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THE CONCEPT OF SUSTAINABLE DEVELOPMENT: TWO CASE STUDIES, THE ARAL SEA AND THE BILLINGS RESERVOIR

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ABSTRACT

This is a study of the analysis of the concept of sustainable development. The linkages between environment and development, the meaning of sustainability and a critique of the decision making process are analysed through the comparison of two case studies the Aral Sea and the Billings reservoir.

The first study case is the Aral Sea. During the last thirty years the development of crop production was the goal of regional strategy of the Aral region countries. Withdrawls from the rivers caused inflows to the Aral to fall at an average of over 50 km^3 annually to 1-5 km^3 in the 80's. There have been observed accute environmental, health and social problems attributed to the development process.

The Billings reservoir is located at the Southeastern region of the city of São Paulo, and was constructed in 1937 with the objective of energy generation. During the years it was turned into a multiple-use reservoir including domestic and industrial water uses, as well as well as domestic and industrial deject reception.The accelerated development of the city and the lack of basic infrastructure projects such as sewage treatment have led to the advanced degradation of the reservoir. and to negative impacts and conflicts for the entities and communities involved in the system.

The study has shown that integration of environmental and developmental issues is very important for a balanced and efficient decisionmaking. This can be achieved through thorough studies of environmental, economic and social factors of the system under analysis. The meaning of sustainability has different dimensions for each system. Also a reformulation of the decisionmaking process is essential for the concept become operational.

CHAPTER 1 - INTRODUCTION

1.1 SCOPE

The world faces a wide variety of critical environmental threats for human life itself, ecosystem diversity and atmospheric depletion. At the same time it faces enormous human problems in the form of widespread, persistent poverty and misery.

The current development paradigms concentrated only on economic growth as the means to better life quality, have failed, since this pattern is worsening rather than remedying such disparities. World economic activity has grown at about 3 percent per year since 1950. The world population has doubled since the 1950's. If this growth rates continue resource use will increase dramatically in the future.

With the failure of the current development paradigms and the intense resource use, there have emerged concepts and ideologies which explore the possibilty of a new direction. The paradigm of sustainable development is the most prominent and widespread. The general definition of the concept is that *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs "*. [1] The redefinition of the concept of development, the linkages between the development process and environmental resource use and decisionmaking envisioning the sustainability of ecosystems, are the main ideas of the concept.

The popularity and the novelty of the concept of SD were the stimuli for its analysis and elaboration in this thesis. A question which surrounds the concept concerns its operationality since studied cases and methodologies are still in progress. This was an additional

motivation for the specific study of two cases, the Aral Sea in Kazakhstan and the Billings reservoir in the city of São Paulo, Brazil, with the latter case being analyzed in more detail.

The two studies were chosen firstly due to advanced level environmental degradation caused by action of the development process. These actions created further environmental and socioeconomic negative impacts, and in this way a vicious circle was formed.

The Aral situation has become critical during the last 30 years. As a result of diminishing inflow, the Aral Sea began to shrink in volume and area and is now on the verge of total collapse. Tragedy is due to anthropogenic factors, namely the wrong development strategy for expansion of cotton and rice cultures. Intensive development of irrigation agriculture was carried out in a large scale. This was possible through reclamation of large salted areas, or lands with shortage of irrigation water. Ecologically harmful agriculture and crop care methods were used. There have been observed high levels of intestinal infectious diseases, of difficult pathologies including intestinal disorders and other diseases.

The Billings reservoir, constructed during the 1930's, is located at the Southeastern region of the city of São Paulo. Originally it was destined for energy generation, and today is a multiple use reservoir, including domestic and industrial water provision as well as industrial and domestic deject reception. While the reservoir has played an important role in the development of the city of São Paulo through energy generation, today is a source of great controversy and conflicts between the entities involved in its uses. This is due to the fact that the reservoir during the 1960's and afterwards, has been turned into a sewage receptor since it has been receiving water from the polluted Tietê river. The source of the pollution is the untreated domestic and industrial sewage of the city of São Paulo.The government through an effort for the improvement of the environmental quality of the reservoir has created

further environmental, economic and social consequences for the entities and communities involved in the system.

The Billings case, was chosen due to the outcry, confusion and conflicts created by the government's actions, and to the lack of an integrated perspective concerning environmental and socioeconomic impacts. It seemed important to make a comparison with a regional case outside Brazil so that the applicability of the concept worldwidely would be examined. Apparently the Aral Sea is a different system from the Billings reservoir, and its environmental degradation involves the negative consequences of irrigation and not untreated sewage disposal.

However, studies concerning the analysis of systems under the sustainable development perspective are still few and the Aral Sea is one of them due to the intensity of the problem. In addition, a common and most important parameter between the two cases is the influence the development process had on the environmental conditions. In the case of the Aral the communities , to expand the economy through the expansion of cotton, incentivated large scale irrigation which had negative environmental impacts. In the Billings case the development of the city of São Paulo lacked organization and basic infrastructure projects, leading to pollution of water resources. The relation and linkages of the development process and environmental conditions is one of the major highlights of this thesis. The differences between the two systems will be used in such a way to show that the operationality of the concept sustainable development is applicable independently of the physical and economical characteristics of the system.

The study is limited to the identification of the linkages between environment and development and to the presentation of an integrated perspective of the cases involving the

environmental, socioeconomic and institutional aspects.In addition suggestions are made based on the premises of the concept of SD and to their contributions to a more efficient decisionmaking process.

1.2 OBJECTIVES

The objectives of this study are:

1. The proof of the existence of strong linkages between environment and development.
2. The necessity for sustainable solutions
3. Analysis of the meaning of sustainability.
4. Recommendations based on the concept of sustainable development.

1.3 METHODOLOGY

The identification and analysis of the components, the strengths and weaknesses of the concept of sustainable development is done, and is further utilized as a "guide" for the analysis of the two case studies. A detailed description of each system is made, including a historical review, description of the development process and environemntal degradation as well as identification of their links. The analysis of the sustainability component is done through the comparison of the case studies.

1.4 CHAPTER REVIEW

This thesis has seven chapters in all. This chapter provides an introduction to the thesis and an explanation of the area of study. It defines the parameters of the research and pinpoints the key issues that will be discussed. A review of the concept of sustainable development, in

Chapter 2 serves as the basis for the elaboration and discussion of the two study cases. The components of the concept are identified as well as their connections . A more critical discussion of the concept is also included highlighting controversies, strengths and weakeness of the concept.

In chapter 3 the Aral Sea case is examined through a historical review, description of existing human and natural environment, and the causes for its degradation . Current actions and plans for the future are also cited.

The Billings case is studied in more detail in comparison with the Aral Sea problem, in Chapters 4, 5, and 6. Chapter 4 reviews the history of the reservoir, and the current positions of the entities and communities involved in the system. Chapter 5 analyzes the environmental impacts and conflicts of the reservoir and the systems affected. Chapter 6 starts with a description of the cause of the problem and the actions taken to resolve it.The second part of this chapter is a socioeconomic analysis of the impacts and conflicts of the entities and communities involved; a comparative cost benefit analysis is done between the current situation and already proposed solutions as well as a critical discussion concerning government's actions.

Chapter 7 integrates the information given in Chapters 2-6, by first summarizing the development processes of the two study cases and their interactions with the surrounding environmental systems . A comparison of the two cases is done under the perspective of the concept of sustainable development together with recommendations which could lead to a more efficient development process.

1.5 LITERATURE REVIEW

The section is devided in three parts, each one describing the literature review for the analysis of the concept of sustainable development, the Aral Sea and the Billings reservoir respectively.

1.5.1 THE CONCEPT OF SUSTAINABLE DEVELOPMENT

The review starts with "Our Common Future" written by the World Commission on Environment and Development (1987) due to the fact that it was the first concentrated effort of the formulation and organization of the concept in relation to all aspects and sectors, as well as of the general definition of the concept which is widely accepted.

During the years there have been modifications and elaborations, as well as search for methodologies related to the operationality of the concept. Annual reports from international agencies such as the United Nations and the World Bank, have been utilized to trace and accompany the evolution of the paradigm. Data related to the world as a whole and for specific countries were also drawn from these publications.

Although annual reports from international agencies contain a large amount of information and show world trends, their position tend to be more neutral than those of individual scientists. Articles from periodicals, or parts of books are used for the discussion of the controversies

For the analyses of the components of the concept of sustainable development which are the environment, development and sustainability, literature discussing their evolution and

meaning was considered. The failure of current development paradigms was studied through papers by Goulet (1986) . The environmental issues were discussed through the approaches of ReVelle [12] and Tolba [13], with the former trying to give a general outline of the current problems and the latter showing the evolution of progress towards more accurate and complete environmental assessment and the evolution of the efforts for the resolution of environmental problems.

1.5.2 THE ARAL SEA

For the analysis of the Aral Sea study case the diagnostic study of UNEP [19] considering environmental, economic and social impacts and their linkages, was used in order to describe the development process and environmental degradation. However studies concerning the measures or decisions taken for the resolution of the problem were not included in the report, therefore further articles by Precoda [20] (1991) and Levintanus [21] (1992) were necessary for the provision of this information. Precoda concentrates more on the aspect of the loss os a precious natural resource, while Levintanus emphasizes and describes government's actions, current and future plans. In this way, four important points are covered; the development process, environmental and socioeconomic impacts, and decisionmaking process.

1.5.3 THE BILLINGS RESERVOIR

On the contrary of the Aral Sea case a diagnostic study including historical review environmental as well as socioeconomic components is non-existent. This led to the use of fragmented pieces of information from newspapers, magazines documents from the entities involved as well as personal interviews with the representatives of the communities,

industries and companies which are affected by and concerned with the Billings' current situation. Information for actions taken by the government were collected from the same sources.

CHAPTER 2: THE CONCEPT OF SUSTAINABLE DEVELOPMENT

2.1 INTRODUCTION

Seeing closely our world today, we see a large number of problems as well as changes taking place, such as regime reforms in Eastern Europe, famines in Africa, wars, increases in environmental pollution such as the greenhouse effect and the ozone layer depletion.

This current crisis has led to a questioning of the present development paradigms and to a search for new ones, better fitted to today's needs.

In this effort for new development paradigms the concept of "sustainable development" arose. It became known worldwide by the World Commission for Environment and Development, in 1987 and their report "Our Common Future", who had as a goal the definition of a "global agenda for change" with the concept of sustainable development as the basic ideology.[1]

The general definition given by the Commission is the following:
"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".(1 p. 8)

Although this general definition is widely accepted, there exist differences and controversies having to do with the implications of the concept, studied in detail in the following sections of the chapter.

2.2 THE COMPONENTS OF THE CONCEPT

There are three key "subconcepts" or components, embedded in the concept of sustainable development. These are the concepts of sustainability, development and environment.

2.2.1 SUSTAINABILITY

Sustainability is defined in several ways; Some authors use the term within the ecological concept of natural resources such as forests or fisheries or energy sources, defining sustainable a resource or an ecological system which is renewable or resilient to large scale disturbances.[2]

There are others who support that in conjuction with these ecological conditions there are also social conditions which influence the ecological sustainability of the people-nature interaction such as S. Lele[2] (1991), and others like John Robinson[3] (1990) go even further defining sustainability as the "the persistence over the apparently indefinite future of certain necessary characteristics of the sociopolitical system and its natural environment." (3, p 39)

Although there is a strong link between environmental and social conditions influencing a people-nature system, defining sustainability in the way defined above by John Robinson, makes the operationality of the concept almost impossible, since the factors involved cannot be analysed in a comparable manner neither quantitatively nor qualitatively.

Many authors define sustainability as a dynamic state of optimum use of resources- human as well as environmental- of a certain system during a given time period which is not indefinite. In these terms sustainability could be understood as an ideal concept. However,

the problem comes up when one tries to "translate" the concept into practical terms. Including parameters of completely different natures is a difficult as well as a dangerous and risky process leading to questionable and controversial conclusions.

Within this "translation" problem of the concept to practical terms, the proper dimension of sustainability is also questioned. We could divide the human-nature interactive systems into two large groups; the systems already existing or developed, and the systems to be developed or are in their initiation phase. Sustainability for these two groups could take a completely different dimension.

In a developed or already existing system, development "has acted" in most probably an irreversible way which could prejudice the system's sustainability. If the system is considered unsustainable, finding a solution which could lead to satisfaction of both enviromental and social factors is quite improbable.

In this case, sustainability means a less problematic operation of the system at least for a certain time period and not the optimum operation of it.

In the case of newly constructed systems or ones under construction, sustainability could be less compromised through preventive measures or more detailed and encompassing studies.

As a consequence one important question which comes up, is the predictability of disturbances within a system, or in the surroundings of a system which could affect it. Predictability is necessary in order for these changes to be anticipated and prevented or at least to impede the decrease of the resilience or recovery capacity of the system.

The predictability of a system is a point of controversy among scientists, some believing that scientific information and consensus are incomplete in most cases, or even lacking in others, thus the achievement of sustainability is compromised or not feasible.[4] D. Luckwig (1992) also supports that sustainability is impossible due to human defects which are not usually taken into consideration when systems are analysed.

Others such as R.Socolow[5] (1993) believe that although scientific information is still incomplete, significant progress has been achieved in the last years concerning nature functions and human-nature interactions therefore facilitating a more balanced decision making process.

As J. Goldemberg[6] (1993) mentions, consensus is important, however not indespensable nor it is prerequisite for action. For example, in the Climate Convention adopted in Rio de Janeiro in ECO92[7] it is stated that "where there are threats of serious or irreversible damage, lack of full scientific certainty, should not be used as a reason for postponing such measures.

There is no doubt that human defects could contribute greatly to the disturbances occured in a system. However this does not imply that the influence of these defects on the system could not be included in the study for more accurate predictability to be achieved.

After the above analysis of the sustainability component within the concept of sustainable development, one can see an array of opinions and definitions given. These definitions could be considered "ideal", however at the same time non-operational, sometimes leading to a "dead end" way.

Sustainable resource use within a system during a certain time is an achievable goal. In order to reach this objective, sustainability should be studied in terms of comparable parameters to have real quantitative and qualitative significance. As mentioned before, it is also important to recognize that systems differ substantially from one another, thus giving a different essence to this component.

2.2.2 DEVELOPMENT

"Development has been called by many. a semantic, political and moral minefield" (Goulet 1983). It is still an ambiguous and elusive concept, creating great controversies.

The definitions vary from simple, generic ones to others really complicated. S. Lele[2] (1991) defines development as a process of directed change, embodying both the objectives of this process as well as the means of achieving these objectives. In general, the main goal of development is the removal of proverty. During the years, different paradigms have surged trying each time to satisfy this goal.

One of the most recently prevalent and applied development paradigms, is the one that development has as an only objective the creation of wealth through industrialization. As countries experience increased growth, their productive capacity expands and they "develop". However, during the last decade it has been realized that it is impossible to define the goal of development in terms of endless economic growth and the achievements of living standards typical of the rich countries.[8,9]

D. Goulet[10] attributes the failure of earlier paradigms in four domains: distribution, employment, self reliance and human costs. Conventional strategies have not led to

satisfactory economic growth, that is improvement in real material living standards, despite the improvements in indices for infant mortality, life expectancy and literacy. Between 1960 and 1979 the world's thirty six poorest countries averaged GNP growth rates of 1.65 while undergoing a population increase of 2.1% yearly. High growth where occured, created massive inequalities in the distribution of benefits among people of diverse classes, regions and nations. The worst national disparity occured in Brazil, where the difference of per capita income of the 20% richest and the 20% poorest people of the country is 26 times.[11]

Strategies prescribing industrial growth and high technology have to create jobs. According to D. Goulet, studies show that rapid industrialization and growth of GNP do not reduce unemployment, since the labor force in the Third World countries is composed mainly of food growers and artisans, unskilled in industrial tasks. In addition, the majority of Third World did not provide sufficient incentives for the skilled proffessional workers to remain in their country.[10]

There is still dependency of developing (Third World Countries) on foreign capital, a fact which shows a massive failure of strategies for attaining self reliance. This can be seen clearly by the accumulation of large amounts of foreign debt of countries such as Brazil or Mexico.[10]

The conventional paradigms were "transported" from countries of Europe or the United States to countries culturally different, thus becoming unsuitable to satisfy these countries' needs. Even developed countries today see that endless economic growth is quite impossible.[10]

In view of this development paradigm failures, new ones have surged, "adjusted to today's needs".

The Human Development Report[11] published bu UNDP has defined human development as the process of enlarging the range of people's choices, increasing their opportunities for education, healthcare, income and employment, and covering the full range of human choices from a sound physical environment to economic and physical freedoms.

In "Our Common Future"[1], the Commission for Environment and Development" refers to development in its broader sense, not only including processes of economic and social change, but also including the integration of environment and development. While this is an essential objective for progress, the way to achieve it is still controversial and varied among scientists, nations and international organizations.

There is controversy surrounding these objectives' feasibility. Some scientists believe that they are set too high up in order to be achieved, therefore their significance is weakened. Others feel that what is needed is a massive effort for changing the present situation; As V. Rajagopalan comments in the "Global Environment"[12] the challenges are global with the stakes being high for both industrial and developing countries, as well as formidable but we **can** meet them" (12, p.442.).

2.2.3 THE ENVIRONMENT

As mentioned above, the third important component of the concept of sustainable development is the environmental component.

The environment in its broader sense is composed of several interelated parts such as the ecology, population, land and species preservation, air and water pollution, human health, energy etc.[12]

In the earlier part of this century, environmentalism was essentially synonymous with wildlife conservation and was considered to be the domain of a previleged few. In the 1960's environmentalism has become a movement with widespread popular support and an extensive range of interests. [12] Scientific groups and non-governmental organizations (NGOs) have played a major role in the environmental movement from its start.

According to M.K.Tolba [13], significant improvements have been achieved in some areas, such as the lowering of urban air pollution in most cities of the developed world, the rapid advancing in the scientific understanding of statospheric ozone depletion and its causes.

Though this significant progress has been achieved, there are still serious gaps in the understanding of the environment, in the ability to estimate the cost of repairing the damage done to it and in the assessment of the cost of failing to take rapid action to halt its degradation.[13]

Other problems include the variable quality of the world database, and the shortage of data from developing countries. As a result only best estimates, not comprehensive data, on major environmental problems can be compiled. Also recent great scientific advances have not been uniformly applied, mainly because many countries lack equipment and trained personnel.[13]

No general agreement has been reached on standards for a decent environment or on the socioeconomic indicators, of a "healthy" relationship between people and environment. Comprehensive assessments of the environmental situation and of the earth's carrying capacity are still difficult.

According to ReVelle and ReVelle[12], a society should interact with its environment in ways that leave the environment free to be used again and again, in ways that maintain the integrity and interaction of the biosphere, with little over than short term change.

According to M. Munasinghe (1991), the environment provides three main types of services to human society; first the environment is a source of essential materials and other inputs which support human life; second the environment serves as a sink which absorbs and recycles the waste products of economic activity; and third it provides life support functions which are irriplaceable such as the ozone layer.

2.3 LINKING ENVIRONMENT WITH DEVELOPMENT

As emphasized in "Our Common Future" by the World Commission on Environment and Development, environment and development are not separate challenges. Development projects that seriously degrade the environment, also threaten the essential resource base upon which national growth depends. It is widely recognized that sustainable development and management of natural resources are inseparable. These problems are linked in a complex, cause and effect system, where four links have been identified.[1]

The first link in this complex system is the relationship between the environmental stresses themselves and the necessity of these problems to be dealt simultaneously. Examples such as

deforestation which by increasing run-off accelerates soil erosion and siltation of rivers and lakes, or air pollution and acidification which play their part in killing forests and lakes. [1]

The second link is that of environmental stresses and patterns of economic development. Agricultural policies could be the main cause for land, water and forest degradation. Energy policies are closely related to the global greenhouse effect, with acidification and with deforestation for fuelwood in many developing nations. These stresses all threaten economic development, therefore they should be integrated in decision and lawmaking processes, not just to protect the environment, but also to protect and promote development. [1]

The third link is between environmental - economic problems and social-political factors. Two examples are population growth and poverty which have a great impact on the environment and vice versa. Also environmental issues and uneven development can increase social tensions. [1]

A fourth link is that of environmental problems and nations since some problems such as water pollution do not "recognize" boundaries; the atmosphere carries air pollution over vast distances. Major accidents - particularly those at nuclear reactors or at plants or warehouses containing toxic materials-can have widespread regional effects. [1]

From what has been seen, the integration of environmental and developmental issues seems to be imperative, and the concept of sustainable development is an effort to clarify and define this relationship.

2.4 COMPARISON OF SD WITH OTHER PARADIGMS

Today, there exist several schools of thinking concerning the relationship of environment and development. In this following section a comparison of the sustainable development paradigm and other prevalent ones will be made, based on Michael Colby's classification.[14]

The paradigm which embodies the concept of sustainable development as defined by the World Commission on Environment and Development, is called Resource Management. Natural resource exhaustion is of great concern. There is incorporation of all types of capital and resources - biophysical, human, infrastructural, and monetary- into calculations of national accounts, productivity, and policies for development and investment planning. The primary goal of development especially in developing countries is growth, however with sustainability being the necessary constraint. Methodologies for the internalization of environmental quality and natural capital in economic planning and development project analysis are being developed and debated.[14]

The paradigm which mostly contradicts the Resource Management one is called Frontier Economics, completely anthropocentric, where nature is treated as an infinite supply of physical resources to be used for human benefits, as well as an infinite sink for the by-products of development and consumption of these benefits in the form of various types of pollution and ecological degradation. According to M. Colby, most developing countries have applied this approach to economic and environmental management. Resources have value only when scarce, the only case where they can be internalized in economic analysis and planning. Economic growth without any constraints is the central concern.[14]

Environmental Protection is somewhere between the Frontier Economics and Resource Management. The importance of environmental protection plays a more important role than in Frontier Economis, though environmental and economic priorities are still in contrast. Protection of the environment is considered an added cost. Degradation of natural resources is seen as a growth indicator, rather than as a loss in capital stocks.[14]

The paradigm of Deep Ecology which developed as a reaction to industrialization and mass consumption, has as a centre of things not humans but nature. The exploitation of nature must be kept strictly within necessities, and technology is rejected. This paradigm though served as an antithesis to the Frontier Economics one, has not been applied anywhere, due to its radicality.[14]

Eco-Development is a new emerging paradigm, an alternative approach compared with the other ones. The main theme in this paradigm is that reorganization of human activities in a convergent, synergistic way with nature, is necessary. This paradigm does not reject technology. Development is not seen as a "top-down" enterprise but as a "grass-roots" empowerment and self determination. Eco-Development finds it necessary to incorporate uncertainty into economic modelling and planning, a factor not included in the Resource Management paradigm. This paradigm is still far from being applied since its operationality is questioned and not tested.

2.5 SEVERAL DEFINITIONS OF WHAT SEEMS TO BE THE SAME CONCEPT.

Although the definition of SD given by the World Commission on Environment and Development cited at the beginning of this chapter, is widely accepted there are controversies surrounding the real meaning of the concept. In the definition given by the

WCED, there is emphasized reference to intergenerational equity, which is very important though hard to estimate.

In other "more practical" definitions such as that of ReVelle and ReVelle, sustainable development "is development that attempts to cause the least possible permanent, harmful impact on the environment".[12] It is inferred that there is a trade-off, though minimum, between environmental degradation and the development process. Sustainability takes another broader meaning in this definition when compared with that of WCED, since it allows a minimum necessary environmental degradation.

Although within the concept of SD, as mentioned before, the relationship between environment and development is convergent rather than divergent and antagonistic, there is still intense debate about the relative importance of the two components; in developing countries where life quality for most people is still extremely low, development takes precedence over environmental degradation. While some advocate zero growth as the main objective of the sustainable development paradigm it seems impossible and unwanted for most of the Third World. Zero growth could be an objective achieved from highly industrialized countries where material consumption reached unprecedent levels.

However, extreme poverty or overconsumption, have a similar effect on the environment - its degradation - which has further negative synergistic influences on both society and nature. In the two cases, "working with" the environment and not against it, seems to be the only beneficial way in the long run. According to S.S. Husain (1992) (World Bank-Vice President for Latin America and the Carribean region) there has been a growing consciounsness of the need to adopt policies and programs to preserve the environment [15,16]. Due to lack of financial means, in developing countries preventive measures are taken

instead of curative more costly ones [17]. Although in the concept of SD it is clear that environment and development should be convergent, the way to achieve this, is neither agreed nor defined.

Due to these different perspectives and priorities of developing and developed countries, there is a certain misunderstanding created concerning the type of actions to be taken to accelerate the development process or to prevent environmental degradation. This "communication" problem can only be resolved through long and "goodwilled" negotiations between governments, as well as through exchange of opinions and knowledge of the scientific communities. Also the role of international organizations such as the World Bank and the United Nations is crucial in facilitating the communication process.

