paddy irrigation, this merits fisheries as it brings in leading marine fish into the lake and purifies lake water quality. This phenomenon seriously affects the vegetation, fish ecosystem, and birds that prey on fish in the wetland including the salt-marsh along the lake shore. The effect of saltwater intrusion should be forecast using the water quality simulation model, when the Rio Grande channel structure is changed or when other channels are opened and closed after a common ground between fishing and agricultural goals is established.

(9) Deterioration of Wetland Ecosystem

Many wetlands of various scale characterize the natural environment of the study area. Biological diversity around the Patos and Mirim lakes significantly depends on the surrounding wetlands, including the riverine forests. As water in the wetland only stands for a short period of time, water bloom is hardly observed. However, the ecosystem of Peixe Lake, which is a famous place of transit for migratory birds, requires adequate management because it is easily affected by man-made activities due to the abundance of baits, the level of salinity, and its delicate water balance. Fully vegetated places have decreased in area due to the drainage and conversion of wetlands into pastures, harming biodiversity as a result. In particular, the number of swamp forests has considerably declined leading to the decrease in biodiversity (including bird species in forests) and fishing resources within the lake. It is, therefore, important to adopt measures to prevent the illegal drainage of the wetlands – one of the activities that cause such adverse conditions. In addition, water level control measures in harmony with ecosystem conservation are also required because many of the remaining wetlands are used as irrigation sources.

4.2 Projected Environmental Problems if Countermeasures are not Implemented

Fig. 4.2-1 shows the causal relationship between the pollutants and the deterioration in water quality and the ecosystem as mentioned in the previous section. The causal relationship between the pollutants and the deteriorating ecosystem is not quantifiable. This study, therefore, quantitatively estimated the relationship between the pollutants and the deterioration in water quality using the hydrology and water quality simulation models developed for this study. The conditions assumed for the calculation are shown in **Table 4.2-1**.

Case 1 estimates to what degree the TP level in the lake increases when the inflow load from all rivers flowing into Patos Lake becomes 20% higher than the current value.

Case 2 and Case 3 estimate the Chla level in case phytoplanktons other than diatoms become prevalent in the southern water section, assuming that eutrophication in Patos Lake will progress in the future and that the proliferation of huge algae in the southern lake section will be as alarming as in 1994.

The calculation of the items shown in **Table 4.2-1** was based on current conditions.