2.6 NEED FOR REORGANIZATION OF THE DECISION MAKING SYSTEM

Before ECO92, special conferences have been held in order to discuss one specific global problem as a single topic and have not tried to analyse it in a more holistic manner, that is the discussion of the problem's linkages with both environment and development. Most U.N. agencies due to their specialization have difficulties in dealing with the complexity of these problems.

The integration of up till now separate issues such as economic growth and environmental degradation have led to a need for a different decision making process. As Tatsuro Kunugi (1992)[18] points out, " sustainable development can only be achieved through a broad participatory process involving all layers of societies, both in the public and private sectors."

The changes in the decision making process should take place at national as well as at international levels. At the national level regulation or government intervention is necessary to ensure standards for the public good. It is also necesary a wide participation of community and non-governmental organizations so that the regulations set by the government be effective [18].

At the international level, collaboration among nations is necessary to enhance the resolution of global environmental problems such as the greenhouse effect and population growth. Also cooperation helps to transfer knowledge and technology, accelerate learning, and integrate companies into world markets.

The role of international agencies is essential to ensure the standards and framework necessary for this global collaboration. In this effort the Global Environmental Facility was created, a tripartite arrangement, of the World Bank, UNDP and UNEP. The Bank is administering the fund of the facility, while UNDP is responsible for technical assistance projects, pre-investment activities and very small investment projects, and UNEP is responsible to oversee the operations of the GEF are in line with the existing and emerging global environmental conventions, and to serve as a center for disseminating information to and from GEF agencies [13].

There have also been efforts within the agencies of the United Nations, UNDP, UNICEF, UNFPA, WFP (World Food Programme), IFAD (International Fund for Agricultural Development) to organize collaborative arrangements relating to sustainable development, through a coordination mechanism called Joint Consultive Group on Policy which has recently been extended to consultations on operational activities in the field [17].

These positive efforts do not seem to be enough. As mentioned above further more fundamental changes are necessary. However, the way to achieve these changes neither clearly defined nor put in practice.

2.7 CONCLUSION: STRENGTHS AND WEAKNESSES

2.7.1 STRENGTHS

From what has been discussed, the following strengths of the concept of SD have been identified:

a) There has been a shift from the economic development emphasis on industrialization and export sectors, towards the social development sectors such as education, human resource development, public health etc.

b)There has also been a shift towards more efficient and "green" technologies, for example through programs promoted by EPA, namely "Green Lights".

c)The integration of population considerations beyond just numbers, like composition characteristics and distribution have started to enter environment and development plans, both on short-term and long term basis.

d)Partly due to its generality, the concept of SD has been accepted by many, a necessary prerequisite for collaboration in both national and international levels. For the first time a serious effort for integration of environment and development has been taking place, a very important step for improving world's conditions. The fact that the definition of the concept

is general, unlike passed development paradigms, makes it easier to be adapted to the different countries's needs without entering in opposition with cultural and social values.

2.7.2 WEAKNESSES

Perhaps one of the greatest weaknesses of the concept of SD is its lack of clarity in the definitions of sustainability and development. As aforementioned, there is great controversy concerning the concept of sustainability such as the setting time limits, as well as what the development process should encompass apart from the purely economic factors. The multiple dimensions of sustainability must be understood and an effort must be made to develop measures, criteria and principles for them.

Another obstacle which surges is in relation with the operationality of the concept or its lack of it. A point of great controversy is the way to combine the need of economic growth, especially in developing countries, and ecological sustainability, and if it is really feasible to have both. Its resolution is essential for the creation of a methodology of the paradigm. To achieve this, the communication between governments, and scientific communities is more than necessary.

The existing pluralism could be both a positive and a negative point. On the one hand it is positive since it could lead to creative solutions to problems, however on the other, it could lead to misunderstandings and in consequence delays of actions to be taken. The broader participatory process should be well defined and accepted especially at the international level.

The challenges are great for developed and developing countries as well as for international agencies. A great triumph of ECO92 is the confirmation of the political acceptance of the concept of SD. Although these problems like the ones mentioned in this study, are yet to be resolved, there has been achieved significant progress towards international collaboration, including governments, scientific communities, and non-governmental organizations.

CHAPTER 3: THE ARAL SEA

3.1 INTRODUCTION

The Aral Sea situation has become critical during the last 30 years. As a result of diminishing inflow, the Aral Sea began to shrink in volume and area and is now on the verge of total collapse. The tragedy is mainly due to anthropogenic factors, namely the wrong development strategy for expansion of cotton and rice cultures. The present conditions, social, economic and environmental, are described in the following sections of this chapter, with information based on three sources, papers by Arkady Levintanus, Norman Precoda and the Diagnostic Study for the development of an action plan by UNDP.

3.2 LOCATION

The Aral Sea is located to the East of the Caspian sea, at the junction of the barren Plato Ustuyurt and the Kyzylkum and Karakum deserts. Its basin includes the basins of the Syr Darya, Amu Darya, Tedjen, and Murgab rivers. It also includes a number of smaller rivers draining the western part of Tien Shan and Copet Dag, the area of the Karakum Canal, and the closed drainage basin between these rivers and around the Aral Sea.

The Aral region includes the entire areas of Uzbekistan, Tadjikistan, part of the territory of Kazakhstan, Kirghistan, Turkmenistan, and parts of northern Afghanistan and northeastern Iran. The Soviet area of the region is about $1{,}5.10^6$ km^2 , and the whole region is about $1.8.10^6$ km^2 [19].

The region has a complicated geomorphology, including the enormous Turanian plain and huge mountain ranges with peaks reaching 6.000 to 7.000 meters and higher. The plains take up to 80% of the total area while the mountains 20%. In the Aral basin, the mountain ridges of Kopet Dag, Paromisus and Hindu Kush form an orographic barrier between the sub-tropical climate of Iran and Afghanistan and the temperate zone. The climate in the northern parts of the Aral Sea basin is continental, while in the southern parts is subtropical. The position of the basin in the center of the continent, and far from the oceans, produces the continental climate.The territory receives considerably more solar energy than any other part of the former USSR. In the winter, cold air masses reach the area causing a significant decrease in the temperature.

Transport of moisture is mainly from the west, with an additional input of moisture from the south to form precipitation, and to glacier formation on the southern slopes of Gissaro-Alay, Pamir, and Tien Shan.

On the plains of the Aral region, the annual amount of precipitation is 90 to 120 millimeters. In the piedmont areas, it is 400 to 500 millimeters, while on the western slopes of Tien Shan it is more than 2.000 millimeters. The total quantity of precipitation reaches 500 km^3/yr . Atmospheric precipitation is mostly limited to that brought to the area by the humid air masses of the Atlantic ocean, resulting in the extremely arid climate. In the northern deserts, the humidity coefficient is 0,1 to 0,2 and in the southern deserts it is less than 0,1.

Before the decline of its water level in the mid-twentieth century, the area of the Aral Sea was 68,320 km^2, including 66,090 km^2 of water and 2,230 km^2 of islands[19]. Its water volume was about 1,066 km^3. The maximal depth was 69 meters although most of the Aral Sea was less then 30 meters deep. Mineralization of the Aral water was 10 to 12% .

The Aral Sea type is that of embayed coast, with numerous lagoons, shallow and narrow passages between the islands, lakes and closed basins periodically communicating with the Aral Sea and forming natural evaporator basins which strongly affect the salt balance of the sea. River run-off and evaporation has the greatest influence on the water balance of the Aral Sea.

The water level is determined by a combination of the effects of climate, geomorphology, and tectonics; in the last few thousand years, it has been affected by human economic activity. The Aral Sea probably first appeared in the Pliocene Era or even as early as the late Pleistocene Era. In historic times, the water level of the Aral Sea was affected not only by natural factors, but anthropogenic factors as well. During the Mongolian invasion of the region in the twelfth century, many irrigation systems were destroyed.

From 1750-1950, the water level of the Aral Sea has fluctuated not more than four meters. In the first half of this century, the water level variations have not been more than one meter.

3.3 HISTORY OF THE ARAL REGION

A very significant feature of the history of the population in the Aral region is a long-term interaction of the settled agricultural population with the semi-nomadic, cattle raising people of the deserts and steppes. On the territory of the Syr Darya and Amu Darya interfluve, the principles of primitive irrigation and semi-settled cattle-breeding and agriculture-fishing economies have been persistently maintained since the Bronze Age.

The peak of ancient irrigation was reached in the Kushan Age in the first centuries A.D., with the growth of cities, handicraft industries and hydrotechnical knowledge. The essential transformation of the entire irrigation system in the Khoresm oasis was achieved during the rule of Khoresm Shahs in the 11th and 12th centuries. The development of irrigation in the area of Samarkand reduced the water supply to the lower part of the Bakhara oasis, where irrigation decreased. Timur who became Emir in 1370 made Samarkand the metropolis of his vast land properties.

In the Middle Ages, the Chack and Ilak oases in the Chirchik and Auguen valleys in the middle reaches of the Syr Darya were the most thriving oases with developed irrigation.

At the beginning of the twentieth century, the populations inhabiting the agrarian oases of the Aral Sea basin,due to their rich experience of irrigation husbandry, turned the deserts to cultivated oases. In the piedmont zone, irrigation was combined with cattle grazing.

Intensive development of irrigation agriculture during the second half of the twentieth century was carried out on a large scale. This was possible through reclamation of large salted areas, or lands with shortage of irrigation water. This intensive development was followed by population growth and extensive pesticide and herbicide use mostly for cotton production. Ecologically harmful agriculture and crop care methods were used. All these factors have led to the present ecological, social and economic crises in the Aral Sea region.

3.4 GENERAL CHARACTERISTICS OF THE ARAL REGION

In general lines, the Aral region has a considerable economic and scientific-technical potential, and significant areas of arable land. However, industrial and social structure is insufficiently developed.

The major characteristics of the basin are:

a) High population growth rate.

b) High number of labour resources.

c) Increasing deficit in water resources

d) Ecological crisis.

The states of the Aral basin are great producers of cotton and silk, 90 and 75% of the former USSR production, as well as of wool which accounts of 67% of the former USSR manufacture[3]. The area is a prominent fuel and power base, as well as an important producer of nonferrous and ferrous metals and chemicals. It is also a source of subtropical fruit, vegetables and grapes, melons and other agricultural products.

3.4.1 HUMAN RESOURCES

Between 1976 and 1990, the population of the region increased from 23.5 million to 34.0 million people. 32 million of these people live in the republics of Central Asia, and 2.5 million in southern Kazakhstan in the Aral basin. The natural reproduction rate of the Central Asia region is very high exceeding the the average all-Union indices by two or three times

Table 3.1 Area and Population of the Aral Sea Basin, referenced to January 1, 1987

States	Area (*1000 km^2)	Percent of basin	Population (in thousands)			
			1959	1970	1980	1989
Uzbekistan	448,8	24,6	8119	11973	15961	19906
Kirghistan	126,7	7,0	1010	1434	1815	2238
Tadjikistan	143,0	7,9	1981	2941	3953	5112
Turkmenista	491,2	26,9	1516	2188	2861	3534
Kazakhastan	302,2	16,6	1180	1766	2131	2420
Subtotal:	1511,5	83,0	13806	20302	26721	33210
Nothern Afghanistan	243,0	13,4				
Northeastern Iran	65,0	3,6				
Total for Aral Sea Basin	1815,5	100,0				

Source: Reference no 19 - (Page 14)

Table 3.2- Average annual rate of population increase 1986-1990

	TOTAL	Average annual rate in towns	in villages
ex USSR	0,95	1,5	0,2
Uzbekistan	2,88	3,25	2,55
Kirghiztan	2,60	3,0	2,45
Including the Aral Basin	2,60	3,0	2,45
Tadjikistan	3,2	3,2	3,25
Turkmenistan	2,65	3,15	2,2
Southern Kazakhstan	1,06	2,10	0,30
Total for the Aral basin	2,75	3,10	2,40

Source: Reference no 19 - (Page 15)

The region has a considerable labour potential. However, a large number of young, educated people have problems finding employment, mainly because labour resources grow disproportionately larger than does job availability. A low mobility of the native population also concentrates labour in agricultural regions. 75.2% of labour in Central Asia is occupied in production, while the index is 73.8% for Uzbekistan, 78.1% for Kirghistan, and 79.7% for Turkmenia.

The fact that about one third of the region's labour is concentrated in agriculture, a percentage relatively higher than the country's as a whole, shows that there is a surplus of labour. One of the most serious problems the region is facing, is the lack of qualified and trained workers in other branches of economy. By motivating people working for industries

the costs of technical schools would lower, due to the higher number of students enrolled, thus alieviating the surplus of labour resources.

3.4.2 NATURAL RESOURCES

Water resources

The water resources of the Aral Sea drainage basin are composed of surface and ground waters, distributed in an extremely irregular pattern throughout the basin.

.Surface Waters

The basin is a closed drainage region completely cut from the oceans. Hydrogeographically it contains several separate and independent basins of the rivers of Amu Darya, Syr Darya which are the principal water arteries, Zarafshan, Kasha Darya, Murgab, Tedjen and the blind rivers of Turkmenia and northern Afghanistan. The distribution of water streams is extremely irregular with the primary source of all rivers being the snow and glacier runoff.

Table 3.3-Surface runoff in the Aral Sea drainage basin

Basin	Natural runoff of different degrees of guarantee (km^3)		Guaranteed runoff (km^3)	
	Average perennial	90%	At present 2000- 2005	Forecast for
Amu Darya	77.4	61.3	62.5	68.6
Syr Darya	38.4	28.2	35.3	35.3
Total for Basin	115.8	89.5	97.8	104.1

*The guaranteed runoff will increase by the years 2000-2005, due to introduction of the Rangoon and other reservoirs.

Source: Reference no 19- (Page 25)

..Amu Darya basin.

It is the largest area with the highest water-bearing capacity of the region. It includes streams that form the run-off of Amu Darya and smaller rivers whose waters are completely consumed. The basin is divided into two physico-geographic parts, which include the eastern mountain area with the highest peaks in the former USSR, a primary source of river waters, and the western part of lowland deserts and semideserts where the runoff is dispersed.

..Syr Darya basin.

It is the largest river in Central Asia with 142.000 km^2, runoff of 38,4km^3/yr with 50% of supply. The water is supplied from snow/glacier runoff.

Despite long periods of hydrologic observations, estimation of the parameters of the natural runoff (water resources) of the Amu Darya and Syr Darya basins is complicated due to the

present economic activity which includes intake and discharge of water for irrigation, regulation of reservoir discharge, which distorts estimation of the natural runoff.

.Ground Waters

The distribution of ground waters over the region is irregular because of the difference in the geologic structure of the crust, different climatic conditions, relief elements, and composition of water bearing rocks.

Table 3.4-Predicated ground water resources of the Aral Sea drainage basin.

Basin or Republic	**Total Resource**	**Mineral Content (g/l)**			
		up to 1	**1 to 3**	**3-5**	**more than 5**
				(Km^3/yr)	
Amu Darya basin, including	40,56	7,42	2,92	3,33	26,89
1.Uzbekistan	8,0	3,13	1,65	1,85	1,37
2.Tadjikistan	4,28	3,83	--	0,45	--
3.Turkmenistan	28,28	0,46	1,27	1,03	25,52
Syr Darya basin, including	21,03	15,31	4,65	0,24	0,83
1.Uzbekistan	11,04	10,40	0,64	--	--
2.Kazakhstan	6,76	2,05	3,64	0,24	0,82
3.Kirghistan	1,66	1,66	--	--	--
4.Tadjikistan	1,57	1,20	0,37	--	--

Continued next page

Total Aral Sea basin, including	61,59	22,73	7,57	3,57	27,72
1.Uzbekistan	19,04	11,53	2,29	1,85	1,37
2.Kazakhstan	6,76	2,05	3,64	0,24	0,83
3.Kirghiztan	1,66	1,66	--	--	--
4.Tadjikistan	5,85	5,03	0,37	0,45	--

Source: Reference 19- (Page 27)

At present, more than 250 underground water reservoirs of economic significance have been identified in the basin. The intake of ground waters in the Aral basin totals 12.3 km^3/yr, including 3.98 km^3/yr in the Amu Darya basin and 9.32 km^3/yr in the Syr Darya basin. The total perennial resources in the basin are 118.3 km^3

3.4.3 LAND RESOURCES

Land resources of the Aral Sea basin total 151,200,000[19] hectares where 99.100.000 hectares is agricultural land

8.300.000 ha are actively farmed
300.000 ha is fallow
600.000 ha are hayfields
89.400.000 ha are pastures
600.000 ha are perennial plantations.

The largest area of farmed land is in Uzbekistan, and the smallest in Kirghiztan. Desert pastures are predominant in Turkmenistan, and the land used for hayfields is insignificant in

all republics. Because of the arid climate approximately 90% of all farmland (7,400,000 hectares) is irrigated. There exist three agricultural zones, the desert, piedmont-desert, and mountainous shrub-steppe areas.[19]

The classes of fertile land are composed as follows[19]:

First Class 46%

Second Class 42%

Third and Fourth Classes 22%

The crops cultivated are cotton 51%, fodder 27%, grain 16%, and potatoes, vegetables and melons 5%.[19]

3.4.4 MINERAL SOURCES AND RAW MATERIAL.

The fuel and energy reserves of the region are composed of large reserves of coal (30.5 MM tons), oil resources (1.4 Billion tons) and natural gas resources (17.3 Trillion m^3)[19].The degree of exploration of these resources is not high, implying possible industrial reserves for the future.

There is also a significant potential for the development of various polycomponent minerals, which would enhance the development of mining industry.

The potential hydropower resources of the Amu Darya and Syr Darya, concentrated in Tadjikistan and Kirghistan, total 306 162 TWh respectively. The economic potential of the hydropower resources is 127 TWh.

The resource base for ferrous metallurgy is composed of several small ferrous deposits and of numerous ore deposits. The potential ferrous ore resources total about 5.53 billion tons with the balance of the reserves totaling 117.6 million tons.

The Aral Sea region contains more than half of the All-Union potential resources of antimony, a third of quicksilver, and a considerable share of copper, lead, zinc, tin, tungsten, molybdenum, fluorite, strontium, lithium, and many other nonferrous rare and precious metals.

3.4.5 RECREATIONAL RESOURCES

There are extensive possibilities for the development of tourism in the area. There are beautiful historical monuments, a large variety of mineral waters and medicinal muds, 200 of warm days per year, steady periods of sunshine, hot and dry weather, and low relative humidity.

3.5 PRINCIPAL CHANGES TAKING PLACE DURING THE LAST 40 YEARS

Human Induced Climatic Changes

Previous development did not reduce the river spill into the Aral because the areas developed were primarily in valleys and river deltas, areas with abundant moisture. After preparing the land for cultivation, even less water was utilized when compared with the vegetation existing before[20].

Intensive changes in the Aral region have taken place in the last twenty years. Water diversions have increased. River runoff has decreased, a fact which caused a decline in the water level of the Aral Sea as well as the drying of branches and arms of the Amu Darya and Syr Darya river deltas. Withdrawls from the rivers caused inflows to the Aral to fall at an average of over 50 km^3 annually between 1930 and 1960, to 35.2 km^3 in 1970, to 10 km^3 by 1980 and 1-5 km^3 in the 1980's[21]. Natural lakes on the plains of the Aral Sea basin have disappeared, or are reduced. Irrigation waste water has been formed along the periphery of irrigated zones.

There has also been a decrease in the propagation of steppe and desert vegetation, along with the formation of new landscapes on the exposed and desiccated bottoms of lakes and the Aral Sea and the disturbance of natural dynamics of the water medium.

A growing phytomass increment on irrigated massives and near the canals resulted in higher transpiration. The microclimate in the zone of influence of the Karakum canal also was affected, the transpiration reached 0,6 km^3/yr, and the evaporation from the canal bed and filtration lakes also has increased.

There has been a change of soil moistening, of the depths of ground water levels and of the natural heat-water balance correlation, and on the climate in general which has become more continental. The amplitude of the summer and winter air temperatures at coastal stations increased by 1,5 to 2,5 ^oC. [19] Highest temperature variations during the last decade were accompanied by the reduction of the Aral Sea water surface level.

In addition, the albedo of areas formerly occupied by the Aral Sea increased severalfold, producing a more than threefold increase in the reflected solar radiaiton value in the Aral area.

A dry coastal band on the northeastern and eastern seashore, 40 to 50 kilometers wide, contributes to the development of dust debris cones reaching over 500 kilometers in length.

From 1966 to 1980, the number of days with dust storms, and storms with drifting dust in coastal regions, increased by more than 50%, with some locations the number increasing 360%.

3.5.1 SURFACE RUNOFF WATER LOSSES

Irreversible water consumption by various industrial and agricultural activities, and human populations as well as additional evaporation from reservoir surfaces.

Table 3.5-Average runoff losses in the Aral sea drainage basin.

	ANNUAL RUNOFF LOSSES (km^3/yr)									
Period	**SYR DARYA BASIN**			**AMU DARYA BASIN**			**TOTAL FOR THE ARAL SEA**			**
	natural	Anthrop	Sum	natural	anthrop	sum	natural	anthrop	sum	
1932-40	6,7	14,7	21,4	15,1	6,3	21,4	21,8	21,0	42,8	--
1941-50	6,0	18,8	24,8	10,3	15,5	25,8	16,3	34,3	50,6	--
1951-60	3,7	24,7	28,4	9,7	18,9	28,6	13,4	43,6	57,0	56,0
1961-70	2,9	30,0	32,9	8,2	29,5	37,7	11,1	59,5	70,6	43,3
1971-80	1,7	31,8	33,5	3,3	50,2	53,5	5,0	82,0	87,0	16,7
1981-85	1,6	31,9	33,5	2,5	62,7	65,2	4,1	94,6	98,7	2,0
1986-88	--	--	--	--	--	--	--	--	--	10,8
1989	--	--	--	--	--	--	--	--	--	5,3

** Discharge to lower parts of deltas to Aral Sea

Source:Reference 19 - (Page 27)

Table 3.6-The use of water resources in the Aral Sea basin

Branch of Economy	**Water Intake (km^3/yr)**	**Water Diversion (km^3/yr)**	**Consumptive water use (km^3/yr)**
Municipal economy	3,1	1,6	1,5
Industry and power generation	8,3	6,4	1,9
Rural drinking water supply	0,86	no data	no data
Fishery	2.0	1,0	1,0
Irrigated Agriculture	113,9	38,7	75,2
Total:	**128,16**	**47,7**	**79,6**

(Note: The water intake volume is larger than the average perennial runoff, due to the waste of drainage and runoff water to rivers and their secondary use).

Source: Reference 19 - (Page 47)

Agricultural irrigation includes the diversion of water from rivers, as well as operational wastes from irrigated massives back to the river. It is calculated that 65% to 70% (in some locations reaching 80%) of the irrigation water is lost before reaching the vegetation.

Irreversible water consumption includes evaporation and transpiration in irrigation systems, operational waste from irrigated massives to closed drainage depressions, to lakes without outflow and to the desert.

Anthropogenic runoff uses in the basin over the last 60 years have increased more than three times. It now exceeds 90 km^3/yr. 85% to 98% of anthropogenic use of runoff is for irrigated agriculture, with only 8% to 15% of the decrease caused by climatic factors.

3.5.2 CHANGES IN THE FAUNA AND FLORA

Impoverishment of the flora, of formerly existing and newly-formed communities has happened. Prior to the desiccation of the Aral Sea, the flora of its basin approximated 1,200 species of angiosperms. The richest tugay forest (fringing forests of moisture) of the Amu Darya today have 576 species, including 29 species endemic to Central Asia. Today 54 species of these plants are on the verge of extinction.[19]

Animal populations of argillaceous deserts were significantly affected by direct human activity such as cultivation of new territories, including transport, construction, plowing, laying of firing and fires.

Desertification of deltas and flood plains resulted in the regrouping of species in zoocomplexes.

Desiccation of aquatic ecosystems have made new land available for 25 mammal species, 15 bird species and approximately 10 reptile species together with a small number of invertebrates.[19]

3.5.3 CHANGES IN THE WATER AND SALT BALANCE OF THE ARAL SEA

Water Balance: In the last thirty years there has been a decrease of 15.6 m. By early 1990's the sea's falling level has reduced the Aral into two waterbodies, the so-called Small and Big Seas, separated by dry land more than a hundred meters wide at its narrowest point. The exposed former seabed is now covered by white alkali soil, namely solonchak.

Table 3.7-Annual water balance and main parameters of the Aral Sea 1911-1992.

Years	Sea Level	Sea Volume	Sea Surface	Average Salinity	River Inflow into sea	Precipitation	Evaporation
Years	m	km^3	*103 km^2	o/oo	km^3	km^3	km^3
1	2	3	4	5	6	7	8
1911-1960	53,0	1064	66,10	10,2	--	--	--
					56.0	9.1	66.1
1961-1965	53,38	1089	67,34	9,94	197,2	43,9	344,9
					39.4	8.9	68,9
1966-1970	52,06	1004	62,96	10,91	235,7	36,8	313,0
					47.0	7.36	68,6
1971-1975	51,27	955	60,41	11,23	106,9	29,8	292,3
					21.2	6.0	58,5
1976-1980	48,52	795	56,03	13,95	58,0	31,9	251,6
					11.6	6.4	50,3
1981-1985	45,52	632	51,03	17,70	10,0	30,7	229,3
					2,0	6.1	45,9
1986	41.4	440,0	43.00	22.00	--	--	--
1987	40,54	404	41.06	26,8	8,8	6,9	48,4
1988	39,84	365	39,40	28,3	5,37	3,48	38,0
1989	38,6	330	36,90	30,1	9,4	4,3	35,0
1990	37,3	304	34,80	33,3	9,4	4,3	35,0
1991	34,4	--	--	--	13,88	5,2	30,0
1992	37,2	--	--	--	7,16	2,5	--

Source: Reference 19 - (page 54)

Salt Balance: Chlorides, sulfates, sodium and magnesium come mostly from irrigated lands. The quantity of sodium and chloride ions of the Amu Darya and Syr Darya basins has increased 2.5-5.3 times. Sulfates predominate in the water basin of Amu Darya and chlorides in the water basin of Syr Darya.

As a result of the development of irrigation, the ion ratio in the water in different parts of the river has changed. The flow of salts in the water from irrigated lands was higher than from the land which served as a source of the river flow.

The supply of salts to the land increased considerably as a result of water filtration in canals, of withdrawal of ground water from irrigated lands , and outflow of drainage water to the limits of oases. Development of irrigation led to the movement of salts that were stored in the ground, and their redistribution over vast territories of arid land.[19]

Secondary salinization: Nearly 40% of the irrigated land in Turkmenistan is subject to secondary salinization. Increased by seepage losses from transport and irrigation canals and from reservoirs, and by the careless disposal of collector and drainage waters from the fields, the highly mineralized ground waters rise toward the surface carrying with them the salt. More than 62 million tons of salts are estimated to have accummulated on about 80.000 km^2 of land along the Karakum canal.[19]

Table 3.8- Salt accumulation in the water of the Aral sea

Year	Salt Accumulation ($*10^9$ t)	Year	Salt Accumulation ($*10^9$ t)	Year	Salt Accumulation ($*10^9$ t)
1961	10,74	1970	11,09	1979	10,86
1962	10,81	1971	10,57	1980	10,89
1963	10,76	1972	10,75	1981	10,96
1964	10,94	1973	10,68	1982	11,06
1965	10,89	1974	10,68	1983	11,03
1966	10,81	1975	11,17	1984	10,86
1967	10,54	1976	10,85	1985	10,08
1968	10,90	1977	10,66	1986	9,07
1969	10,57	1978	10,69		

Source: Reference 19 - (Page 61)

3.5.4 WIND EROSION

Salty deposits coat the once productive agricultural lands of the Amu delta and more than a million ha of agricultural land are unproductive. The Karakum and Kyzylkum deserts have now met on the Aral's exposed seabed is about a 120 tons per ha (two-thirds to three-fourths of the salt in the upper half meter are sodium chloride and sodium sulfate).[21]

The salty dust particles settle on cotton plantations and ricefields and harvests deteriorate. It was estimated that up to 75 million tons of fine dust particles and salts are transported by wind each year. In the Aral region, an average of 520 kg of sands and salts fall on each hectare of land.[19]

During the summer time the mountain peaks are scarcely visible because of aerosole settling on them, as much as 3-4 tons per ha of which 100-500 kilos are soluble salts accelerating the thawing process. Glaciers became noticeably smaller.[21]

Changes in the acquatic ecology

The physical factors which have changed are the following:

1. Higher Salinity
2. Drop in the water level
3. Introduction of new species.
4. Input of biogenic substances to the lake.

Changes in the phytoplankton community reflected not only changes in salinity, but also in the concentration of biogenes. Lower water levels had a negative effect on phytobenthos as well.

Since 1987, 18 fish species have been introduced. When salinity reached levels above 14% all freshwater and moderately halophilic plankton died with euryhaline zooplankton surviving and reaching high densities. [19]

The effects of high salinity have been intensified since 1971; the growth norms for many fishes declined, mortality rate increased, population numbers decreased rapidly, and morphological aberrations appeared.

3.6 SOURCES OF POLLUTION OF THE ARAL BASIN

Industrial Pollution: The pollution caused by the industrial sector is a significant source. The emissions are high, there is low environmental investment. The 33 waste-purification plants do not operate efficiently. Wastes from oil processing, chemical, heavy industry, non-ferrous metallurgy production, enterprises producing mineral fertilizers are not treated properly.[19]

Agricultural Pollution: The limits for the use of chemicals in the area are exceeded severalfold. Yearly up to 300 kg of mineral fertilizers and at least 50 kg of toxic chemicals are used per ha. [21]

Application of pesticides by airplanes causes air pollution. In addition banned pesticides are still being kept in storehouses while at the same time there is not sufficient space for fertilizers and pesticides.

There is liquid waste from cattle-breeding farms with only 30% of the region's agricultural facilities having manure deposits and discharge of drainage and sewage waters to rivers.

Atmospheric pollution: The permissible levels of industrial emissions have been exceeded by the following factors [19]:

1. Carbon monoxide in Fergana and Samarkand by 7 to 8 times.
2. Fluorhydric in Almayik by 9 times; and
3. Ammonia in Chirchik by 24 to 30 times.

Soil Contamination: Pesticides, mineral fertilizers and various nitrites accumulate in the soil and find their way into the crops. In Kirghizin, DDT soil contamination exceeded the MPC

by a factor of two to nine in vegetable-growing areas, and by a factor of 33 to 46 in cereal-growing areas. In Uzbekistan, soils in cotton growing areas exceeded the MPC by a factor of 31 to 86. [19]

Water pollution: The use of pesticides banned in the rest of the former USSR have been causing pollution, high concentration of organochlorides in the rivers of the Aral region, with values reaching ten times the MPC. Salt is another pollutant, since intensive irrigation leads to salinization of land and water in the absence of careful management. Increases of the mean annual mineralization have been observed in the Amu Darya, which consequently led to change of its ionic composition.

3.7 STATE OF HUMAN HEALTH IN THE ARAL REGION

According to official data of local health services, scientific publications, reports from scientific institutions and other data, the state of human health in the Aral basin is quite alarming. [19]

There have been observed high levels of intestinal infectious diseases, of difficult pathologies including intestinal disorders, oncologic, cardiovascular, blood-formation organs and respiratory system problems, of infant morbidity and mortality, of congenital deformation and of other genetic diseases. [19]

There have also been observed high numbers of typhoid, viral hepatits, paratyphoid occurences. An otherwise decrease of tuberculosis and natural infection has not occured. 70% of the mothers suffered from anemia. From 1981-1987 heart disease and hypertone have doubled.

The causes of the current health situation have been attributed to factors such as microbial and chemical factors transferred by water, food or human contact. The microbial pollution in drinking water is probably due to the poorly treated sewage and the insufficient sewage network, as well as to the minerals and pesticides disposed in the rivers. High atmospheric salt concentrations and pesticides added in food production are two additional factors.

3.8 CAUSES OF THE ARAL SEA CRISIS

The causes of the situation described in the Aral Sea basin are mainly anthropogenic. According to A. Levintanus, the origins of the disaster lie in the wrong strategy of economic development in the area of ex Soviet Central Asia and Kazakhstan, as well as in the objective of increasing production of agricultural raw materials rather than finished products, with neglect of sound demographic policy and negligence of ecological problems. In this section the main causes of the crisis are described in more detail:

1) Problems concerning the development strategy and the implementation of the strategy.[19] The development of crop production mainly cotton production was the goal of the regional strategy of the states of the Aral Sea region. Although accurate analysis of the effectiveness of this production, especially for irrigated agriculture, was more than necessary, the economic effectiveness of land reclamation was overestimated, since calculations were based on gross yields instead of additional yields. Moreover, priority supplies of resources, better equipment and fertilizers were not considered in calculations. Another factor leading to miscalculation is that agriculture in Central Asia is not as effective as generally believed.

As mentioned above, land reclamation was mainly driven for increase of cotton production for the provision of clothing material for the country and for the increase of the export of cotton and cotton products. However, availability of cotton substitutes led to decrease in cotton price and in the exports of cotton fabrics.

2) Cotton has been grown in monoculture systems leading to extensive use of pesticides which together with their improper storage led to the negative effects on the environment and human health described in earlier sections.[19]

3) Great water quantity was used for rice cultivation in areas where land productivity was low (Central Asia and Kazakhstan). Irrigation systems were designed, built and maintained at a very poor level. Low quality of construction, bad maintenance of irrigation systems made lands unsuitable for irrigation.[19]

Table 3.9-Actual specific consumption of water for irrigation purposes and comparison with average based irrigation norms.

Ex-Republic	**Average-based irrigation norm (m^3/ha.yr)**	**Actual specific water application in 1980 (m^3/ha.yr)**	**(percent irrig norm)**
Kazakhstan	7721	13704	201
Kirghizan	6061	7402	122
Uzbekistan	9380	15404	164
Tadjikistan	9586	15190	158
Turkmenistan	10536	17635	167

Source: Reference 19 - (Page 97)

4) Large part of the land was irrigated without the necessary preparation. Data show that the real growth of irrigated land in Turkmenistan, and in some periods in Tadjikistan, was much higher that the official number. This implies that a large part of the land was irrigated without the necessary preparation.

5) Lower quality lands (of high soil salinity, degraded soil composition, unfavorable, hydrologic, geomorphologic or other conditions) reclaimed, led to negative ecological effects such as secondary salinity and formation of large quantities of salt drainage.

6) The difficulties related to land reclamation constitute of lack of facilities for combatting infiltration in the canals, a fact which intensifies filtration and loss of water, of the non satisfactory levelling of the land which leads to the need for additional water supply, of the increasing irrigational erosion, water logging and diversification of soil conditions of the same field.

7) The inappropriate discharging of agricultural drainage water in the deserts increases soil salinity and in the rivers it increases mineralization, the content of toxic substances, the deterioration of the drinking water quality and makes necessary an increase in the supply of the water for irrigation.

8) The excessive water use could be attributed partly to the fact that water use has zero cost for the users. Organic farming has not been promoted. The Ministry of Waters budget was mostly spent for expansion of the irrigated lands instead for the resolution of the crucial existing problems of the region.

9) Lack of good economic planning system led to the fulfillment of intermediate operations rather than on the final product. There was no encouragement of water saving technologies.

10) The departments who regulate water economy and usage in every river basin have no power over the users who violate the regulations of water use plans.

11) The water monitoring system is not well developed with lack of precise determinations of water quantities and qualities. The monitoring of population health did not produce satisfactory, reliable comprehensive data on the problems.

12) General population, managers and politicians are not aware of the problems related to the pollution of the basin. Education of the public for these issues is more than necessary.

13) The lack of independent institution funding led frequently to biased results favorable to ministries and departments since they are the only source of financing of research. In addition, insufficient funds did not allow adequate technology or some necessary research to be performed.

3.9 MITIGATING MEASURES AND ACTIONS TO BE TAKEN

Though the first signs of the crisis became evident in the 1970's they were ignored under the prevailing command-administrative system of management whereby water was the monopoly of ministries and other governmental bodies. Only in the years of Perestroika the situation changed.

The first step was taken in 1989 when the USSR Supreme Soviet constituted a Government Commission to elaborate measures for the restoration of the Aral Sea region. This committee anounced in June 1990 a competition to work out a concept related to these issues.

The first draft of this document called "Outlines of the Concept of conservation and restoration of the Aral Sea" was produced in 1991. The main these of this concept is that the regional economy has degraded to a disastrous state not because of the drying up of the Aral Sea but, on the contrary, the Aral catastrophe is an inevitable outcome of a deep crisis that struck the region (A. Levintanus,1992).

In January of 1994, the presidents of the five countries of Central Asia (Kazakhstan, Uzbekistan, Turkmenistan, Tadjikistan and (CEI) signed a protocol, which they are obliged to spend 1% of their annual budgets in a common fund to save the Aral sea. The decision was taken after pressuring from the World Bank, in the city of Nukus one of the most affected cities, adopting recommendations done by the United nations.22

Policies suggested from the diagnostic study of the UNDP and this concept include the following:

3.9.1 SHORT TERM ACTIONS

.Provision of drinking and housewater supplies.

.Provision of sewage systems and treatment facilities.

.Elimination of the direct discharge of pesticides, untreated sewage and saline waters to the rivers.

.Raising the level of medical services and increasing supplies of quality food products of the population of the area.

.The creation of republic, union and international foundations for the rehabilitation of the Aral Sea region.

3.9.2 MID-TERM ACTIONS

.Reconstruction of irrigation and water supply systems. At present the efficiency of the system is low, to 0,55-0,67. The available technologies could lead to an increase to 0,8. Reduction of seepage losses from irrigation canals would permit a gain of an additional 10 km^3 21.

.Use of operational wastes. Annual losses of some agricultural products due to inadequate storage and processing facilities are very high. Reduction of these losses would lead to water savings since the water use for cultivation of these crops is lost.

.Introduction of new forms of economy, such as labour consuming industries with low water consumption, or the increase in consumer's goods production.

.Reduction of areas under rice, since is the most water consuming crop and as mentioned before and is not as effective as thought.

.Afforestation and phytoreclamation are also very important in order to increase overall moisture by protecting watersheds. Phytoreclamation is also important to improve the ecological situation of the dried bed of the Aral Sea.

3.9.3 LONG-TERM ACTIONS

.Change of the strategy of the development of economic and productive forces in the Aral Sea region. Tranformation of the cotton growing and processing sector. The reduction of

raw cotton exports and raw cotton fibre production to 1.4-1.6 million tons, equivalent to 4.3-5.0 million tons of raw cotton, will release land which could be used for growing food and fodder crops[21].

.Expansion of the number of branches of the economy.Reduction in cotton production can be met by a significant increase in the output of chemical fibers that is also beneficial for saving water.

.Resolution of demographic problems.

.Improvement of the administrative division of the region.

To achieve these goals the following is necessary:[19]

-Detailed detrmination of the ecological demands of the Aral Sea.

-A more precise salt balance equation.

-Prediction of regional climatic variations.

-Detailed assessment of each proposed project for the rehabilitation of the Aral Sea.

-Wide discussion of the social and economic requirements, including comparison of the wishes of the population with the necesssary funds to develop and implement them.

3.10 ECONOMIC COSTS

According to A. Levintanus[21], the cost for improving the existing water potential and the ecological situation in the Aral Sea basin is around 60 million roubles an amount which could double due to the economic instability of the country. The financing of the strategy would come from the former USSR government and from the area itself. A. Levintanus believes that the only concrete possibility is financing originating from the Aral Sea region itself.

The following table shows the water saved and the required investments for implementing the strategies mentioned above.

Table 3.10 Guide plan for implementing an integrated program to solve the Aral Sea problem.

MEASURES	AMOUNTS OF WATER TO BE OBTAINED OR SAVED (Km^3)	CAPITAL INVESTMENT REQUIRED (BILLION ROUBLES).
FIRST STAGE: 1991-1995		
Discharge into the Aral Sea of the non-regulated river flow.	15	3
Development of infrastructure and processing industry	--	3
Reduction of sown areas under rice	4	0.1
Fixation of the Aral sea dried bed	--	0.25
Modernization of irrigation systems in an area of 2.5 million ha.	5	14.5
Measures to prevent inflow of drainage water into rivers.	--	1.5
Introduction of water charges.	8	3
TOTAL	32	25.32

(table continued in next page)

SECOND STAGE: 1996-2000		
Development of infrastructure and processing industry.	--	4.5
Fixation of the dried sea bed.	--	0.25
Modernization of irrigation systems in an area of 2 million ha.	5	11.5
Measures to prevent inflow of drainage water into rivers.	--	5
TOTAL	5	21.25
THIRD STAGE: 2001-2010		
Elimination of losses caused by inadequate infrastructure and processing industry.	2	1.5
Fixation of the dried sea bed	--	0.25
Modernization of irrigation systems in an area of 0.7 million ha.	2	4
Other measures	5	6.5
TOTAL	9	12.25
TOTAL FOR THREE STAGES	46	59

Source: Reference 21

3.11 CONCLUSIONS

The situation of the Aral Sea described above is indeed very critical, and immediate action is essential. Despite that degradation of the region has reached high levels, reversing the situation is not impossible. High investments are needed for this recovery, as well as massive regional and national efforts.

The Aral Sea is an example of the wrong development strategy leading to eventual environmental, social and economic degradation. It proves the strength and complexity of the relations between environment and development. The integration of the two is essential for the well being of both human as well as the ecological environments.

CHAPTER 4: THE BILLINGS CASE

4.1 INTRODUCTION

The Billings reservoir is located at the Southeastern region of the city of São Paulo and integrates the Upper Tietê system, occupying areas of the municipalities of São Paulo, São Bernardo do Campo, Santo André, Ribeirão Pires and Rio Grande da Serra.

The reservoir, with a maximum reserve volume of 1.200 MMm^3, is a result of the damming up of the river Grande in Pedreira and was constructed with the objective of energy generation, in accordance with the state legislation of 1925.

4.2 GENERAL CHARACTERISTICS OF THE BILLINGS RESERVOIR

The Billings reservoir has the following characteristics [23]:

.Natural Drainage Area: 590 km^2

.Useful Maximum Volume: 1206,5 m^3

.Maximum Inundated Area: 127 km^2

.Useful Maximum Level: 747,65 m.

The inflow of the reservoir comes from the rivers Grande, Pequeni, Capivari, Pedra Branca, Taquacetuba, Alvarengas, Bororé, Cocaia and its average flow is 18 m^3/s. The reservoir of irregular shape of perimeter 900 km, is surrounded by the Planalto subtropical forest.

The climate is humid tropical and has one of the highest precipitation indices of the country (annual average of 1300 to 1500 mm). January is the rainiest month and July the driest.

Temperatures are higher during December and March at about 20-21° C and lowest during April-July at 14-15° C.

The drainage basin of the Billings reservoir is limited to the North by the drainage areas of the rivers Tamanduatei, Guaio and Taiacubeba as well as by all the trubutaries of the Tietê river, to the South by the coastal basins of the rivers Quilombo, Cubatão and Capivari-Monos, and to the west by the drainage basin of the Guarapiranga river.

The adjacent cities to the basin include Ribeirão Pires, Rio Grande da Serra, Diadema, Santo André, São Bernardo do Campo and São Paulo. The rural zones of these cities include natural forests, cultivated and pasture lands as well as fruit production activities. The urban soil use is predominantly small recreational country houses and clubs with higher frequence during weekends.

Water uses of the reservoir include [24]:

.Domestic water provision included in the provision system of the Metropolitan region of São Paulo (Rio Grande Compartment).

.Domestic sewage reception, due to periodical or sporadical water pumping from the river Tietê to the Pinheiros.

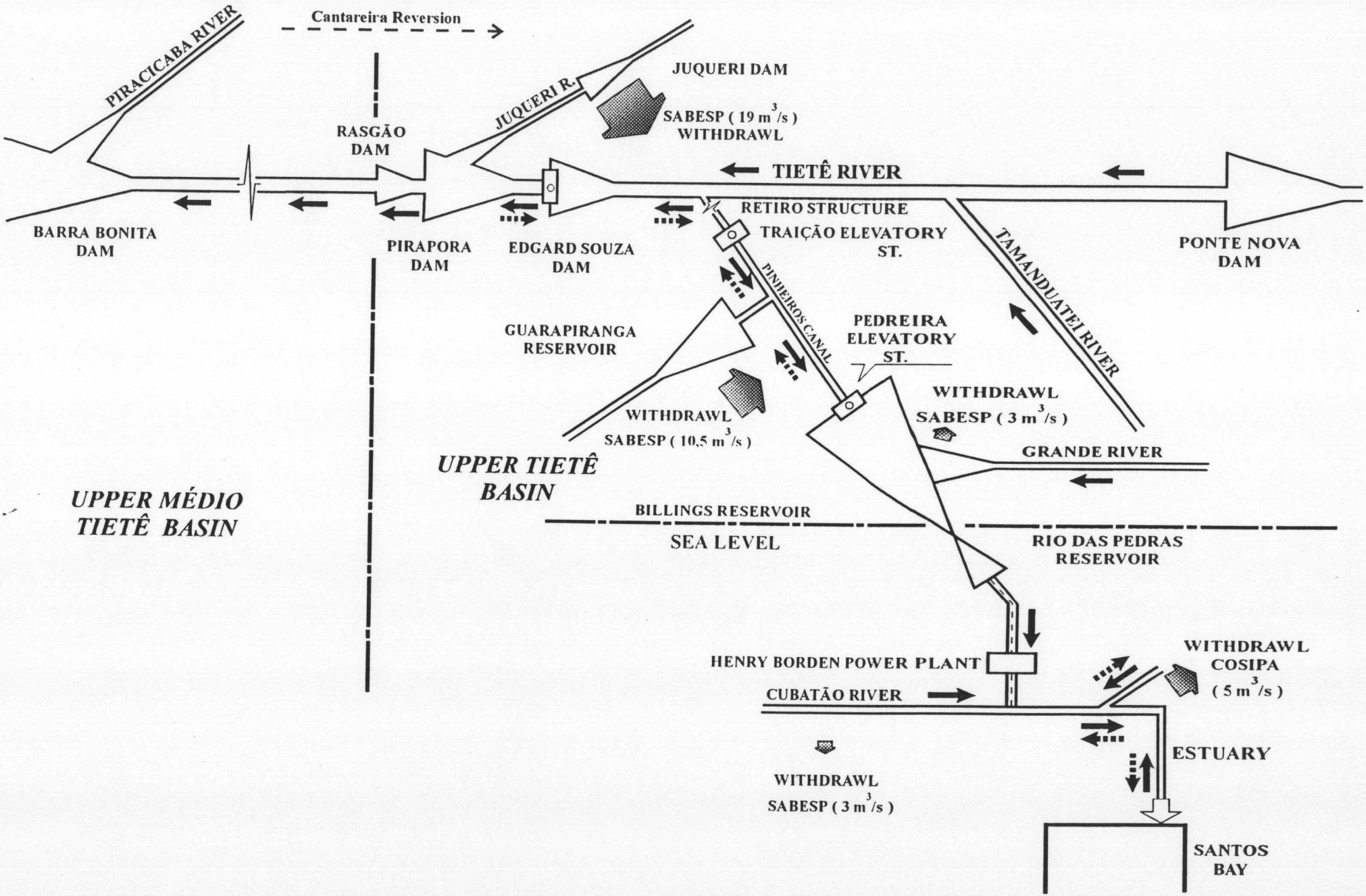
.Flood control.

.Industrial water provision.

.Industrial deject reception.

4.3 DESCRIPTION OF THE BILLINGS SYSTEM

The system Billings-Upper Tietê is shown in Figure 4.1 and described in this section [25].


PIRACICABA RIVER
Cantareira Reversion
JUQUERI DAM
JUQUERI R.
SABESP (19 m3/s)
WITHDRAWL
RASGÃO
DAM
TIETÊ RIVER
BARRA BONITA
DAM
PIRAPORA
DAM
EDGARD SOUZA
DAM
RETIRO STRUCTURE
TRAIÇÃO ELEVATORY
ST.
TAMANDUATEI RIVER
PONTE NOVA
DAM
PINHEIROS CANAL
GUARAPIRANGA
RESERVOIR
PEDREIRA
ELEVATORY
ST.
WITHDRAWL
SABESP (3 m3/s)
WITHDRAWL
SABESP (10,5 m3/s)
GRANDE RIVER
UPPER TIETÊ
BASIN
UPPER MÉDIO
TIETÊ BASIN
BILLINGS RESERVOIR
SEA LEVEL
RIO DAS PEDRAS
RESERVOIR
HENRY BORDEN POWER PLANT
WITHDRAWL
COSIPA
(5 m3/s)
CUBATÃO RIVER
ESTUARY
WITHDRAWL
SABESP (3 m3/s)
SANTOS
BAY

The affluent waters from the Upper Tietê basin are drained to the Tietê river, after receiving flows from the river Tamanduatei and other smaller tributaries, and become conffluent with the Pinheiros river.

From this point, the waters can follow their natural course to Tiete downstream, or can be directed to the Pinheiros river with the Billings being their final destination. This is done through water pumping from the two elevatory stations (Traição and Pedreira) located at the Pinheiros river.

In the Billings reservoir there is the additional flow of the natural flow of the resevoir, and togetther with the waters from the Tiete waters are directed to a smaller reservoir, the Rio das Pedras, and finally go through the Henry Borden power plant, in Cubatão. After water passes through the turbines, is directed to the Cubatão river.

The water which is not deviated to the Billings reservoir goes downstream the Tietê river, passing the CESP hydroelectric power plants, to the Paraná river and finally to the Prata estuary.