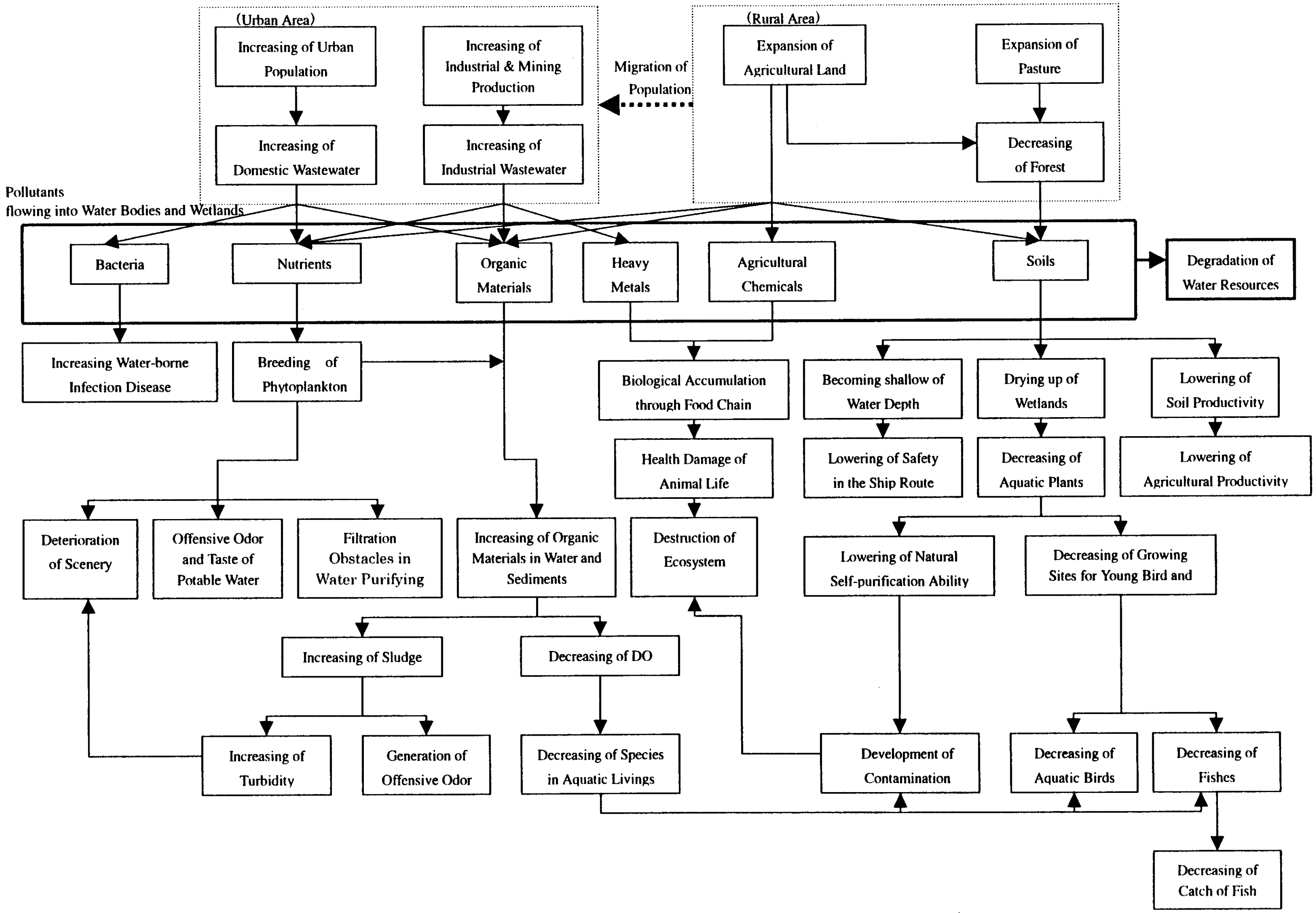
Table 4.2-1 Cases for the Calculation of Water Quality without Countermeasures

Case No.	River Flow	Rate of Diatoms in Southern Area	Seasons
1	20% increase	0.5 (as in the present)	annual mean
2	As in the present	0.2	Summer
3	20% increase	0.2	summer

Fig. 4.2-2 compares the TP level in the representative points in Patos Lake based on the Case 1 scenario. **Fig. 4.6-4** shows the location of these representative points. If the river load increases, lake water quality, particularly in the northern water section and the northwestern lake coast – sections that are strongly affected by river load – is forecast to further deteriorate. Even in the central water section where the water is comparatively pure, eutrophication level exceeds the stipulated lower limit of 0.03mg/l. These conditions bring about fear that the entire lake area might be in a state of eutrophication.

Figs. 4.2-3 and **4.2-4** show the distribution of Chl-a levels based on Case 2 and Case 3.

Calculations carried out assuming that phytoplanktons other than diatoms predominate in the southern water section indicate Chl-a levels of over 10μg/l in the entire southern water section. If the river load increases by 20%, the Chl-a level was calculated to further increase, which means that more sections of the lake would have a Chl-a level exceeding 20μg/l. The proliferation of huge algae in the southern section was confirmed in 1994. Increase in load is feared to bring about large scale and frequent proliferation of algae, and serious damage to fisheries and water use.