The waters reverted to the Billings reservoir go through a depuration process. $4m^3/s$, part of the natural flow, from the separated compartment Rio Grande, are utilized for domestic provision.

After water use for energy production at the Henry Borden power plant, the waters go to the Cubatão river, where they serve for the blocking of salt water intrusion to the Cubatão river, a phenomenon which has negative influences on the operation of the industries which utilize river water for the cooling of their equipment.

As far as flood control is concerned, excess water is pumped to the Pinheiros with the Billings reservoir as the final destination . In this way the Billings reservoir is a multiple use reservoir.

4.4 HISTORICAL REVIEW OF THE BILLINGS RESERVOIR.

In 1889, LIGHT, a canadian company, received the concession for the exploration of the transportation sector of the city of São Paulo. However, for the trump operation, an expansion of energy supply was necessary.

At that time São Paulo was still at the beginning of its development. At the end of the 19th century (1890), the city of São Paulo had a population of 1384 753 inhabitants reaching 2000000 only ten years later. In 1900 there were installed 165 industrial establishments of the textil, metallury and food and beverage sectors [26].

Around 1888 the second coffee culture expansion phase started, which was characterized by the construction of trailways for the transportation of production to the Santos port, and by the establishment of the Companhia Agricola Imobiliária e Colonizadora, the objective of which was to bring european immigrants to the plantations. During this time the second siderurgic plant was installed in Jacupiranguinha, as well as gas lighting, oil, textile, furnishing and ice companies [26].

In this initial growing phase of the city of São Paulo, LIGHT, decided to invest in energy production, mainly through hydroelectric power. For this reason it asked for the concession of the river Tietê which was granted in 1906, and initiated the construction of the plant

Parnaiba of installed capacity 2 MW at the banks of the Upper Tietê. In 1908 LIGHT obtained the concession of the Guarapiranga, a tributary of the Pinheiros river, which was dammed-up [26].

Other concessions permitted the canadian company to maintain the monopoly for energy distribution and generation. Apart from the trumps and electricity for the city of São Paulo, the services of the utility reached São Bernardo do Campo, Santo Amaro (at the time a suburb), Guarulhos, Parnaiba, Sorocaba, São Roque, Una, and Jundiai [26].

After the operation the thermoelectric power plant Paula Souza in 1912 of installed capacity 5 MW and amplified to 10 MW in 1924, LIGHT constructed Itupararanga in 1914, at the banks of the Sorocaba river of 30 MW and expanded to 50 MW in 1925. After the drought in 1924, a new concession led to the construction of the Rasgão power plant of 22 MW capacity [26].

In 18.2.25, after a solicitation, LIGHT asked for the collaboration of the Ministry of War Affairs, for the collection of information about the Serra do Mar (Sea Mountain range), "for studies and projects on flood attenuation projects of the river Tietê and production of hydroelectricity" (27 page 6).

The plan included the construction of a hydroelectric power plant at the piedmont of the Serra do mar, and the formation of reservoirs at the Tietê river and its tributaries, Grande, Parelheiros, M'Boi Guaçu, Balainho, Jundiai, and Biritiba, which would be interlinked through tunnels and canals [27].

One of the objectives of the denominated "Serra Project", was the exploration of the level difference of 747m between the Rio das Pedras river and Cubatão for energy generation.

In 27.3.25 the Federal decree no 16.844 took effect, approving the construction plans proposed by LIGHT; in accordance with a unique paragraph of article 1 of this Decree, LIGHT had the following obligations [27]:

a) Not to affect negatively water provision to the populations served from the denominated tributaries.

b) To execute works, judged as necessary, so that the increase in the flow of the Cubatão river should not affect the normal water regime close to the city of Santos.

c) Substitute or reconstruct, in accordance with the public agencies' requirements, all the works such as roads, pathways and telegraphe lines which would be damaged or not accesible for utilization due to the construction of the specific project.

The first construction was that of the Rio das Pedras reservoir. On 10.10.26 the first unit of 24 MW capacity entered in operation [26].

Until the end of the 1930's the second coffee phase ends in São Paulo. The industrial expansion and colonization from this moment on turns to be extremely rapid and is acentuated even more because of the two world wars.

In 1937 the construction of the denominated Billings reservoir is completed and named in honor to the engineer A.K. Billings ended. In 1939, the first pressure pump was installed in Pedreira, followed by the installation of others in the same location and in the Elevatory Station of Traição. With the beginning of the operation of the two elevatory stations, water pumping starts to be performed from the Pinheiros river.

As mentioned above, the city of São Paulo started to grow in an accelerated way, thus demanding larger amounts of energy. To attend the necessities of the city the Henry Borden I was amplified. For more energy production, greater water flow than the available at the time was necessary. In order to increase water flow, the Pinheiros river was reverted through the modification of the Parnaiba power plant to a reversion structure.

In the mid '40's, to allow the passage of the Anchieta Highway, a land fill was constructed close to the Riacho Grande, allowing only a straight passage of the upper part of the Rio Grande to be connected to the central reservoir, at the point where water is captured today for the provision of the ABC municipalities.

With the decree 22.008 of 29.10.46 LIGHT was authorized to modify the old barricade of the Parnaiba power plant, which was demolished. A new one was built with a spillway of 710,60 m. There were installed three gates which when closed were causing a countercurrent near the riverside which reached Guarulhos [27].

In 1955, the Pirapora reservoir was built substituting the Parnaiba barricade, and a pressure pump was installed ($50m^3/s$). Tha name of this new elevatory elevatory station was Edgard de Souza. The existence of the barricade Edgard de Souza and the gates installed were reasons for intense discussion and were considered causes of flood reaching São Gaetano [28].

Despite the discussions, the increased flow to the Billings from the Tietê river through water reversion was a fact. In this way the first unit of the subterranean section of the Henry Borden began operation, in March 1956.

At about the same time the industries began their installation at the Cubatão region, due to the favorable characteristics of the region which included energy provision from the Henry Borden, the Santos port and the proximate highways thus facilitating product transportation, the market of the city of São Paulo, and finally the water abundance of the Cubatão river and the flow from the Henry Borden power plant.

Until 1975, 18 industries were installed in Cubatão including COSIPA, RHODIA, CARBOCLORO, PETROBRAS, ESTIRENO, ULTRAFERTIL which depend most on the water flow after it goes through the Henry Borden power plant to Cubatão.

In 1961, the sixteenth and last unit of the subterranean section of the Henry Borden power plant began operation. In this way the power plant reached its final capacity of 880 MW [28].

During the 60's, ELETROPAULO the successor of LIGHT, having as objective the efficiency increase of flood control, installed new pluviometric points, prepared manuals related to the operation of the system including generation and transmission .

The 50's and the 60's as well as in the 70's, are characterized by intense, accelerated development of the city of São Paulo. This phenomenon had various effects, on one hand transforming the city of São Paulo to a businness and industrial mega and epicentre in Latin America, and on the other affecting life quality in negative ways such as overcrowding of the population, lack of organized planning, lack of basic infrastructure projects and a subsequent increase of pollution indices.

The Billings reservoir, the "energy machine" of the city during the first steps of this phenomenon did not stay unaffected. The lack of one of the most basic infrastructure projects, domestic and industrial sewage treatment is the main reason for the advanced pollution level occured in water resources close to the city especially the Upper Tietê Metropolitan zone. The Billings is one of the most "damaged" reservoirs, since through water pumping from the Tietê received untreated sewage of 11 million inhabitants and almost 40 thousand industries! Water pumping was necessary for flood control and for energy production.

The deterioration of the reservoir motivated environmental groups as well as the government of the State of São Paulo. In 1975 the first manifestation from the Federal government was also expressed, through an order of the Ministry of Mines and Energy; on the 6th of February with the mediation of DNAEE (National Department of Waters, Energy and Electricity), ELETROBRAS, and the Secretariat of Services and Public Works of the State of São Paulo, the so called Operative Convention between the companies LIGHT (future ELETROPAULO), FURNAS and CESP was signed, with the objective of the decrease of pollution indices of Billings reservoir, through the reduction of water pumping, and through the utilization of secondary energy from the CESP and FURNAS power plants.

Consolidating the solicitation, the Regulation MME-nº 270/75 took effect, authorizing DNAEE to constitute a special Commission for the implementation and further accompaniment of the actions of the Convention. After decisions of the Special Commission, DNAEE put in effect Regulation no 66, through the aproval of the operational scheme of the Billings reservoir for the year 1976. The predominant operation for 1976 was Operation Energy (the flow redirection of the Tietê to the Pinheiros canal and to the Billings). During

this year the anaeorobic stain (area of the reservoir without oxygen) reached 58% of the area of the reservoir [29].

Parallel to these activities, the Government of the State of São Paulo initiated cooperations with the Ministry o Mines and Energy, aiming at the improvement of sanitary conditions of the Upper Tietê and Cubatão basins. In July 1976, the so-called MME-GESP agreement was signed, and the constitution of a Special Committee was decided to substitute the Special Commission at the end of that same year. The Special Committee was responsible for studies, recommendations, implementations of the proceedings decided as well as for monitoring of the results [27].

The first rcommendation of this Committe was the compartmentation of the arm of the reservoir through which water domestic provision of the ABC was done. This was achieved through the construction of a dique (finished in 1982) at the right side of Anchieta Highway (direction São Paulo-Santos), which barred completely water passage in this way impeding the mixing of the waters of Rio Grande (upper section) and the central part of the Billings reservoir [27].

It was also decided that LIGHT (future ELETROPAULO) should take into account in the operations the sanitary conditions of the reservoir. Until 1982, parameter F1 was still continuing extremely high, reaching its greatest value in 1979 at 0.62.

In 02.12.82 the Operation Edgard de Souza was initiated, during which the gates were kept completely open during the rainy season to attenuate flood control. This operation lasted until 11.05.83 and contributed to the improvement of the environmental conditions at the

Billings reservoir, since it resulted to the decrease of water quantity pumped to the Pinheiros Canal and the elevatory station of Pedreira [27].

However, at the point Edgard de Souza, the Tietê river bed is not deep enough for the rapid removal of water volume downstream. As a consequence the water level at the conffluence Tietê and Pinheiros were kept high, therefore pumping to the Billings was necessary. Average pumping was 32 m^3/s and turbination at Henry Borden reached 74 m^3/s during that year. Also due to the exceptional natural flow of the Billings and Pedras reservoirs (very high precipitation levels), the volume of the Billings reservoir was only reduced by 3,5% [27].

During the period 16.06.83 to 23.01.84 the Operation "Saneamento"(Sanitation) was applied aiming at zero water pumping levels to the Billings reservoir (except in case of heavy rains). This new operation mode had as basis the F1 parameter. Through a mathematical model the minimum "pumped" water flow from the Tietê was determined to keep parameter F1 at defined low levels [27].

However since September 1983, the environmental conditions at the Médio Tietê Superior (Upper Middle Tietê) basin were deteriorating, especially at Pirapora de Bom Jesus. Due to this consequence, the liberation of pumping to Pedreira was authorized reaching average values of 52 m^3/s. The volume of the reservoir was only reduced by 1%, due mainly to the natural flow of the reservoir resulting from heavy precipitation. The turbination during that period reached average values of 61,5 m^3/s thus enabling water provision for the necessities of the industries in Cubatão [27].

Due to the dispute between the entities who wanted the Billings clean and the communities of Médio Tietê who wanted the reactivation of pumping due to the increased pollution levels

in the basin, the Government of the State of São Paulo, in September 1983 decided to implement a intermediary solution; 50% of the flow pumped to the Billings reservoir and 50% of the flow following the natural direction of the river downstream until Paraná. This was more of a temporary solution to the pollution problem since even 50% at each side was high enough to create environmental degradation. In this way the so called operation "Balanceada" was initiated.

In 1986 two gates were installed at the Elevatory Station Edgard de Souza and the barricade was demolished, in this way partially attenuating the flood control problem of the city of São Paulo with the condition that the gates would be opened at the right time.

In 1989, taking into consideration the already advanced environmental degradation at the Billings, on the 5th of October with the promulgation of the Constitution a deadline of three years was given to the Government to take efficient measures aiming at water quality improvement of the reservoir, through Article 46 of the Act of Transitory Constitutional Clauses which introduces the exception to article 208 of the State Constitution.

Article 208 [30]: "The disposal of urban and industrial effluents and sewage without the proper treatment is prohibited at any water volume".

Article 46 [30]: "During the term of three years, starting from the promulgation of the Constitution, the State and Municipal Public Authorities should take efficient measures to impede the pumping of water, dejects and other polluting substances to the Billings reservoir.

Paragraph: Whatever the solution is to be adopted, the State must consult the Public Authorities of the affected municipalities".

On the 5th of October of 1992 upon the completion of the three year deadline, the implementation of the so-called Resolução Conjunta SMA-SES no 03/92 of 04/09/92 was initiated, interrupting water pumping to the Billings reservoir for an undefined period.

However, in order to avoid damages to people or other goods resultant from the excess of, or lack of water in the subsystems influenced by the Upper Tietê-Metropolitan zone, there were defined five cases where water pumping to the Billings could be activated, after the authorization of the State Secretaries of the Environment, Energy and Sanitation [31] [27].

The resolution considers the five following conditions in the occurence of which pumping could be reactivated [31]:

"a"-Floods at the Metropolitan region of São Paulo; increase in the flow of the Tietê river at its confluence with the Pinheiros, above 160 m^3/s, or prediction of precipitation high enough for flood creation.

"b"- Electricity provision in situations of emergency; water flow decrease levels not adequate for energy generation in emergency situations.

"c"- Foam formation; foam formation due to surfactant concentrations in the Tietê river, downstream Edgard de Souza.

"d"-Algal bloom; formation of algal "bloom" in the water volumes of the Metropolitan region of São Paulo and Médio Tietê and consequent lower water quality not adequate for public provision.

"e"- Occurence of salt water intrusion or decrease of water level at the Cubatão river; Occurence of salt water intrusion or decrease of water level affecting the operation of the industries which capture water necessary for their poduction process.

During the meetings of the Executive Committee, it was defined the minimum volume of the Billings reservoir, Pedreira compartment at 60% of the volume of the reservoir (taking into consideration the wait volumes for flood control) after studies done by CTH (Center of Hydraulic Technology) [32].

On the 6th of October, some hours after the interruption of pumping to the Billings it was necessary to reactivate it due to the flood possibilities in the city of São Paulo. After fifteen days of the interruption, the mayors of the municipalities of Médio Tietê protested about the water pollution transferred to their cities. Until the end of 1992 only 11,5 m^3/s were pumped in the Billings. This led to reservoir depletion of 30,88% [32,33].

Table 4.1-Hydraulic System of ELETROPAULO-monthly averages between 92/93

Month	Hydrologi Regime (%MLT)	Affluence E.Souza (m^3/s)	Pumping at Pedreira (m^3/s)	Pumping at Pedreira (%)	Affluence Billings + Pedras (m^3/s)	turbinatio H.Borden (m^3/s)	Storage Billings (Pedreira) End Month (m^3/s)
Oct	135,0	118,2	8,0	6,8	30,2	49,5	73,28
Nov	137,0	134,6	11,2	8,3	37,4	49,9	71,46
Dec	92,0	164,8	15,5	9,4	25,5	47,5	69,12
Jan	84,0	156,1	10,4	6,7	17,2	49,6	63,27
Feb	110,0	194,1	27,5	14,2	27,2	50,6	63,70
Mar	78,0	150,5	8,6	5,7	38,0	52,0	60,98
Apr	101,0	121,0	4,1	3,4	11,9	51,1	51,72
Avg	-----	148,5	12,2	7,8	26,8	50,0	-----

Source: Operations Department of ELETROPAULO, 1994

Untit April 1993 the volume of the reservoir was 60% below the normal volume therefore water pumping possibilities were increasing again. To resolve the depletion problem, CONSEMA (Environmental Council) suggested the decrease of turbination at the Henry Borden and consequently to Cubatão. On the 28th of June water provision to the industries in Cubatão was suspended, and the industries threatened to fire almost twenty thousand people since the lack of water was damaging their equipment.

Due to pressure from the industries, water pumping was reactivated. After seven days, the anaerobic stain reached 20% of the reservoir. The Justice department recieved the third lawsuit against this measure. After a month of the rectivation the stain reached 33%.

Today, water pumping from the Tietê to the Billings is zero except in cases of flood risks. It was verified that [34]:

1. Rapid regression of the anaerobic stain with parameter F1 reaching zero values most of the time. Dissolved oxygen levels (DO) have increased in surface waters.
2. Reduction of nutrient concentrations with reductions in phytoplankton densities and chlorophile concentrations.

However, negative effects related to the entities involved in the system and to other communities still continue. In the following section, a brief description of the position of each entity involved in the system after the application of Article 46 is done.

4.5 CONSEQUENCES FROM THE APPLICATION OF ARTICLE 46.

4.5.1 ELETROPAULO

ELETROPAULO, as the successor of LIGHT maintains the rights of water resource exploration at the Upper Tietê basin, for the production of energy at Henry Borden. Nevertheless, it is obligated to provide for flood risks in the city of São Paulo. With the interruption of pumping, energy production stopped completely because turbination fell at $4m^3/s$, since increased turbination together with the lack of pumping depleted the reservoir. There were also negative impacts on flood control due to the fact that authorization from the State Secretaries of the Environment and of Energy and Sanitation was necessary to

reactivate pumping, in this way leading to delays of the initiation of pumping. Also increased solid waste concentration near the machines at the elevatory stations interfere with the efficiency of their operation [35].

4.5.2 INDUSTRIES OF CUBATÃO

As already mentioned the installation of the industries of Cubatão started in 1955 since it combined various factors such as access to highways and port, water provision and the market of São Paulo.

After the interruption of pumping turbination at Henry Borden decreased to $4m^3/s$ to avoid depletion of the reservoir. In this way water provision to the industries almost stopped since $4m^3/s$ were insignificant compared with their necessities of $50m^3/s$. The lack of water transferred from the Henry Borden created two problems for the industries; lack of sufficient water quantities and salt water intrusion at the Cubatão river which damages the equipment designed for fresh water use.

Table 4.2 shows water availability from the Cubatão region and Table 4.3 shows the necessities of the industries. From what is seen there is insufficient water supply of the rivers from the Cubatão region.

Table 4.2-Natural Flow Availability -Q(m^3/s)

RIVER	AVERAGE	MINIMUM
Cubatão	9,37	1,75
Perequê	2,94	0,40
Piaçaguera	1,20	0,16
Mogi	5,44	0,74
Quilombo	4,90	0,67
TOTAL	23,85	3,72

Source: Reference 34.

Table 4.3-Water necessities of the industries

INDUSTRY	WITHDRAWL (m^3/s)	RETURN TO THE RIVER (m^3/s)
1. STA PAPEL	0,08	0,069
2.FAFER	1,80	1,60
3.PETROBRAS	4,80	4,52
4.ESTIRENO	0,90	0,60
5.PETROCOQUE	0,008	0,0008
6.U.CARBIDE	0,11	0,014
7.A.ADRIA	0,030	0,01
8.SOLORRICO	0,01	0,0026
9.CARBOCLORO	0,39	0,33
10.LIQUID	0,90	0,60
11.COPEBRAS	0,0027	-----
12.GESPA	0,003	-----
13.STA RITA	0,11	steam
14.FERTIL UN	0,014	-----
15. IAP	0,10	0,10
16 .SABESP	4,00	-----
17.COSIPA	7,40	6,13
18.ULTRAFERTIL	0,12	0,11
19.MANAH	0,06	-----
TOTAL	20,76	16,91

Source: Reference 34

THE PHENOMENON OF SALT WATER INTRUSION

Due to the formation of the Cubatão river, the intrusion of salt water to its section downstream the escape canal of Henry Borden is a frequent phenomenon. The mixture of salt and fresh water results due to the higher density of the former. To impede salt water entrance the flow and pressure from the water transferred from Henry Borden was utilized. The mixture depends on the following factors [36]:

a) Flow from Henry Borden.

b) Astronomic tides can be predicted with 100% accuracy.

c) Metereologic tides generated by winds and changes of barometric pressures in the Santos bay. These are random and unpredictable.

d) Currents induced by the tides and by water density differences.

e) Wave propagation and flows of the Cubatão river.

f) Geometry of the canals.

The Santos estuary presents a more stable and dense intrusion which penetrates at great depth and in this way defines an interface with surface fresh water. When the affluent fresh water flow increases, salt water intrusion is deslocated to the sea and in case of the opposite situation, is deslocated at the direction of the river [36].

Measures done by the CNEC led to the conclusion that a flow above $90m^3/s$ allowed the impediment of salt water intrusion [36].

In may 1992 after the critical drought period, the Executive Committee of the Upper Tietê was requested to analyze the elevated choride concentrations in the water captured by the

industries taking into consideration that in october of the same year the interruption of pumping would be initiated.

The measure taken are related to the flows turbinated from Henry Borden. The following factors were taken into consideration [37]:

.Operation "Balanceada" at the Tietê.

. Maximum depletion of 40% of the reservoir volume.

.Anaerobic satin

.Average monthly flow from Henry Borden $50m^3/s$.

.Periods of greater probabiliy of salt water intrusion.

.Energy demand peaks

.minimum flow necessary for industrial water provision.

The criterion was the following [37]:

.$70m^3/s$ during one hour before and one after the prevision of high tide .

.$60m^3/s$ at the following hour

.reduction to 30-$35m^3/s$ at the following hours until an hour after the subsequent high tide; in case of irregular tides should be maintained at $50m^3/s$.

From August the application of this criterion permitted the administration of the problems of salt water intrusion at the industrial pole of Cubatão with greater efficiency.In October 1992, the interruption of pumping did not influence the application of the aforementioned measure due to heavy precipitation which kept the volume of the reservoir at high levels. Chloride levels were maintained at low levels most of the time; however in cases of cold fronts and tide alterations, chloride levels increased sufficiently to create problems for the operation of

industries. This showed that the measure was not efficient in case of an impredictable event. Some modifications were suggested to avoid the chloride increase [37].

In 26.3.93 due to the extened depletion of the reservoir, turbination at Henry Borden was reduced to $4m^3/s$. This had grave consequences for the industries which threatened to fire their employees . Temporary solutions were sought which will be discussed in Chapter 6 in more detail [32,33].

4.5.3 SABESP

The strategic position of the Billings reservoir, in relation to the Metropolitan region of the city of São Paulo, makes it extremely favorable for domestic provision use, especially for the ABC region. In this way SABESP has been utilizing the Rio Grande arm to attend the denominated region with a flow of $4,0m^3/s$, with plans of amplification of this use to $6,0m^3/s$. Apart from this plan, SABESP in its long term planning includes the use of 10-$15m^3/s$ from the Billings reservoir starting from 2006. SABESP also uses the flow of the reservoir after it is turbinated at the Henry Borden for provision of the Baixada Santista [38].

With the interruption of water pumping there exist risks of barricade damage due to water level differences between the compartments of the reservoir. However the reservoir's water quality improvement is favorable to SABESP [39].

SABESP believes that the solution to the Billings problem must be efficient and permanent, with the elimination of the organic waste pollution from the Tietê river [39].

4.5.4 MUNICIPALITIES OF MÉDIO TIETÊ

With the interruption of pumping to the Billings, waters from theTietê are following their natural course, Tietê downstream to the Paraná river. With the operation "Balanceada" the pollution at the Upper Tietê zone was divided between the Billings reservoir and the Tietê. After the application of Article 46 all the pollution was transferred downstream Tietê and consequently to the Médio Tietê Basin [40].

This brought negative consequences for the communities of the basin. Environmental impacts included more frequent foam formation and eutrophication probabilities increased. There was also an increase in Biochemical Demand of Oxygen levels showing the increase of the organic material quantities transferred to the basin. Increase in respiratory and other health problems are also observed. Economic impacts are also negative since tourism flow fell, water of the Tietê for agricultural use is not adequate due to its toxicity, and the appearance of a minute green mosquito in great quantities interferes with the operation of factories at the night shift. Social consequences cannot be omitted since the cultural identity of the people at the basin is directly related to the river activities [40].

ACTIONS TAKEN

The representatives of the municipalities of Médio Tietê and the mayors of the cities accused the State of having taken a decision about the interruption of pumping, disobeying Article 225 of the Federal Constitution which establishes the rights to a balanced environment for all, especially for common use of the people and for the essentials to a healthy life quality, and obligates the community and the State to preserve and defend it for present and future generations. Also the decision of the interruption of pumping did not take into consideration

the opinion of the communities of Médio Tietê as they are entities involved in the consequences of this action [41,42].

4.5.5 INTERMUNICIPAL CONSORTIUM OF THE BASINS OF UPPER TAMANDUATEI AND BILLINGS AND ENVIRONMENTAL ORGANIZATIONS.

The consortium and the environmental agencies "lament the current situation of the Biilings reservoir". They believe that priority should be given to public water provision, recreation and tourism and not to its use as an anaerobic lake for sewage treatment. São Paulo is utilizing other basins more distant to the city to attend water provision, a fact which raises the provision costs significantly and induces resource use competition for sources pertaining to other communities.Their belief is that the interruption of pumping is beneficial due to the improvement of environmental conditions at the reservoir and its future use for the activities aforementioned [34].

4.6 CONCLUSIONS

The Billings reservoir was one of the most important means which contributed to the development of the city of São Paulo. Energy generation, the original use of the reservoir, made possible the urbanization of the city and the beginning of its industrialization.

After the 1940's due to the accelerated as well as uncontrolled rate of development of the city, the importance of the reservoir as far as energy generation is concerned has relatively decreased as energy demand increased rapidly. However, other uses of the reservoir were explored in a larger scale, such as water provision for domestic and industrial use, flood control of the city, recreational activities.

As described in Chapter 2, the development process is extremely complex, with unexpected or overlooked negative consequences. In the case of the city of São Paulo, the thriving of its industrialization and urbanization, was accompanied by the depletion and pollution of its natural resources. The unplanned and disorganized manner that the development process occured was clearly shown in the lack of treatment of domestic and industrial dejects.

Therefore the Billings reservoir had to serve an additional use, the one of a sewage stabilization lake, affecting negatively the entities involved in the various uses, as well as the society as a whole. Society which originally constructed the reservoir for its own benefit, has been polluting and destroying its own creation 60 years later.

The public and state entities showing concern about environmental degradation of the reservoir decided to take measures which according to them were considered efficient.

ELETROPAULO, the owner of Henry Borden power plant and responsible for the operation of the Billings system has suffered great economic losses, since energy generation stopped and maintenance costs have increased. The industries do not agree with the implementation of Resolução Conjunta since the lack of water pumping to Cubatão made the occurence of water salinization more frequent. The municipalities of the Médio Tietê basin are suffering from pollution which is transferred to their cities, creating health problems as well as environmental and economic losses. SABESP has a more undefined position concerning the interruption of pumping; on the one hand the lack of pumping could transfer polluted water from the Billings reservoir to the Rio Grande compartment which is destined for domestic water provision, and on the other low water quality makes more difficult water treatment and impedes future water use of the reservoir. Environmental

groups and the Intermunicipal Consortium of ABC support the interruption of pumping believing that the benefits of a clean Billings are greater than the costs.

It has to be taken into consideration that the pollution at the Billings reservoir is indirect since it is transferred from the Tietê river through pumping. If water quality of the Tietê river does not improve, the reservoir will be polluted each time one of the five emergency conditions of the Resolução Conjunta are applied and pumping is permitted. One could question the efficiency of this decision since as aforementioned there have been created numerous and intense conflicts.

The conditions described above with the Billings reservoir as epicentre, is an outcome of an intense conflict between the development process of the city of São Paulo in the last 75 years and the environmental degradation of the reservoir which played an important role in this process. In its turn this environmental degradation has further consequences on the development process.

CHAPTER 5: ENVIRONMENTAL IMPACTS AND CONFLICTS

5.1 INTRODUCTION

As was seen in Chapter 4, there are strong linkages between the various environmental impacts, such as the pollution of the Upper Tietê Metropolitan Zone the closest to the city of São Paulo, and the pollution of the Billings reservoir, the Pirapora reservoir, and the Barra Bonita reservoir at the Médio (Middle) Tiete basin.

This chapter is an analysis of the environmental impacts of the systems affected by the sewage disposal to the Upper Tiete-Metropolitan Zone. The information presented are based on studies by CETESB.

The locations of the system analyzed in detail in the following sections are (Figure 4.1):

Upper Tiete Zone - Metropolitan Region

The Billings System

Edgard de Souza Barricade and the Pirapora Reservoir

Médio Tiete Basin - The Barra Bonita Reservoir

5.2 OPERATION TYPES

The Operation Types of the Upper Tiete Metropolitan Zone from 1980-1994 are the following:

5.2.1 OPERATION "FLOOD CONTROL" (Figure 5.1)

This operation has as objective the attenuation of flood waves affluent to the various points of the Upper Tiete river, to minimize inundation risks. In order to achieve this, the anticipated opening of the gates of the barricade Edgard de Souza is performed (in this way directing the waters of the Tiete river to their natural course and eliminating the stagnant water volume to the upstream of this structure), as well as the isolation of the Pinheiros canal (by closing the Retiro structure) and the utilization of the water pumping stations to transfer the water to the Billings system, which has a wait volume available.

5.2.2 OPERATION "ENERGY" (Figure 5.2)

For this operation, almost the entire flow of the Tiete is directed to the Billings reservoir, through the reversion system described in Chapter 4, to enable energy production at the Henry Borden power plant.

5.2.3 OPERATION "BALANCEADA" (Balanced) (Figure 5.3)

Part of the Tietê waters is deviated to the Billings reservoir (approximately 50% of the flow) and the rest follows the river's natural course to the Médio (Middle) Tietê basin and further downstream until its meeting point with the Parana river.

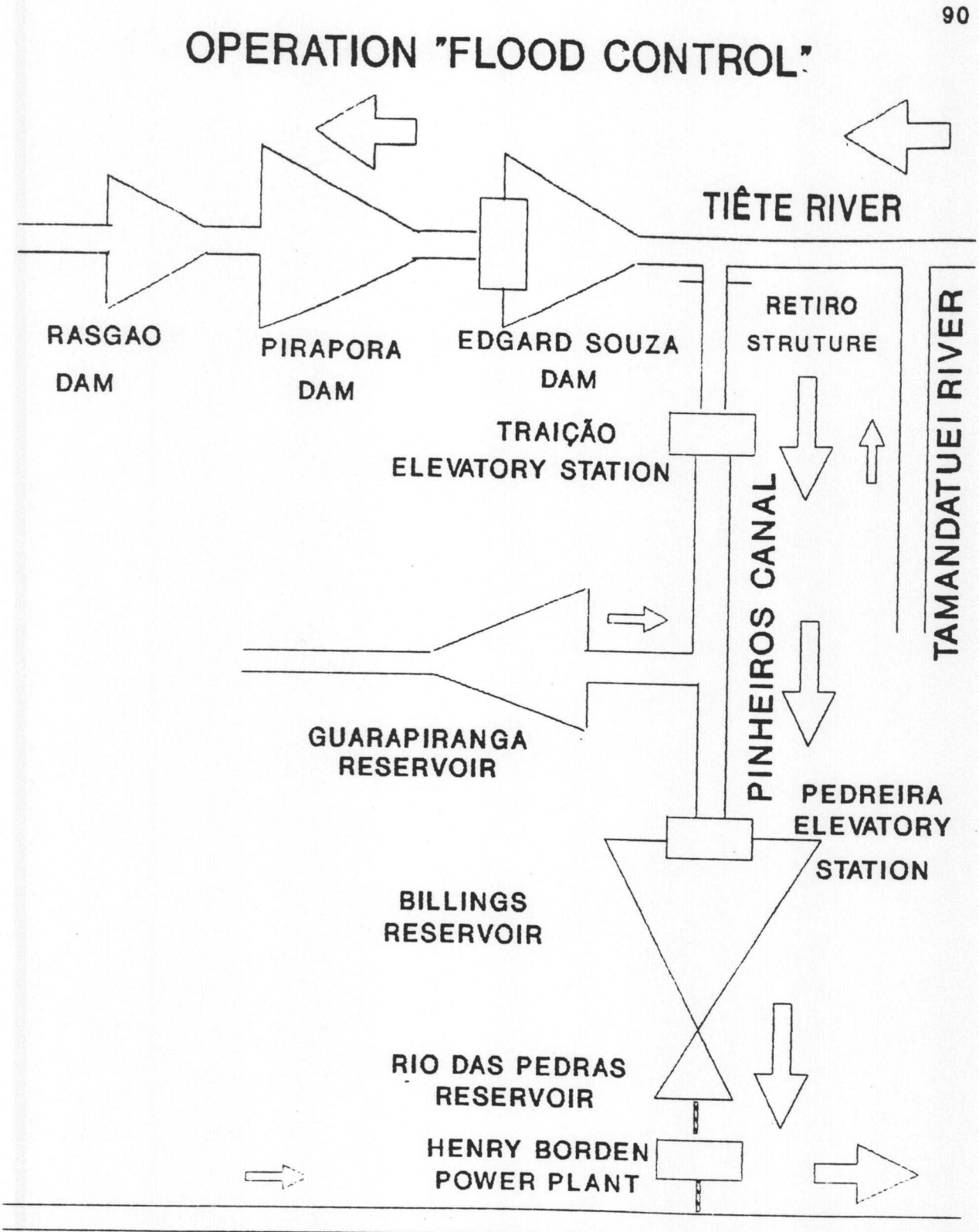

OPERATION "FLOOD CONTROL"
TIÊTE RIVER
RASGAO DAM
PIRAPORA DAM
EDGARD SOUZA DAM
RETIRO STRUTURE
TAMANDATUEI RIVER
TRAIÇÃO ELEVATORY STATION
PINHEIROS CANAL
GUARAPIRANGA RESERVOIR
PEDREIRA ELEVATORY STATION
BILLINGS RESERVOIR
RIO DAS PEDRAS RESERVOIR
HENRY BORDEN POWER PLANT
CUBATÃO RIVER

FIGURE 5.1

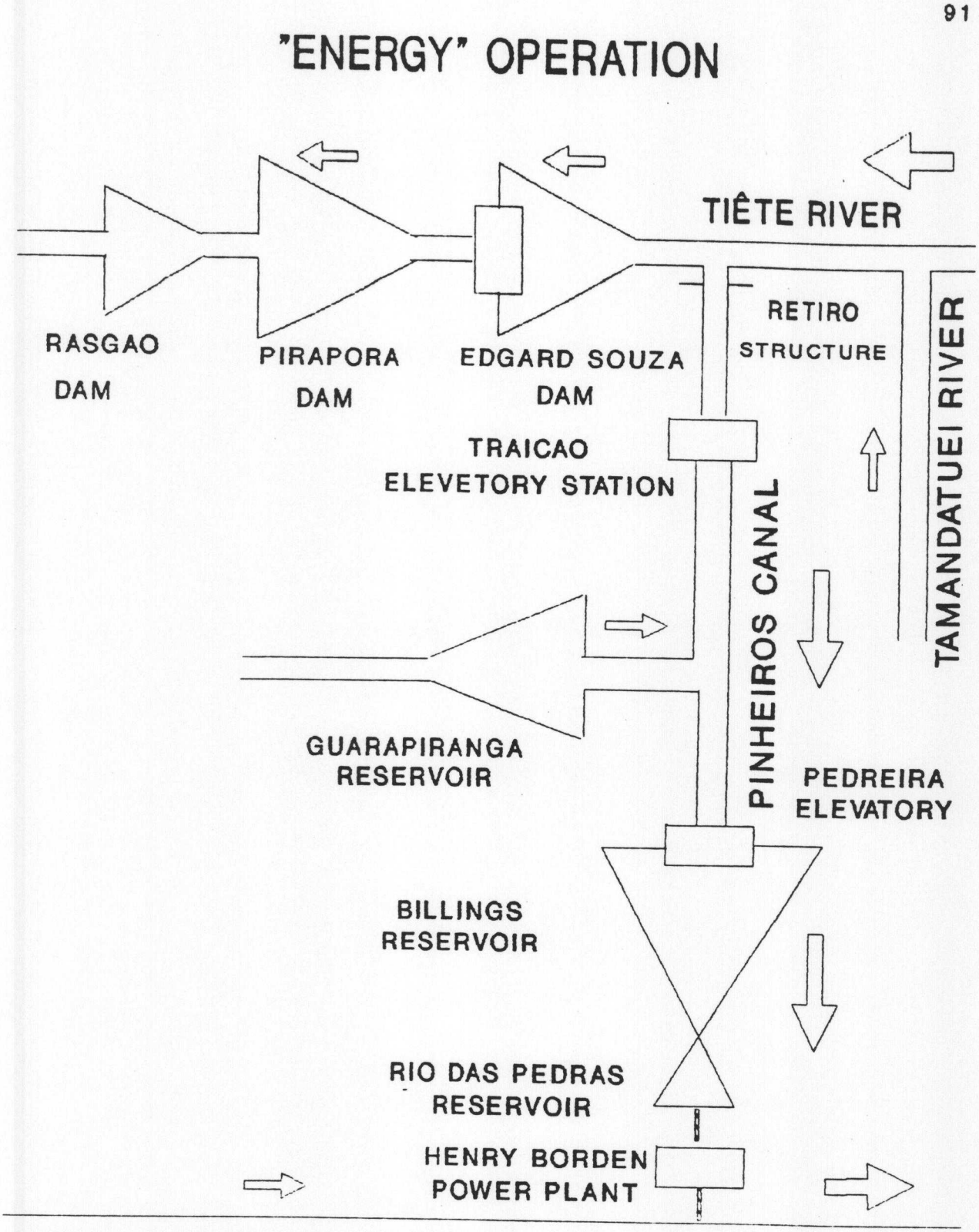

"ENERGY" OPERATION
TIÊTE RIVER
RASGAO DAM
PIRAPORA DAM
EDGARD SOUZA DAM
RETIRO STRUCTURE
TAMANDATUEI RIVER
TRAICAO ELEVETORY STATION
PINHEIROS CANAL
GUARAPIRANGA RESERVOIR
PEDREIRA ELEVATORY
BILLINGS RESERVOIR
RIO DAS PEDRAS RESERVOIR
HENRY BORDEN POWER PLANT
CUBATÃO RIVER

FIGURE 5.2

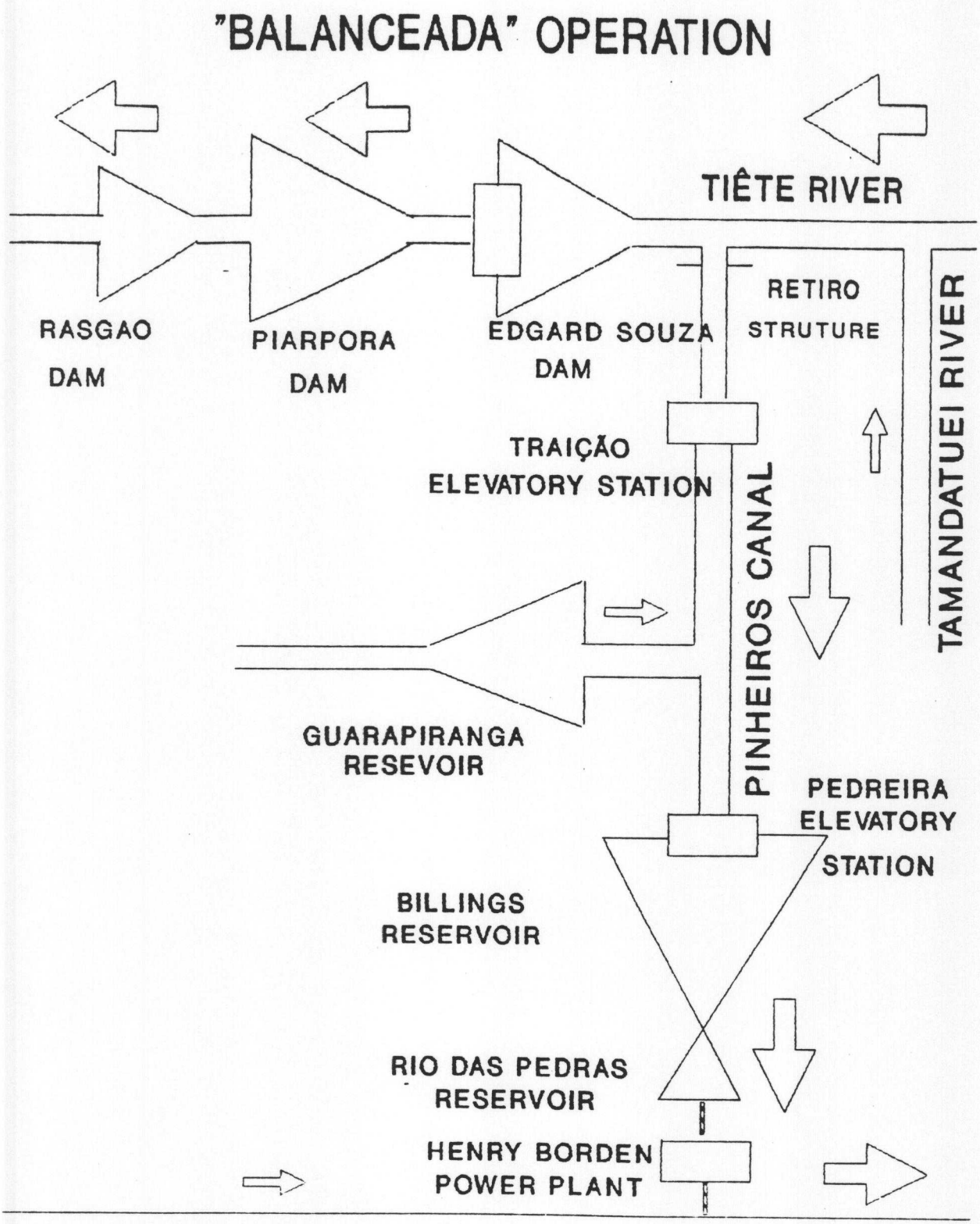

"BALANCEADA" OPERATION
TIÊTE RIVER
RASGAO DAM
PIARPORA DAM
EDGARD SOUZA DAM
RETIRO STRUTURE
TAMANDATUEI RIVER
TRAIÇÃO ELEVATORY STATION
PINHEIROS CANAL
GUARAPIRANGA RESEVOIR
PEDREIRA ELEVATORY STATION
BILLINGS RESERVOIR
RIO DAS PEDRAS RESERVOIR
HENRY BORDEN POWER PLANT
CUBATÃO RIVER

FIGURE 5.3

5.2.4 OPERATION "SANEAMENTO" (Sanitation) (Figure 5.4)

In this case pumping is interrupted completely (reactivated only for Operation Flood Control), with total water flow of the Tietê following its natural direction to the Parana river.

5.2.5 OPERATION "ARTICLE 46" (Figure 5.5)

Suspension of pumping to the Billings reservoir for indefinitive time period since October 5th 1992. Pumping is only allowed in five defined emergency cases. (See Chapter 4).

5.3 THE UPPER TIETÊ RIVER - METROPOLITAN ZONE

The drainage area of this zone covers 2.730 km^2, from the Tiete river from Itaquaquecetuba up to the Pirapora dam, with a length of 86 km including the Baquirivu-Guaçu, Guarapira, Aricanduva, Tamanduatei, Cabuçu de Baixo, Pinheiros and Juqueri rivers. The reservoirs are the Juqueri (Juqueri river), Edgard de Souza (Tietê river), and the Pirapora (Tietê river) [24].

Water uses of this zone include public and industrial provision, receptions of industrial dejects and domestic organic waste from 20 municipalities. The principal industrial sectors are metallurgy, chemical and food and beverage [24].

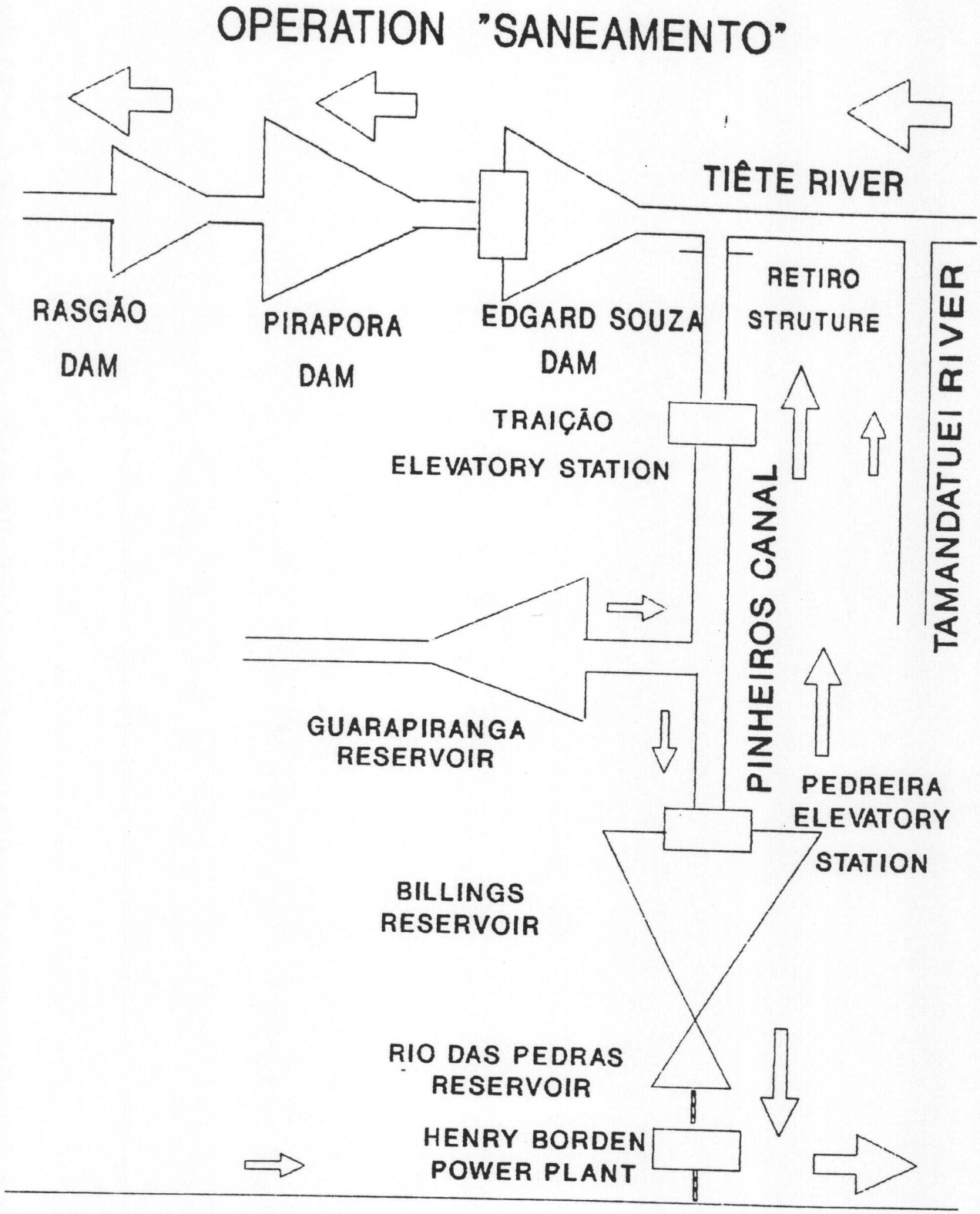


FIGURE 5.4 CUBATÃO RIVER

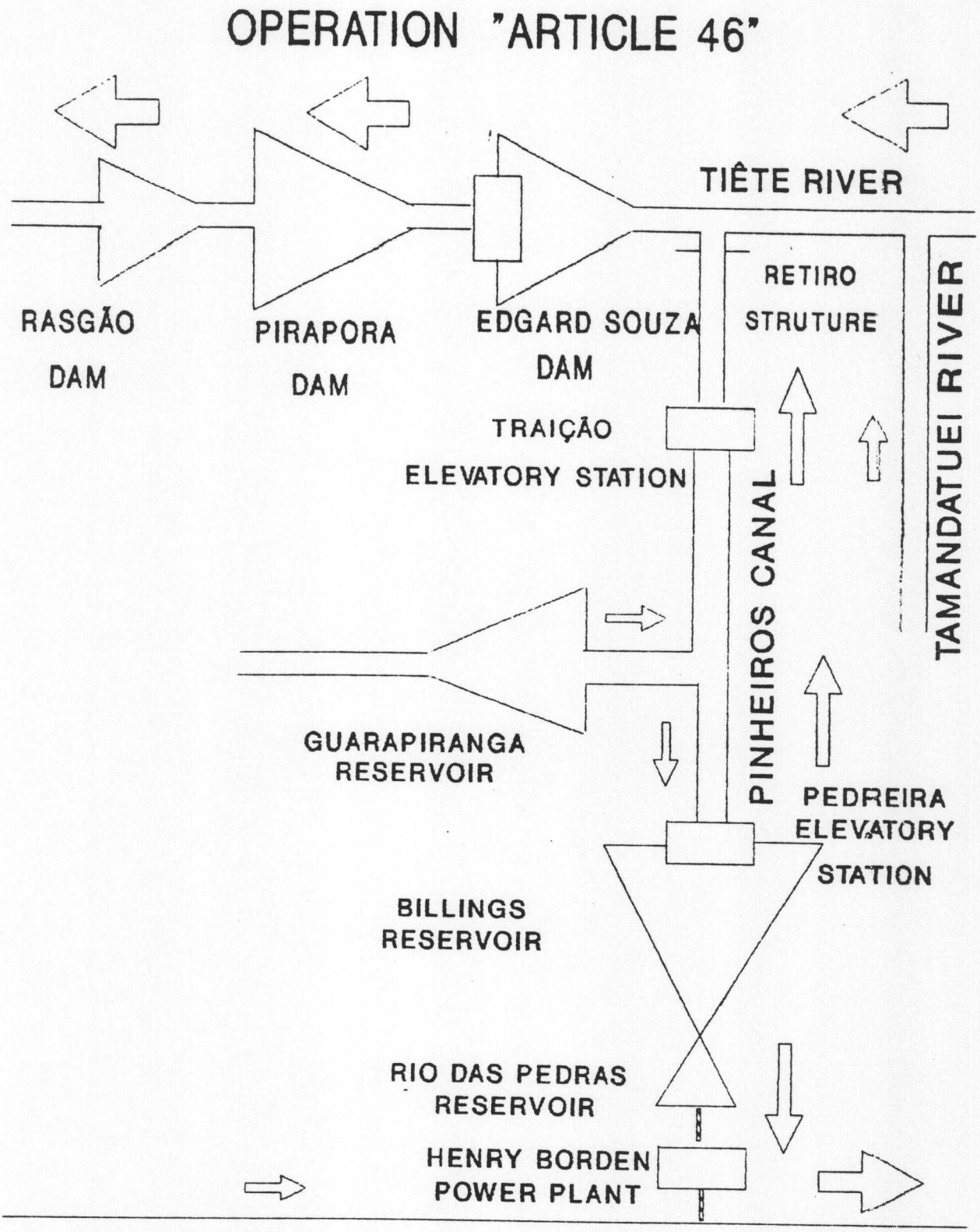


FIGURE 5.5 CUBATÃO RIVER

Table 5.1- Organic Polluting Waste Loads disposed to the Tietê river.