THE STUDY ON THE ENVIRONMENTAL MANAGEMENT
OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES
IN THE FEDERATIVE REPUBLIC OF BRAZIL

JAPAN INTERNATIONAL COOPERATION AGENCY
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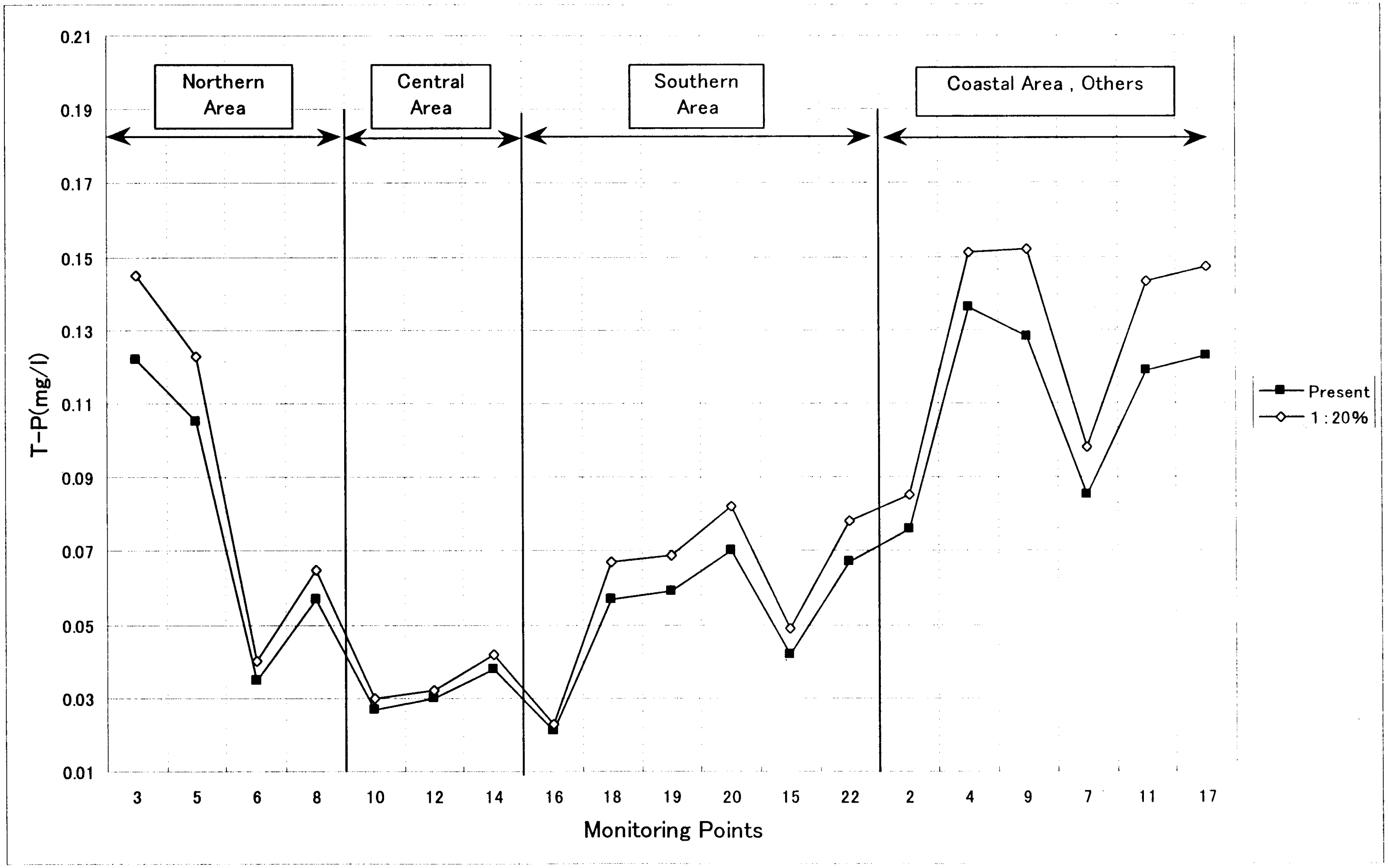
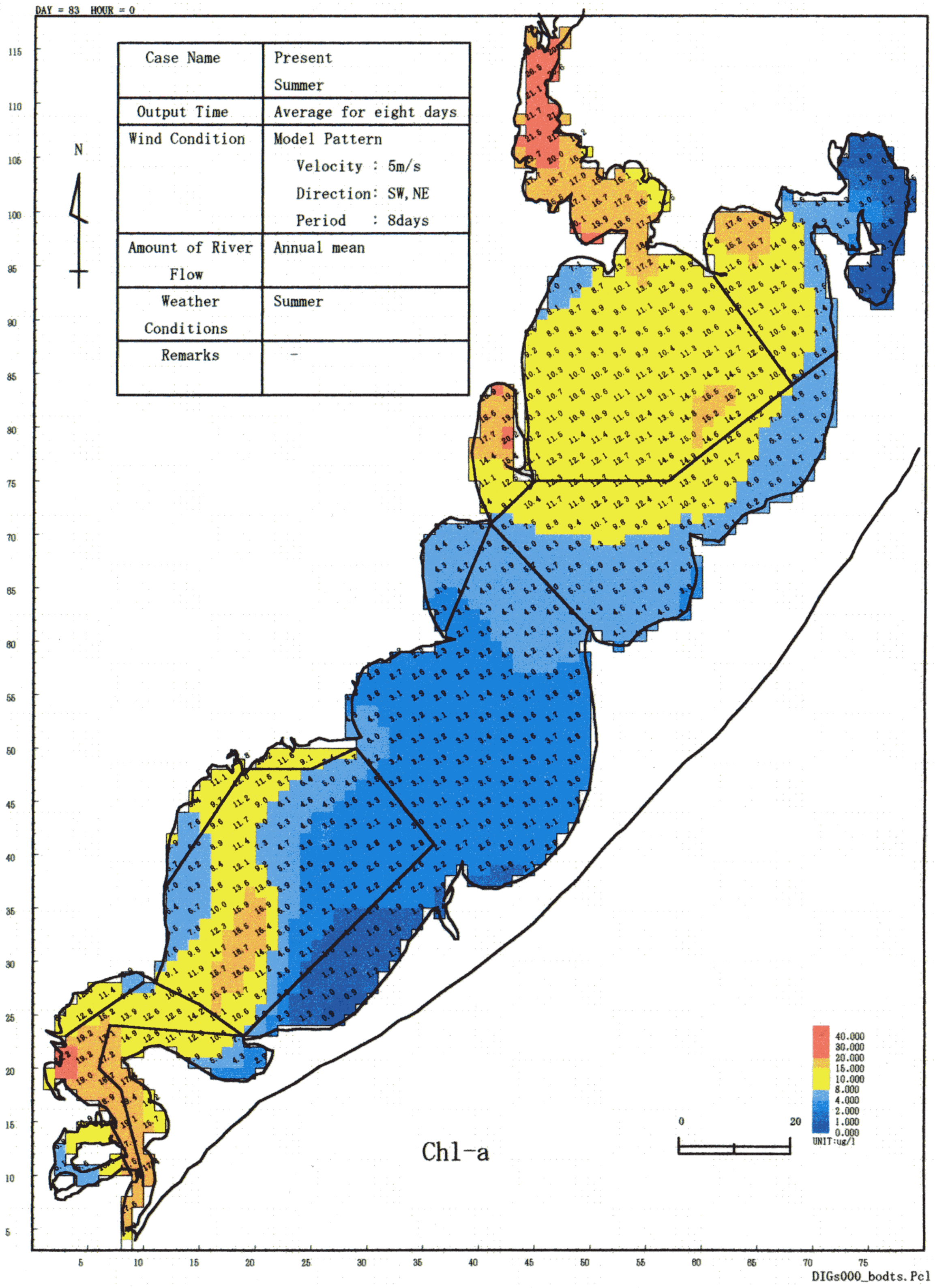
Fig. 4.2-1

Causal Materials of Aquatic Environment Deterioration and the Social Loss Brought by them



THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	Fig. 4.2-2
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	**Comparison of T-P Concentration at the Representation Points in the Patos Lake**



THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	**Fig.4.2-3**
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	**Chl-a Distribution (Case-2:Present)**