Source Type	Potential Load	Remaining Low	% Removal
	kg BDO_5/day	kg BDO_5/day	
City*	802.200	719.600	10,3
Industries	204.400	141.100	31,0
Total	1.006.600	860.700	14,5

* It does not include organic biodegradable loads disposed in Class 4 waters of the basin of Upper Tietê-Metropolitan Zone.

Source: Reference 24

According to CETESB the following results are shown [24]:

-The river Baquirivu Guaçu (BG3010) had its DO levels below the standard established for Class 3, and the concentrations of total phosphate, total coliforms, manganese, (surfactantes and nitrogenio amoniacal), were above the established limits.

-The Tanque Grande reservoir (TG2200) and BDO (Biochemical Demand of Oxygen), and total phosphate and coliform concentrations were above the standards for special class.

-The Tamanduatei river (TA4200 and TA4500) presented Oxygen Demand Levels close to zero.

-The Pinheiros river presented Oxygen Demand Levels at zero during the whole 1992.

-The Juqueri reservoir (JM2050) presented higher coliform concentrations above the limits allowed for special class.

-The Juqueri river (JQ4500) presented Oxygen Demand levels close to zero during all 1992, with higher concentrations of BDO, fecal coliforms, phosphate, total coliform allowed for class 3.

5.4 THE BILLINGS SYSTEM

The information in this section is from Eletropaulo, CESP and CETESB. Hidrological and operational data were given by the first two, and water quality data from CETESB [44].

From Figures 5.6 and 5.7, it can be observed that there is a direct and most significant relation between the volume pumped to the Billings reservoir through the second elevatory station at Pedreira, and the Biochemical Demand of Oxygen at this point and at the Billings reservoir. The biochemical demand of oxygen is an indicator of the amount of organic waste transferred from the Tietê river. It measures the oxygen demand necessary for the decomposition of the biodegradable organic matter in the water. This decomposition is done by microorganisms which consume oxygen to decompose the organic matter [45]. The lower value of BDO, 16 mg/l, was reached in 1983 when the Operation Sanitation was performed, and the highest in 1986, during the Operation Energy where BDO reached 60 mg/l. In 1992 which included two operation modes, the Balanced and Article 46, showed BDO levels close to the average levels during the decade under study. However this does not imply that the organic waste disposed to the Billings during 1992 was reduced at acceptable levels since BDO concentration of 41.5 mg/l implies great quantities of disposed organic waste [44].

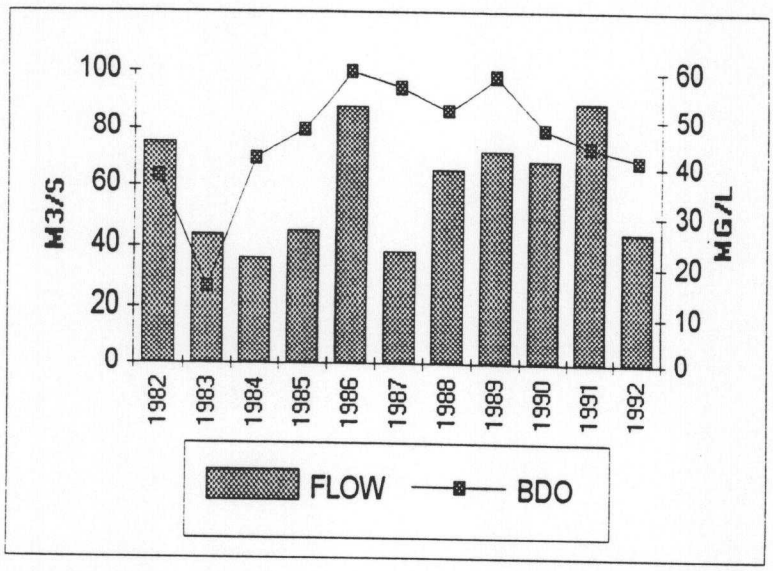


Figure 5.6. Average annual flows and BDO concentrations at the Elevatory Station of Pedreira.

Source: Reference 44.

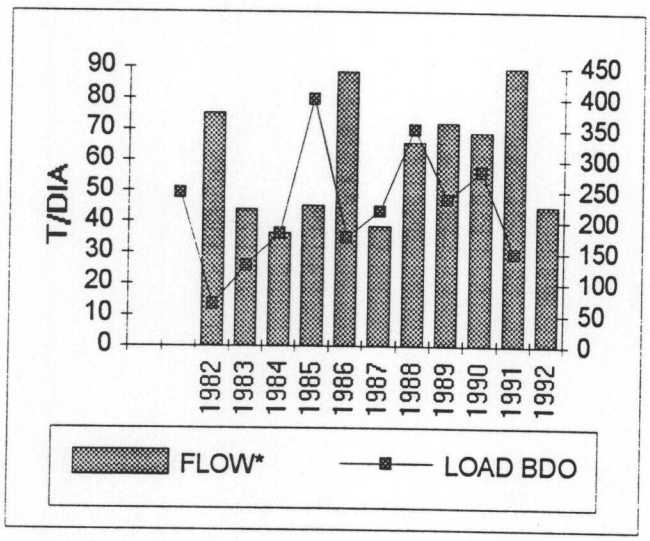


Figure 5.7 Average annual flows and BDO loads at the elevatory station of Pedreira.

Source: Reference 44

5.4.1 ASSIMILATIVE CAPACITY OF THE BILLINGS RESERVOIR

The assimilative capacity of every reservoir depends, on its operational regime, morphology and environmental conditions. At its initial parts the reservoir has its assimilative capacity

reduced due its longitudonal form. After the Pedreira elevatory station, there exist great quantities of polluting material, in a relatively small water volume. The reservoir has several isolated branches, which cannot contribute effectively to the assimilative capacity of the reservoir. All this has as a consequence the large concentration of oxidable material, a phenomenon which leads to anaerobiosis (inexistence of dissolved oxygen in the water volume) [44].

Considering the graph shown below we can conclude that despite the fact that the reservoir receives excessive amounts of organic waste its assimilative capacity is higher than expected. However during the years 1988-1992 there has been a slight decrease in percentage reductions of 4%. The highest reduction is observed in 1983 during Operation "Saneamento" when it reached almost 80% of the biochemical demand of oxygen. Also a decrease of approximately 100% of the coliform density from the elevatory station to the Summit Control point [44].

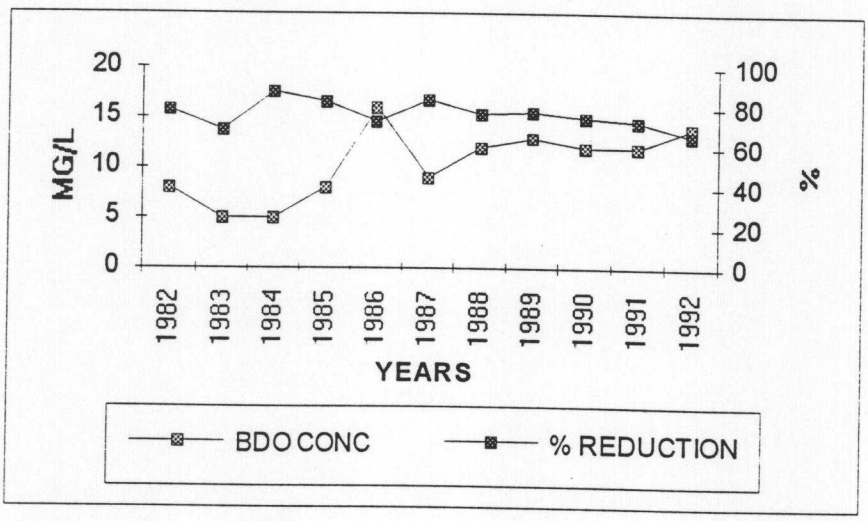


Figure 5.8. Concentrations and loads of BDO and reduction to the "Summit Control" point.

Source: Reference 44.

5.4.2 WATER QUALITY OF THE BILLINGS RESERVOIR

The parameter used by CETESB for water quality evaluation is the Water Quality Index, at various locations of the reservoir. This Index adapted by CETESB, is based on a study from the "National Sanitation Foundation" of the USA. It is a calculation of the weighted product of the following parameters: OD, BDO, Fecal Coliforms, Temperature, pH, Total Nitrogen, Total Phosphate, Total Solids and turbidity [44].

The following classification was made:

WQI (Water Quality Index)	QUALITY
80-100	very good
52-79	good
37-51	acceptable
20-36	bad
0-19	very bad

In the Billings reservoir water quality at four points were estimated: These points are:

PN4500-Pinheiros river at the Elevatory Station at Pedreira. Located at Upper Tietê-Metropolitan zone.

BI2100-Billings reservoir, Compartment Rio Grande, at Anchieta highway.

BI2500-Billings reservoir, Compartment Pedreira, at the point of Imigrantes Highway, 14 km away from the Pedreira elevatory station.

BI2900-Billings reservoir, Pedreira Compartment, at "Summit Control".

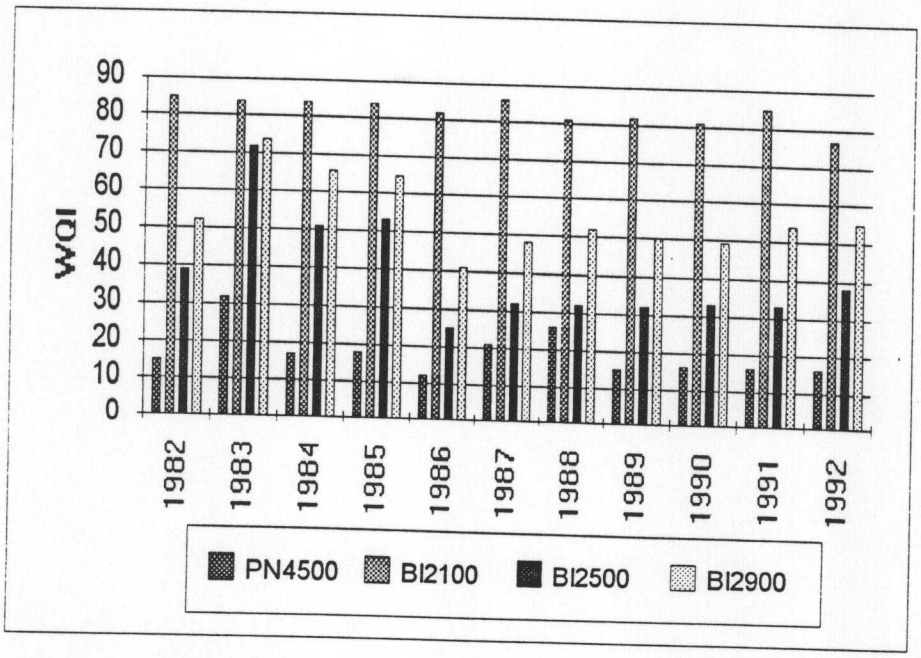


Figure 5.9- Annual Water Quality Index at the denominated points at the Billings reservoir.

Source: Reference 44

From the above figure we can observe that the best water quality in the reservoir is at the Rio Grande compartment as it is separated from the rest of the reservoir, and the worst at the elevatory station of Pedreira where the concentration of BDO is still very high. An improvement of water is observed between points PN4500, BI2500 and BI2900. The highest annual water quality values are observed during year 1983 [44].

5.4.3 EUTROPHICATION

Eutrophication is the process (natural or artificial) of the addition of nutrients to a certain water volume (lake or reservoir) and the effects on its living organisms. It is a part of the natural aging of lakes or reservoirs, with nutrient concentrations increasing with time [45].

Today, in many lakes there is premature eutrophication due to pollution effects, mostly anthropogenic, through disposal of great quantities of organic matter originating from the

urban human environment. Eutrophication causes an ecological disequilibrium, and could have severe effects on the living organisms of the system [45].

One characteristic of the phenomenon is the exaggerated growth of autotrophic acquatic organisms, particularly phytoplankton and macrophytes. The exaggerated growth of phytoplankton has the following consequences [45]:

a) Negative effects on water for domestic provision due to the unpleasant odor and taste.

b)Interference with recreational activities at the lake or reservoir due to turbidity and high algal occurence.

c)Significant variations of Dissolved Oxygen levels, sometimes resulting in zero levels at night, a phenomenon which could cause fish mortalities.

d)Algal deposition at the bottom of the lake, increases benthonic oxygen demand and consequently decreases oxygen concentrations at hipolimnio

e) Excessive growth of macrophytes with negative impacts on navigation and aviation.

The parameter used by CETESB for the definition of the eutrophication levels is the Modified Carson, adapted for tropical climate conditions. The Carlson index is based on three factors: Total Phosphate, chlorophile-a measured at water surface, and the Secchi depth [44].

According to CETESB after studies of the Billings reservoir, it was found that the limiting factor was phosphates, a fact which enabled the utilization of the modified Carlson Index [44].

The Index of Trophic State (ITS) has the following criterion [44]:

ITS < 24 - ultra oligotrophic

24 < ITS < oligotrophic

44 < ITS < mesotrophic

54 < ITS < eutrophic

ITS > 74 - hypertrophic.

According to CETESB, the Billings reservoir is characterized as a highly eutrophicated water volume. Almost during the whole year of 1992 the reservoir was at a hypertrophic state [44].

5.4.4 THE EVOLUTION OF THE ANAEROBIC STAIN

The extention of the anaerobic stain is estimated through measurements of Dissolved Oxygen "in situ". The ratio of the anaerobic area and the total area of the reservoir define the parameter F1, which could be considered an indirect measure of the polluting effects of oxidable material, at surface water levels of the reservoir [44].

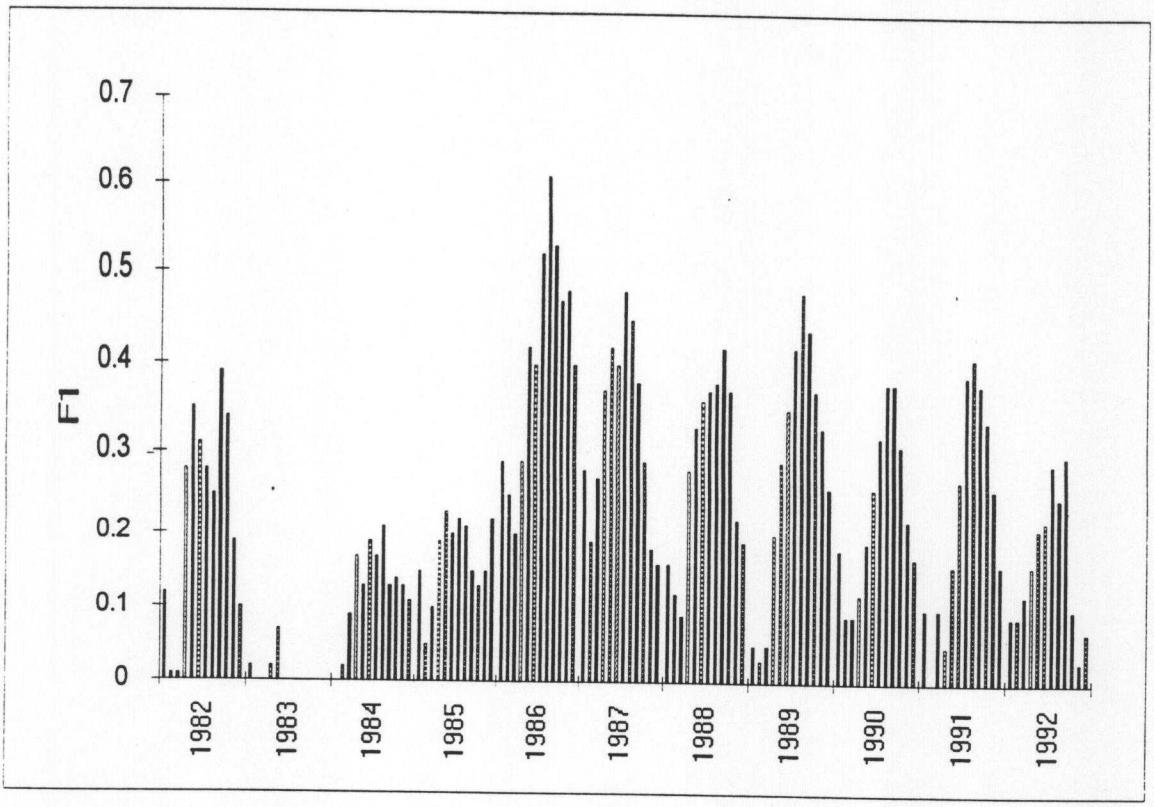


Figure 5.10-F1 values during years 1982-1992.

Source: Reference 44

From what is seen, the greatest F1 was during Operation Energy in 1986. The F1 value in 1992 was within the average values of the last ten years reaching 0.33 at some months of the year. During Operation "Saneamento", the anaerobic stain was almost inexistant during the whole year, due to the interruption of pumping [44].

5.4.5 EVOLUTION OF WATER QUALITY OF THE BILLINGS RESERVOIR AFTER THE APPLICATION OF THE ARTICLE 46.

The article 46 has been applied since the 5th of October of 1992. Due to the fact that the data available are only until 1992, the tendencies of water quality are not defined clearly .

With the drastic reduction of water pumping from the Tietê to Pinheiros, according to CETESB, it has been observed that the anaerobic stain has decreased significantly, even reaching zero levels [44].

Although the F1 parameter is very important in the identification of water quality of the reservoir, other factors play a major role, since F1 measures only Dissolved Oxygen levels at surface waters [44].

Other important factors which influence water quality is the amount of material accumulated. Material accumulation could be through absorption of particulates suspended in the water, or through deposition at the bottom of the reservoir [44].

These substances are not maintained in constant concentrations but could be liberated in a rate related to their own concentrations and the extension of anaerobiosis. During these processes heavy metals which are also accumulated to the reservoir could be released. When thermical stratification occurs, the epilimnio and hipolimnio are isolated, a phenomenon which leads to difficulties of oxygenation of the hipolimnio. Rapid Dissolved Oxygen level recovery, (which was the Billings case after the interruption of pumping), at the surface water levels would not have an immediate effect in the deeper water levels [44].

Even if there is no thermal stratification the liberation of substances could continue until their complete deposition. During this period, inorganic nutrients are also liberated, thus facilitating or maintaing eutrophication levels. Benthic oxygen demand is also maintained since organic material is liberated and dissolved oxygen consumed. In case of occurence of anaerobiosis at surface water levels, material liberation is propitiated.

All these processes depend on the time necessary for the stabilization of the material at the benthic levels of the reservoir.

CETESB, initiated a series of studies related to the recuperation capacity of the reservoir, taking into account water quality, sedimentary material and acquatic organisms. There are available only some preliminary results, showing relatively lower levels of phosphate concentrations, after the interruption of pumping to the Billings (Figure 5.11). Phosphate liberation continues to be high with an increase of almost 50% from the year 1991 (from 22% to 31%). Phosphate retention seems to be high, showing that at the sediments of the reservoir there are still great quantities of nutrients.

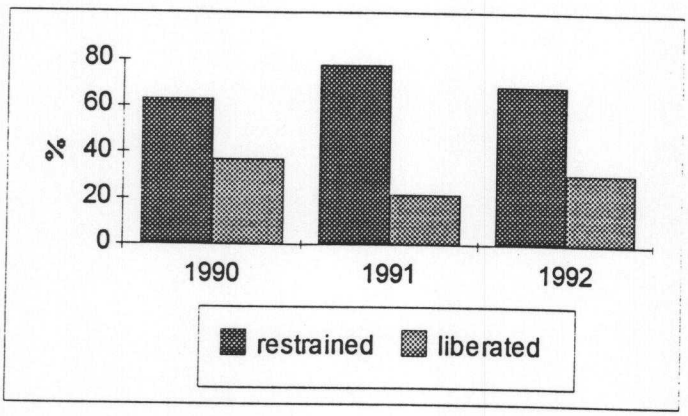


Figure 5.11-.Annual percentage of total phosphate affluent to the Billings reservoir through the Elevatory Station of Pedreira restrained in its sediment, and liberated to the effluent of the reservoir.

Source: Reference 44

5.4.6 FISH MORTALITY

In 1992 were observed 12 cases of fish mortalities.

Table5.2-Fish mortality cases at the Billings reservoir during 1992.

Date	Localization	Cause	Indicators
14.04.92	Grota Funda	Lack of DO Anerobic stain	DO
13.08.92	Central Part-Close to Taquacetuba and Alvarengas	Lack of DO Anaerobic stain	DO
13.08.92	Central Part-Close to Pedra Branca	Decrease of DO	DO
17.08.92 and 18.08.92	Central part close to Taquacetuba and pedra Branca	Decrease of DO	DO
18.08.92	Central Part close to Alvarengas	Lack of DO anaerobic stain	DO
19.08.92	Central Part close to Redra Branca	Increase of DO	DO
19.08.92	Central part close to Taquacetuba	Lack of DO anaerobic stain	DO
3.09.92	Taquacetuba	Decrease of DO	DO
17.09.92	Central part close to Taquacetuba	Lack of DO anaerobic stain	DO
6.11.92 and 10.12.92	Proximities of Pedreira Elevatory station	Lack of DO	DO

Source: Reference 44

In cases of anaerobiosis at deep level waters, caused by a cold front or any other climatic change which could result in winds and vertical circulation, (consequent break-up of stratification), there is exchange of material which leads to lowered dissolved oxygen levels to the point of inducing fish mortality [44].

As mentioned before, in cases of eutrophication due to great oxygen demand and consumption from the large number of algae, significant desreases of dissolved oxygen levels could occur and consequently lead to fish mortalities [44].

5.5 THE TIETÊ RIVER AT PIRAPORA

The Pirapora reservoir receives water from the Edgard de Souza barricade and the Juqueri river.

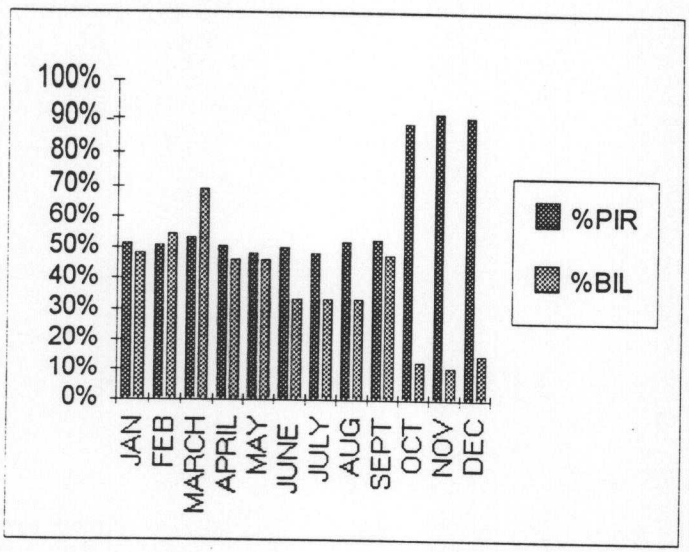


Figure 5.12-. Percentage monthly flows to the Billings and Pirapora.

Source: Reference 44

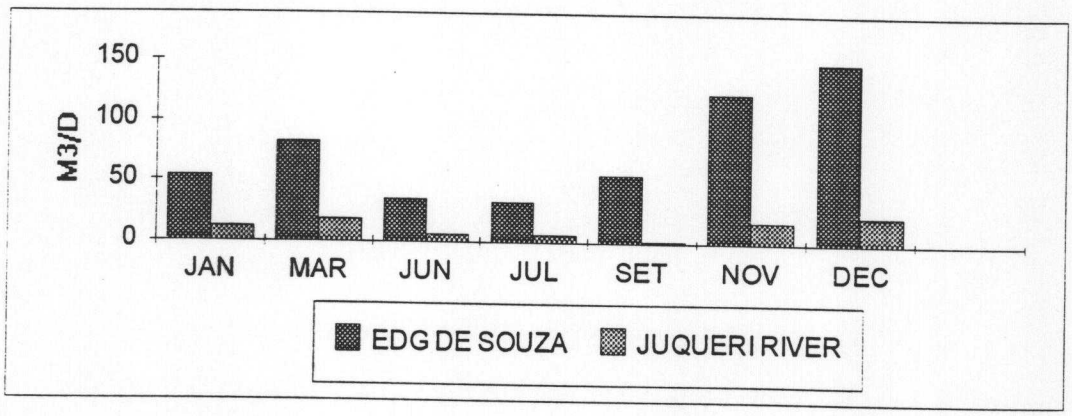


Figure 5.13-Average Monthly BDO loads to the Pirapora reservoir from Edgard de Souza and the Juqueri river.

Source: Reference 44

Figure 5.12 shows the variable flows to the Billings and Pirapora depending on the regime of the Upper Tietê-Metropolitan zone. From Figure 5.13 we can observe that the pollution to the reservoir is mainly transferred from Egdard de Souza barricade.

As far as water depuration capacity is concerned the results from CETESB do not show a definite trend of high or low levels.

5.5.1 WATER QUALITY

The localizations under study were the following:

TE4100-Tietê river close to Pirapora dam

TE4200-Tietê river close to the barricade Edgard de Souza

JQ4500-Juqueri river, Highway Anhanguera

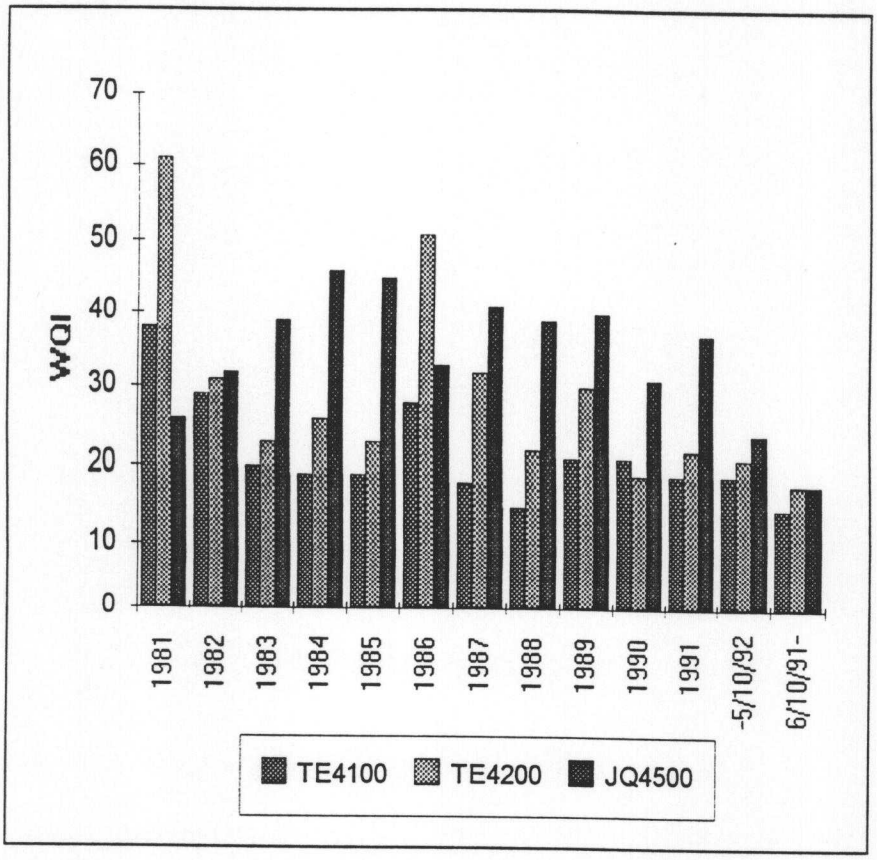


Figure 5.14-Annual Water Quality levels at the Pirapora reservoir.

Source: Reference 44

According to Figure 5.14 there has been observed a deterioration of water quality indices between 1991 and 1992, going from acceptable to bad and very bad water quality. It can also be observed that in 1986 there was observed a significant improvement in water quality at point TE4200 due to the fact that most of the Tietê water flow was going to the Billings reservoir since the Operation "Energy" was applied [44].

5.5.2 THE FOAM EFFECT

In the Pirapora reservoir there exists the "foam effect", due to the presence of surfactants in the water. Currently, cannons are utilized for foam aspersion, though the efficiency of this system is questioned since foam reappears in other points such as the Rasgão barricades, the

São Pedro and Porto Goes power plant. Other more efficient solutions of foam formation should be studied [44].

5.6 THE BASIN OF MÉDIO TIETÊ

The basin of the Upper Médio Tietê covers the areas just right after the end of the Pirapora reservoir until the Barra Bonita reservoir, with an extension of 367 km and a drainage area of 7070 km^2 [46].

5.6.1 POLLUTION ORIGINATING FROM THE CITIES AND INDUSTRIES

Table 5.3. Polluting organic loads originated at the Tietê basin

SOURCE TYPE	**POLLUTING TONS DBO5/DAY**	**LOAD**	**%**	
	POTENTIAL	**REMAINING**	**REMAINING**	**REDUCTION**
CITY	22.7	18.7	79.2	17.3
INDUSTRIAL W/D	9.5	4.9	20.8	48.4
INDUSTRIAL W/OUT/D	119.9	0.0	0.0	100.0
TOTAL	152.1	23.6		

Source: Reference 46

There is no sewage treatment therefore domestic sewage is disposed "in natura" to the river and in consequence to the Barra Bonita reservoir. The remaining load from domestic origin is 18.7 $tBDO_5$/day and from the industries is 4.9 $tBDO_5$/day. These levels are low when compared with organic matter originating at the Upper Tietê-Metropolitan zone [46].

As mentioned above the flow at the Médio Tietê basin is a direct consequence of the Upper Tietê Metropolitan Zone operations and the flows at Edgard de Souza.

5.6.2 THE OPERATIONAL REGIME AND THE BARRA BONITA RESERVOIR

The operational regime of the Barra Bonita reservoir depends on power generation, and the hydrological regime of its principal tributaries, the rivers Tietê and Piracicaba. This regime has been stable in the last 10 years excluding 1983 when the operation "Saneamento" was applied and the last three months of 1992 during operation "Article 46" [44].

Two comparison points were studied, upstream the Barra Bonita reservoir to analyze the river depuration capacity, by CETESB, the one at the Tietê river close to the Rasgão barricade, and the other one at the Tietê more downstream at the Açucar Highway, km 101. The results are based on the averages of the years 1982-1992 showed the following [44]:

Point TE2100-Tietê river, close to the Rasgão reservoir [44]:

-flow:reduction of 53% (66% in comparison with 1991)

-BDO concentration: increase 33%

-Load of BDO:increase of 13%

-Total phosphate concentrations: increase 58%

-Load of total phosphate: increase of 17%.

Point TE2305 - Tietê river at Açucar Highway 44:

-flow:without alterations

-BDO concentrations: decrease of 19% (increase of 25% in relation to 1991)

-BDO load: without significant alteration

-concentration of total phosphate: increase of 100% (20% in relation to 1991)

-total phosphate load: increase of 100%.

We can see that the BDO concentration increased as well as the total phosphate concentrations in both points.

After the application of Article 46 CETESB has been accompaning closely the evolution of the pollution indices. According to their studies, there are only two definite tendencies, the ones concerning the increase in the Biochemical Demand of Oxygen concentrations and the other concerning foam concentrations.

However due to the large quantities of organic waste material transferred to the Barra Bonita reservoir, it is expected that it would lead to a deterioration of environmental quality conditions at the Médio Tietê zone, especially close to Salto due to a decrease in the river slope and a consequent decrease in the self-depuration water capacity. There is a possibilty of eutrophication in this area.

5.6.3 CONTRIBUTION OF THE PIRACICABA AND THE TIETÊ RIVERS TO THE CURRENT SITUATION OF THE RESERVOIR

The Barra Bonita reservoir receives waters from two rivers the Tietê and the Piracicaba. Two points were analyzed, the Point TE2330, at the Tietê river below the bridge of Tietê-

Capivari, and the point PI2800, at the Piracicaba river for the year 1992, and compared with the average values of 1982-1991. The following results were obtained [44]:

Point TE2330:

Flow:Without significant alterations.

BDO concentrations: increase of 17%

BDO load: increase 23% (58% in relation to 1991)

Total Phosphate concentrations: reduction of 10%

Total phosphate load: No alterations

Point PI2800:

Flow: reduction of 40%

BDO concentrations: increase of 43% (100% in relation to 1991).

BDO load:without significant increase

Total Phosphate Load: no alterations.

In figure 5.15 we can observe that the Barra Bonita reservoir receives a higher water volume from the Tietê river than from the Piracicaba river. It is clear from the rest of the figures that the contribution of the Tietê river to the pollution of the reservoir is higher. BDO concentrations were 23% higher, BDO loads were 52% higher. Total phosphate concentrations and loads had a difference of 0,6% and 20% respectively [44].

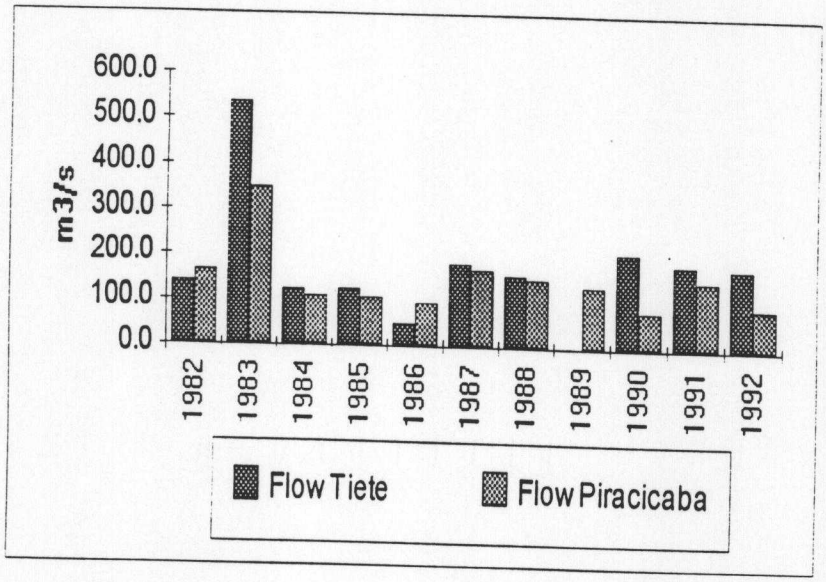


Figure5.15-Flows from the rivers Tietê and Piracicaba to the Barra Bonita reservoir.

Source: Reference 44

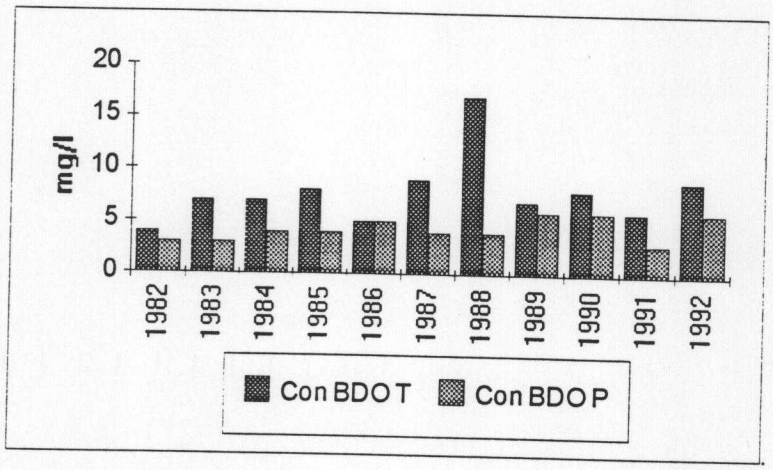


Figure5.16-Concentrations of BDO to the Barra Bonita reservoir originating from the Tietê and Piracicaba.

Source: Reference 44

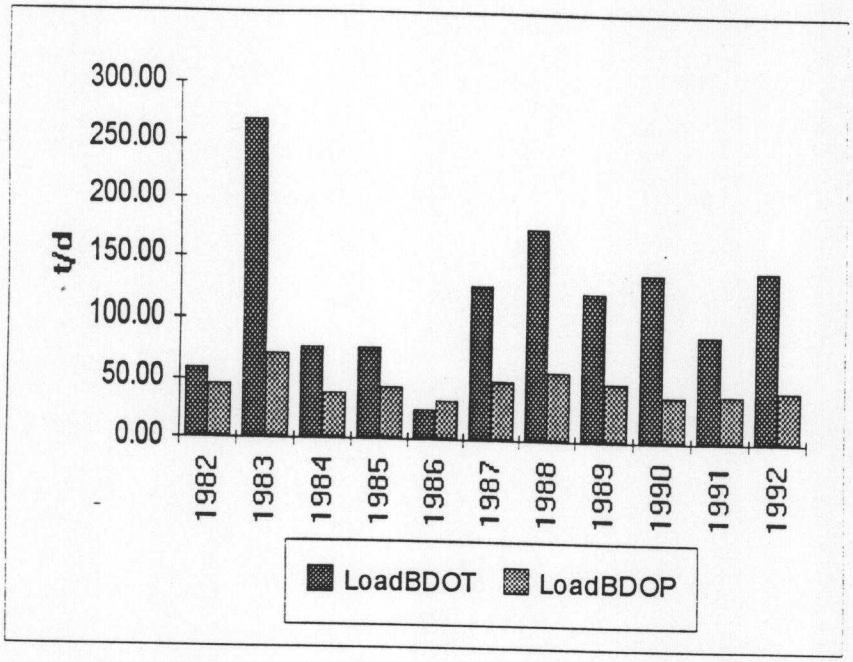


Figure 5.17- Loads of BDO to the Barra Bonita reservoir originating from the rivers Tietê and Piracicaba.

Source: Reference 44

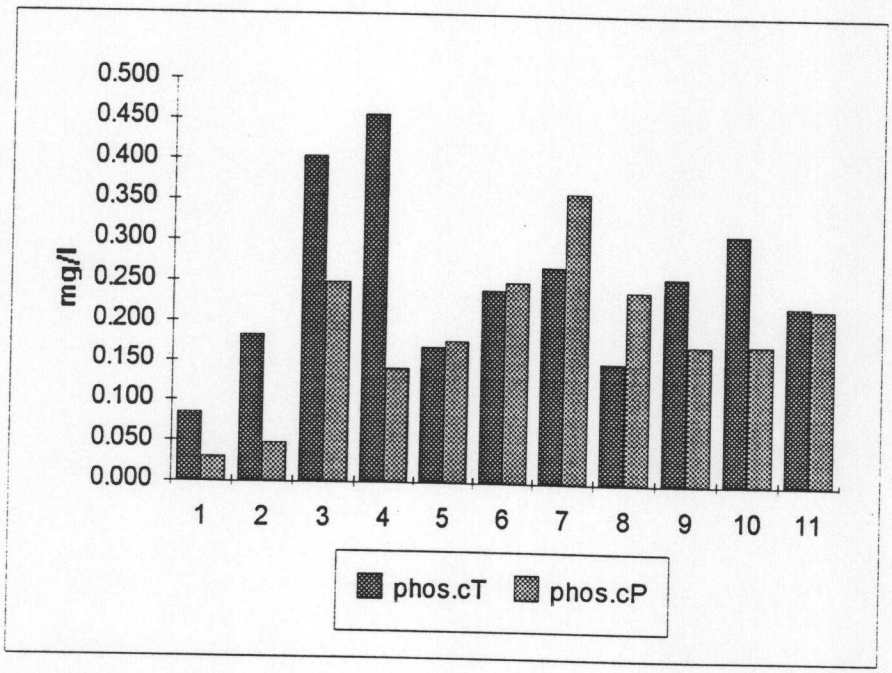
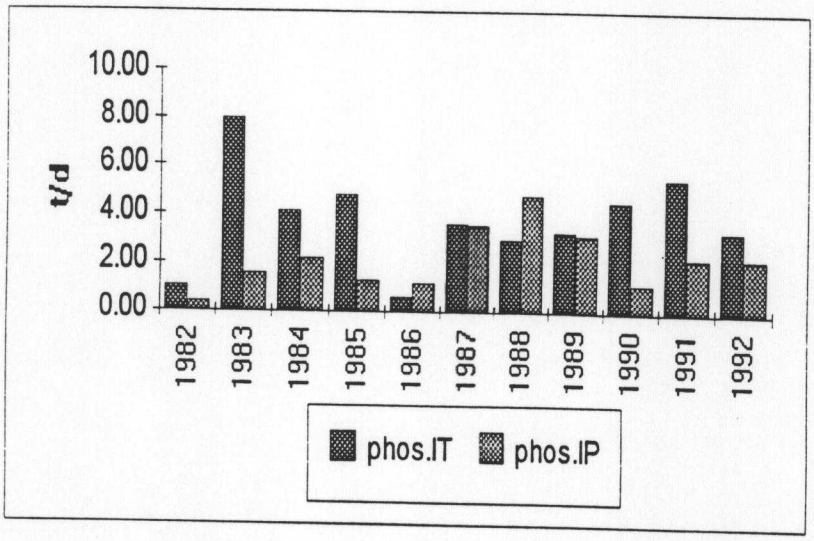


Figure 5.18-Concentrations of phosphates in the Barra Bonita reservoir originating from the Tietê and Piracicaba rivers.

Source: Reference 44



.Figure 5.19- Phosphate loads to the Barra Bonita reservoir originating from the rivers Tietê and Piracicaba.

Source: Reference 44

5.6.4 WATER QUALITY OF THE BARRA BONITA RESERVOIR

Water quality during the years at the Barra Bonita reservoir had the following evolution:

Points of analysis [44]:

TE2100- Tietê river, at the Rasgão reservoir

TE2305-Tietê river, at the Açucar Highway

TE2330-Tietê river at the highway Tietê-Capivari

PI2800-Piracicaba river, Artemis location at the city of Piracicaba.

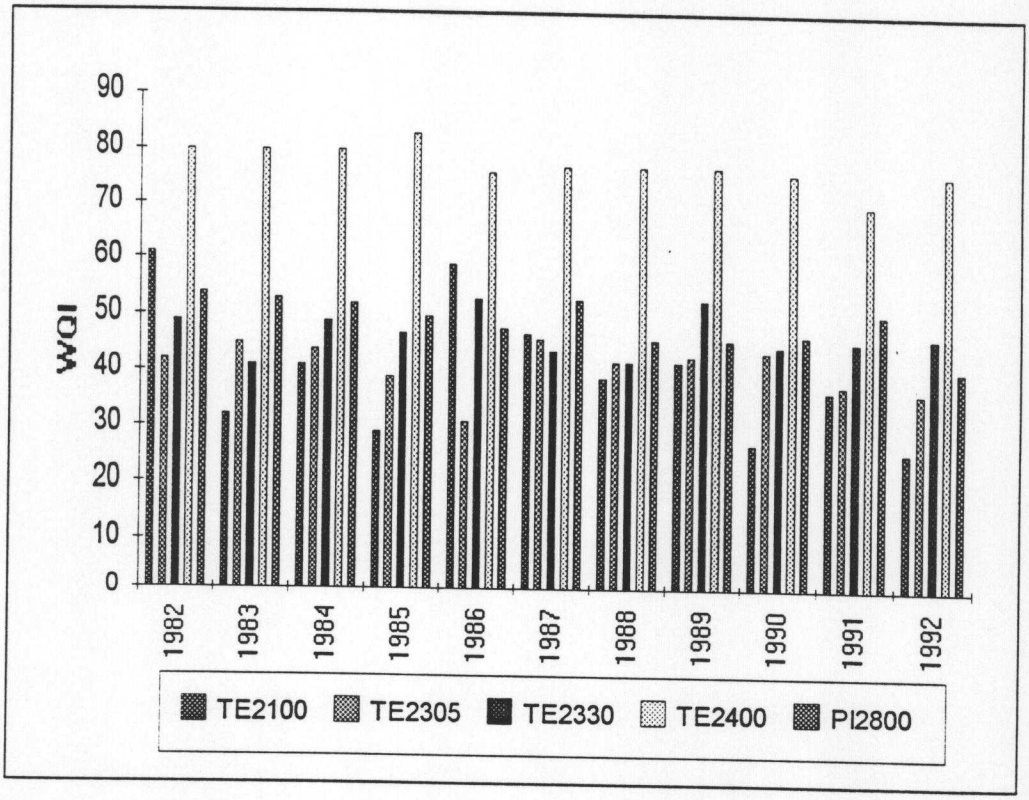


Figure 5.20-Water quality index at the Upper Médio Tietê basin.

Source: Reference 44

There were no significant changes in the water quality index of 1992 when compared with the average of 1982-1991. However these conditions could change in 1993 since the effects of the operation regimes at the Upper Tietê Metropolitan Zone have intermediate rather than immediate impacts [44].

The highest water quality is TE2400 downstream the Barra Bonita reservoir. The lowest is the TE2100 close to the Rasgão barricade. In general water quality varied between good and acceptable during the decade under study.

5.6.5 EUTROPHICATION OF THE BARRA BONITA RESERVOIR

The point which the Trophic State Index was calculated continuously during the last decade is at the effluent part of the reservoir. The reservoir presents periodical algal "blooming", most commonly during spring and summer. An increase in phoshate concentrations was observed in both the Piracicaba and Tietê tributaries. The simulation of the eutrophication model of the Centro Panamericano de Engenharia Sanitária for tropical climate lakes shows that the Barra Bonita reservoir had its eutrophication level increased during the years.

The study showed [44]:

Barra Bonita -1980

Load of phosphorus: 4,6g/m^2/year

Duration time:0,25 years

Average depth: 8 m

Estimated phosphoric concentration at the lake: 0,063 mg/l.

% probability of oligotrophism: 2,4

% probability of mesotrophism: 62,9

%probability of eutrophism: 34

Barra Bonita -1992 [44]

Load of phosphorus: 7,6 g/m^2/year

Duration time : 0,25 years

Average depth: 8m

Estimated phosphoric concentration at the lake: 0,099mg/l

% probability of mesotrophism: 21,7

% probability of eutrophism: 73,3

% probability of hypertrophism: 4,9

From the values presented above we can observe that the phosphoric concentration had an increase of 36% during the last twelve years. The probability of eutrophism increased by 16% and while there was no probability of hypertrophism in 1980, in 1992 4,9% was estimated.

5.7 THE BAIXADA SANTISTA

The Cubatão river at Baixada Santista receives water from the Henry Borden power plant after its use at the plant. Due to the high declivity of the water fall from the regulatory dam to the subterranean section of Henry Borden, the water is depurated, so that it does not influence negatively the water quality of the Cubatão river. (Figures 5.20 and 5.21).

Barra Bonita -1992 [44]

Load of phosphorus: 7,6 g/m^2/year

Duration time : 0,25 years

Average depth: 8m

Estimated phosphoric concentration at the lake: 0,099mg/l

% probability of mesotrophism: 21,7

% probability of eutrophism: 73,3

% probability of hypertrophism: 4,9

From the values presented above we can observe that the phosphoric concentration had an increase of 36% during the last twelve years. The probability of eutrophism increased by 16% and while there was no probability of hypertrophism in 1980, in 1992 4,9% was estimated.

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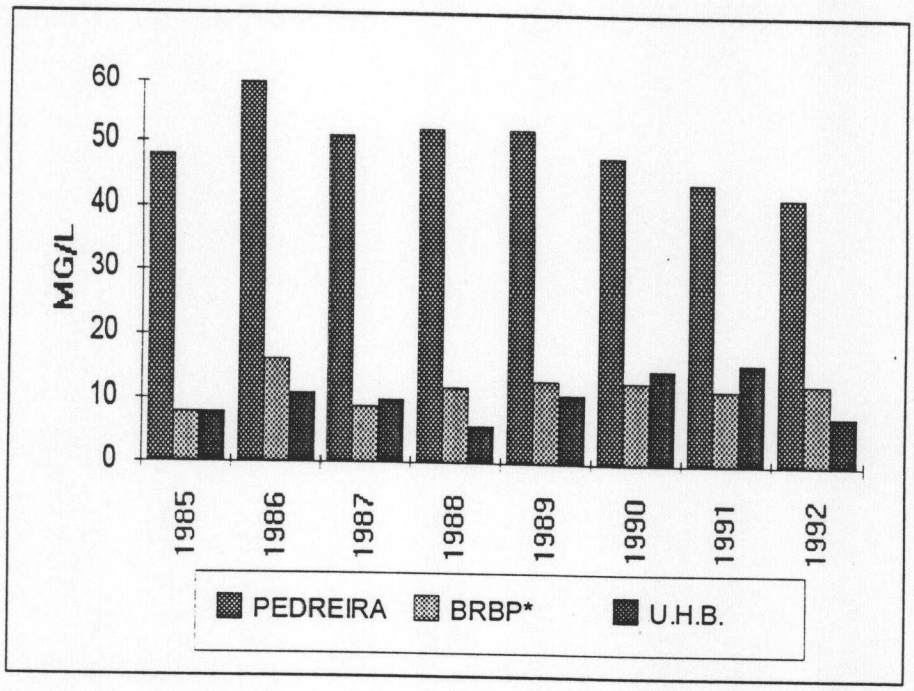

Figure 5.21-BDO reduction along the Billings reservoir

Source: Reference 40

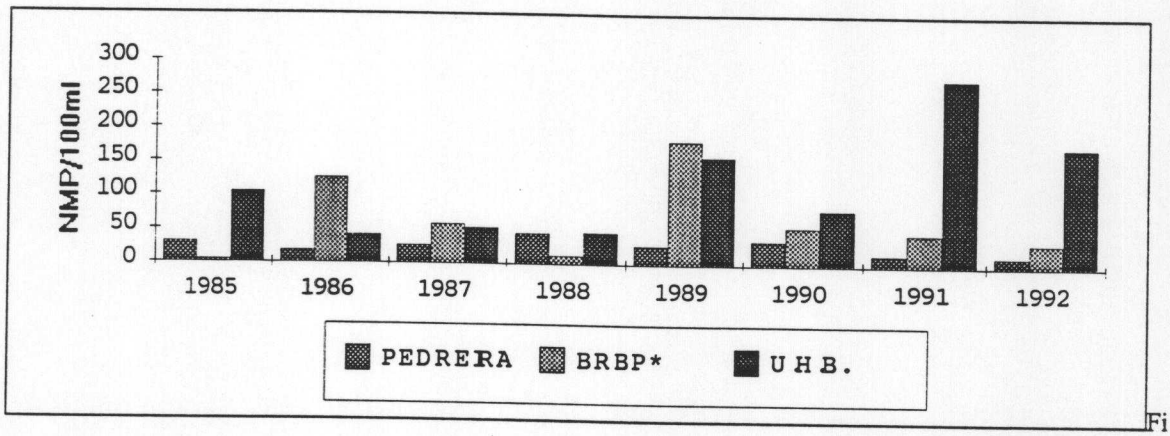

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Figure 5.22-Coliform densities reduction along the Billings reservoir.

Source: Reference 44

5.8 RELATIONS BETWEEN THE ENVIRONMENTAL CONFLICTS

The folllowing diagram shows the relationships between the environmental conflicts. It is clearly demonstrated that the main source of the pollution of the whole system is the

pollution of the Upper Tietê Metropolitan Zone. The aforementioned operation types are mere definitions of the pollution quantities each part of the system downstream the Metropolitan Zone will receive, through the flows in each part.

The competing locations are the Billings and the Barra Bonita reservoirs at the Médio Tietê since with the Operation "Energy" approximately all the Tietê flow and consequently the polluting substances go to the former, and through the Operation "Sanitation" and Operation "Flood Control" all the flow goes to the latter.

With Operation "Balanced" the flow as well as the pollution are somewhat shared, though due to the extremely high levels of polluting materials the problem remains unsolved for both locations.

The Operation "Flood Control", transfers larger amounts of polluting material to the Billings reservoir rather than to Médio Tietê, however has significantly lower frequency (depending only on high precipation levels) than the other operation, a factor which attenuates its negative consequences.

After the application of Operation "Article 46", BDO values at the Billings reservoir have been reduced as well as phosphate levels. This shows that recovery at surface waters is quite rapid. However, its eutrophication levels are high, and concentrations of phosphorous at the sediment continue to be high also.

The Pirapora reservoir has been affected negatively by this application due to the more frequent and intense appearance of foam, which causes fowl smell. Water quality at the

reservoir has lowered during 1992 and a further decrease is predicted due to the larger quantities of organic material going to the reservoir.

The Barra Bonita reservoir at the Médio Tietê basin has been found with an increased eutrophized state in the last ten years. This was due to the continuous increase of the flow of nutrients to the reservoir, mainly from the Tietê river rather then the Piracicaba river. It is expected that conditions will worsen due to the increase of organic material disposed to the Tietê river.

As far as the provision of water to the Baixada Santista from the Billings reservoir after the water passes through Henry Borden, there has been observed a significant reduction in BDO concentrations and coliform densities to levels within the acceptable limits for domestic water provision.

CHAPTER 6: THE PROJECT TIETÊ AND SOCIOECONOMIC IMPACTS AND CONFLICTS OF THE APPLICATION ARTICLE 46.

6.1 ROOT OF THE PROBLEM: THE POLLUTION OF THE TIETÊ RIVER

The Tietê river originates 95 km away from the city of São Paulo, at the municipality of Salesópolis. Its length reaches 1090 km which includes 30 km of "very good" water quality, 660 km of "good" water quality, 95 km of "inadequate" and 119 km of "completely inadequate" water quality. The "good" and "very good" parts go from the city of Barra Bonita (380 km away from the city of São Paulo) up to the meeting point with the Parana river [47].

As described already in Chapter 4, and in Chapter 5, the low water quality at the Tietê river areas close to the city of São Paulo are a result of the disposal of untreated sewage and industrial dejects to the river. The river receives a load of 1100 tons of organic waste per day, with 70% of this being domestic and the rest 30% industrial waste [47].

This heavy pollution was the result of the accelerated development of the city of São Paulo especially after the 1960's and of the lack of the appropriate care for waste disposal infrastructure.

6.1.1 REVIEW OF THE PLANS TO FIGHT POLLUTION AT THE TIETÊ RIVER

In the 1950's right after the creation of DAEE (Department of Waters, Energy and Electricity), the first somewhat organized plan to fight pollution at the Tietê was the "Grilley Hansen" which only involved the city of São Paulo. The construction sewage treatment

stations of Vila Leopoldina and Pinheiros was initiated, and there were plans for the construction of four more. This program failed due to the fact that there were no demographic projections for future sewage estimations in the city of São Paulo. [47].

In 1964 the "Hibrace Director Plan" was proposed, the objective of which was to propitiate the organized development of water resources in the Upper Tietê and Cubatão. The study was concluded in 1967, and retification construction between Osasco and the Edgard de Souza Barricade was initiated, and concluded in 1976 [47]. It was proposing the sewage disposal to the Rio das Pedras, after going through a series of four estabilization lakes constructed at berred arms of the rivers Cocaia, Bororé, Taquacetuba and Capivari.

After the creation of CETESB in 1968, the "Hansen and Sawyer" Plan was analyzed. This plan proposed the diversion of the of the waters of the Tietê river to the Billings reservoir. In order to achieve this, the trajectory of the Tietê river was modified, in this way acquiring its rectilinear aspect close to the city. The consequences of this project were grave for the city, since the river, without any unexplored land along its watercourse, became an additional cause for flood problems in the city. The plan's failure was due to its centralizing tendency and to the negative environmental consequences it would have had on the Billings reservoir since it would have transformed the reservoir into a sewage treatment stabilization lake [47].

In 1974, Nélson Nucci proposed the "Solução Integrada" (Integrated Solution), a plan which suggested the utilization of the self-purification capacity of the Juqueri river and the Pirapora reservoir. This plan very similar to the one which involved the Billings reservoir, would have had a zero cost, including only the construction of a tunnel which would have taken the sewage, captured at the mouth of the Pinheiros river, to Pirapora through the

Cantareira mountain range. This plan did not have a clear definition of the sewage treatment necessary, it was centralizing and had negative consequences for the Pirapora reservoir similar to those of the Billings [47].

After the failure of "Solução Integrada", the SANEGRAN (Director Plan of Basic Sanitation in Great São Paulo) followed, which included the construction of thousands of kilometers of sewage collector networks, interceptors, and of three large treatment stations which altogether in 1990 would have been processing 95 000 liters of sewage per second [47].

The two of them processed only 3% of the capacity expected; 12 km of the collector network were left to be constructed to reach the Barueri station. Due to these delays the plan was revised twice by the World Bank, and finally paralized in 1986 due to the large amount of money spent and the relatively insignificant outcome [47].

In 1986 the "Solução Integrada" Plan was under study again, especially for the resolution of flood problems in the city. The opening of the Edgard de Souza dam was done as well as a 5 meter lowering of its bed. Also 3 million m^3 of waste material per year were planned to be removed from the Tietê river through DAEE. This is done today by cannons installed by ELETROPAULO which are used for water aspersion, right before the Pirapora dam , in order to partially dissolve the foam blocks formed due to the reversion of the Pinheiros river and the elimination of the pumping system to the Billings reservoir [47].

The current program for the improvement of water quality of Tietê river was initiated officially on January 31st of 1992 [47].

6.2 THE TIETÊ PROJECT

This project is a modified proposal of the SANEGRAN project presented above. During ECO92 the Governor of the State of São Paulo at the time, closed several agreements with International Financing Organizations for this project. The InterAmerican Development Bank, and the OECF Agency of the Japanese government contributed together US$ 1,55 billion which added up to the rest of the financial resources of the State of São Paulo, guarantee the recovery of the Tietê river [48].

The program's duration is extended until 2005, with the prevision of 50% of the domestic sewage treated until the end of 1994, an additional 20% until 1997 and another 25% until 2005. For this purpose there have been invested US$ 2,1 billion [47,48].

Also the program includes the treatment of industrial dejects. The most polluting industries were selected, and they have the maximum of two years to eliminate their polluting effluents disposed to the river, and to install their pre-treatment and treatment installations. For this purpose have been invested US$ 500 million financed by the private sector and BNDES/BANESPA [48]. The project involves the following entities and constructions:

6.2.1 DOMESTIC SEWAGE TREATMENT: The cost[48] will come up to US$ 2.100.000.000

SABESP

The role of SABESP in the project is to amplify the collection system, and to treat the domestic waste [47,48].

FIRST PHASE: Ends 1994 - The cost is US$ 900.000.000 [48]

Includes: .The construction of two new Sewage Treatment Stations (STS) in Parque Novo Mundo and São Miguel, with capacities of 7,9 m^3/s and 6,7 m^3/s respectively in 2005.

.Amplification of the Barueri STS from 3,5 m^3/s to 28,5 m^3/s in 2005.

.The conclusion of the STS in ABC, of initial capacity of 4,5 m^3/s and final capacity in 2005 of 8,5 m^3/s.

.Amplification of the STS of Suzano from 0,4 m^3/s to 1,9 m^3/s in 2005.

.Construction of STSs for small isolated systems reaching 2,6 m^3/s in 2005.

.Construction of 183,5 km of interceptors until 2005.

.Construction of 295 km of collector trunks.

.Construction of 2 000 km for the collector domestic sewage network and 200 000 household connections.

SECOND PHASE: ENDS 1997 - The cost is US$ 1.200.000 [48]

Conclusion of the constructions initiated in the first phase.

Amplification of the STS of Barueri, SãoMiguel, Parque Novo Mundo

82 km of interceptors

100 000 new household connections

6.2.2 INDUSTRIAL EFFLUENT TREATMENT - The cost[48] of the plan US$ 500.000.000

CETESB

CETESB is responsible for the industrial pollution control of the river. The first step, in 1990, was the identification of the more polluting industries. CETESB classified the 40 000 industries in the Metropolitan Region of SãoPaulo, according to their emission potentials, toxicity of effluent liquids and flow levels, and concluded that 1250 of them were responsible for 80% of the river industrial pollution. The organic load per day of these installations is 400 tons of BDO/day and the inorganic 4 tons/day (including heavy metals, cyanite and fluorites.

CETESB has defined the following pollution treatment plans:

. Technical solutions satisfying the legal emission standards.

.The pre-treatment of inorganic load and its disposal to the public collection system.

.Complete treatment of organic load.

FIESP [47]

Technical and financial orientation to the industries, as well as the maintenance of data of the various individual industrial waste treatment projects with the cooperation of Senai in the project evaluations.

PROGRESS OF THE INDUSTRIAL TREATMENT

Until 02.04.93 there were the following detailed results:

-Industries chosen: 1250

-Total of presented plans:	1231
.aproved plans	1209
.plans under study	22
-Systems under implantation:	785
-Systems to be implanted:	424
-Plans not presented:	19

As of July 1994, 810 industries have resolved their effluent treatment, and is expected that until December 1994 all of 1250 will be completely adapted to the project's definitions.

CONTROL OF THE INDUSTRIAL LIQUID EFFLUENTS:

CETESB: Control of liquid effluents: 300 industries - 12.92

650 industries - 12.93

1250 industries - 12.94

The cost of the control of liquid effluents will come up to US$2.400.000 [48]

Technical Training of the operations personnel linked at the industrial program; The cost is US$ 800.000 [48]

6.2.3 OTHER RELATED SMALLER PROJECTS

DAEE [48]

It is the entity responsible for auxiliary projects of the despollution of the Tietê river. These are:

.Coordenation of the studies necessary for the elaboration of The Integrated Plan of the Utilization and Control of the Water resources of the Upper Tietê, Piracicaba, and Baixada Santista Basins.

.The lowering of the river bed, increasing its flow from 700 to 1400 m^3/s. The cost [48] is US$221.400.000

.Canalization of the Cabuçu de Cima river (Guarulhos region). The cost is [48] US$ 123.800.000 .Amplification of the dam complex of the Upper Tietê system, where the construction of the two barricades (Biritiba and Paraitinga) is expected. The cost[48] is estimated at US$ 274.100.000

.Infrastructure: Increase in the efficiency of communications, tranportation, an installations through the necessary equipment acquisition. The cost[48] is estimated US$1.700.000

COMGÁS

Responsible for auxiliary projects, such as the construction of a thermoelectric power plant which uses waste and would incinerate 10% of the waste collected in the city of São Paulo [47] The cost [48] is estimated US$ 227.300.000.

CETESB

Information systems:

Installation of an information systems to guarantee effluent control efficiency, and to give support to the connections with SABESP [47]. The cost[48] will be US$ 1.700.000

6.2.4 UNCERTAINTIES CONCERNING THE SUCCESS OF THE PROJECT

Although SABESP and the government of the State of São Paulo have been announcing that until the end of 1994, the first phase of the project would be completed , there have been expressed doubts concerning the fact that 50% of domestic organic waste will be treated [49].

This uncertainty is based on facts such as the difficulties in equipment maintenance since most of the equipment have no simplified control systems or are out of line already. This is due to the fact that they were bought 10-15 years ago, before the advances in control systems simplifications. Another problem is the cleaning of the interceptors, since they have been constructed during the "SANEGRAN" project and have not been utilized. This could be another significant delay factor to the full operation of the plan [49].

6.5 SOCIO-ECONOMIC IMPACTS AND CONFLICTS

This section is a description of the socioeconomic impacts and conflicts of the systems of the Upper Tietê Metropolitan zone, the Billings and the Médio Tietê basin, in other words the analyses of all the costs and benefits involved in the systems.

As seen from the previous section of this chapter, the root of the pollution problem of the three systems is the domestic and industrial waste disposal of the Metropolitan region to the Upper Tietê zone. Apart from the already described environmental consequences, there are further economic and social, involving public and private entities of the systems as well as the communities of São Paulo, Médio Tietê and Cubatão.

This analysis is a comparison of the costs and benefits of the system in its current conditions, that is the interruption of water pumping to the Billings and the consequent water directioning downstream Tietê, with the recuperation project of the Tietê river. There are studied two conditions of the Tietê program; in 2005 the completion of all the constructions planned with the sewage treatment efficiency as defined at the beginning of the project; and the uncertainty involving the completion of the project on the time defined and its operation on a lower sewage treatment efficiency.

This study is limited to the identification of costs and benefits of the entities and communities involved and to recommendations for further elaboration of this issue. The problem of the homeless people at the margins of the Billings reservoir has not been included in the study since there were no data available, and due to the fact that it is not directly related to the cleaning of the Tietê river and the interruption of pumping to the reservoir. These limits were set due to lack of some important data, such as the actual costs

of the application of the Article 46 for the municipalities of Médio Tietê, and to the fact that a more profound analysis would go beyong the scope of this study, the purpose of which is to present the various aspects of the problems involving the Billings systems, through the perspective of the concept of sustainable development.

The socioeconomic costs and benefits involved in the system are divided in two categories, tangible those which are measured or are measurable in monetary terms, and untangible the ones which cannot be estimated in monetary terms.

6.5.1 COSTS AND BENEFITS OF THE INTERRUPTION OF WATER PUMPING TO THE BILLINGS RESERVOIR

5.3.1 ELETROPAULO

ELETROPAULO, is responsible for flood control and energy production at the Henry Borden power plant. After the enforcement of Article 46, ELETROPAULO has not been producing energy, since it can only utilize $4m^3/s$ to avoid water depletion of the reservoir (water volume has decreased significantly due to the interruption of pumping from the Tietê river to the Pinheiros river).

As described in Chapter 4, the costs for flood control are increasing due to the pollution (solid waste accumulation at the bed of the canal) and to an increase of flood risks (extended urbanization).

This was done through a comparison of the average unitary cost of the total energy production at Henry Borden for the options of "keep operating Henry Borden" and

"inactivate Henry Borden", taking into account that the amount of the energy not produced would be substituted by energy produced at the Southeast Interlinked System [35].

It must be noted that with the option "Inactivate Henry Borden" ELETROPAULO stops to be responsible for the operation, and maintenance of the Billings system, with consequent cancellation of this concession to the company [35].

For the option "continue operating Henry Borden" the average unitary cost, operation of the pumping to Henry Borden, remaining non-depreciated capital investments already carried out, future investments, maintenance and operation costs, and cost of energy to be substituted, were taken into consideration.

For the option "inactivate Henry Borden", the remaining non-depreciated capital investments, and the cost of energy to be substituted were included. The amount of base-load energy produced at Henry Borden corresponds to $90 m^3/s$, taking into consideration the reversion system of the Tietê river. The conversion factor of 5,34 $MWh/m^3/s$, (which takes into account energy consumption of pumping at Pedreira and Traição) was utilized [35].

The cost of substituted energy, was determined by ELETROPAULO to US$ 48 / MWh, which is the marginal expansion cost of the Southeast Intelinked System (Data 1993) [35].

According to ELETROPAULO the costs are the following [35]:

A) OPTION "CONTINUE OPERATING HENRY BORDEN"

1. Remaining value of the investments already carried out and are not depreciated: US$ 275.000.000 (it includes the Henry Borden power plant, Rio das Pedras reservoir, Billings reservoir, Guarapiranga reservoir, Pinheiros canal, elevatory stations of Pedreira and Traição, the Retiro structure, the elevatory station of Edgard de Souza, and the Pirapora reservoir.

2. Investments carried out but not immobilized: US$112.300.000 (includes the installation of machine no 8, construction of the Pirapora tunnel, the recuperation of the dicques of CubatÃo de Cima, Passareuva and Pequeno Perequê).

3. Investments to be carried out (until 1998) : US$ 378.656.622. (Meeting the concession decrees, increase of installation safety, redesign and renovation of the equipment of the hydraulic/generation system).

4. Long Term necessary investments (until 2020): US$ 103.093.694. (Amplification of the pumping capacity of Traição and Pedreira, Pinheiros canal).

5. Operation and Maintenance costs: US$ 104.000.000 per year. (labor, waste removal, substitution of parts and equipment).

The fixed annual costs for ELETROPAULO, considering 50 years of return period, interest rate 10%, dolar inflation 3%, are:

.Investments already carried out: US$ 39.059.205

.Investments to be carried out (without long term): US$ 38.191.155.

.Investments to be carried out (including long term): US$ 48.592.877.

- OPTION "Keep operating Henry Borden" (without long term investments) : US$181.250.360 / year. This would lead to a unit price of US$ 43,0 / MWh

ELETROPAULO did a study which analyzes the economic viability of this system considering the economic losses due to other water uses[35]; The results of this study are presented in this section. The minimum pumping which turns financially viable for ELETROPAULO the maintenance and operation of Henry Borden was defined.-OPTION "Keep operating Henry Borden" (including long term investments) : US$191.652.082 This would lead to a unit price of US$ 45,4 / MWh

B) OPTION "INACTIVATE HENRY BORDEN"

1. Non - Depreciated Capital investments already carried out: US$ 275.000.000

2. Investments to be done at the electrical system of ELETROPAULO in case of inactivation of Henry Borden:

US$ 34.100.000 (includes reconstruction of TL of Henry Borden - Baixada Santista 88 kV, installation of third circuit at the TL of Tijuco Preto - Baixada Santista 345 kV, installation of a third transformer bank 345-138/88 kV, of 440 MVA, at the (ETT) of Baixada Santista. Annual Fixed Costs for this option: US$ 42.498.190 - US$ 10,1 / MWh.

With this analysis the minimum pumping at Henry Borden was defined, at 62 m^3/s if long term investments are not taken into consideration, and 66 m^3/s if they are. Water pumping below 62 m^3/s for a prolongated time is not economically favorable for ELETROPAULO to keep the Henry Borden power plant.

This minimum flow economically favorable for ELETROPAULO was defined based on the marginal cost of the expansion of Southeast Intelinked System for the year 1992 which was set by ELETROBRAS at US$ 48/MWh. With the marginal cost at this level it is beneficial for ELETROPAULO to operate Henry Borden. However in 1993 the generation long term

marginal cost was recalculated [50], and in this way it decreased to US$ 34 . This would probably have an effect on the plans of ELETROPAULO since it becomes economically favorable to buy electricity from the Southeast Interlinked System.

INDUSTRIES OF CUBATÃO

The industries in Cubatão, after the application of Article 46, have been facing problems concerning the cooling of their equipment. This is due to the fact that with the interruption of pumping from Tietê to Pinheiros, the Billings reservoir has suffered from water depletion since its natural flow is only 18 m^3/s. To avoid further depletion there has been a decrease of water turbination at the Henry Borden power plant and of its transfer to Cubatão, to $4m^3/s$ compared with the $50m^3/s$ necessary for the equipment cooling of the industries. This flow from the Henry Borden is necessary to avoid intrusion of sea water to the Cubatão river, a phenomenon which creates problems to the industries which are designed for fresh water use.

There are six industries which mostly depend on water pumping from the Henry Borden, with the following economic losses in case of interruption of their operation:

CARBOCLORO [51]: Revenue Loss: US$ 15.000.000/month

ICMS Loss: US$ 2.300.000/month

Employees :480 direct

350 indirect

RHODIA [51]: Revenue Loss:US$ 3.000.000/month

ICMS Loss: US$ 540.000/month

Employees : 250

PETROBRAS [51]: Revenue Loss: US$ 562.000.000/month

ICMS Loss: US$ 98.200.000/month

Employees : 1650

ULTRAFERTIL [51]: Revenue Loss: US$ 100.000.000/month

ICMS Loss:US$ 4.500.000/month

Employees :510

COSIPA [51]: Revenue Loss: US$ 100.000.000/month

ICMS Loss: US$ 21.000.000/month

Employees: 13.265 direct

3.000 indirect

Some of these industries have resolved their problem temporarily, however others have encountered difficulties in finding short term solutions.

COSIPA is the industry with the higher economic losses due to its localization [52]. There have been problems with steel production, with both quality and quantity [52]. COSIPA will invest US$ 3.000.000 for the construction of a new mobile barricade at the two arms of the Cubatão river, and increase water recycling to 72%. In this way, COSIPA will reduce its needs of water pumped from the Henry Borden power plant to 35 m^3/s compared with $50m^3/s$ necessary now [52].

ULTRAFERTIL, has invested US$ 2.000.000 to a closed water circuit, in this way using 40% less water from the Henry Borden flow to Cubatão. The pumping of $4m^3/s$ is sufficient for this industry [52].

CARBOCLORO-RHODIA, have plans for water capture from the Perequê river. This barricade is temporary, only until the Tietê recovery. There are also water recycling plans in both companies [51,52].

ESTIRENO is capturing water from artesian wells, perfurated in its industrial area. This solution is only temporary [52].

The construction of a new water capturing adductor is estimated around US$ 40.000.000 [52]. This investment is seen as highly costly and the industries are not willing to go forward, since, according to them, after the completion of the project Tietê there will not be any problem for pumping water from the Tietê to the Billings a fact which will turn this new adductor construction a sunk cost.

SABESP

As already mentioned SABESP uses 2,0 m^3/s of the Rio Grande Compartment for domestic water provision of the region ABC [38,39]. Also SABESP uses the water pumped from the Henry Borden to provide potable water at the communities of Cubatão and Baixada Santista. The Billings reservoir is included in the company's plan for public water provision of the Metropolitan region of the city of São Paulo [39]. Apart from the costs the company

has to treat the water, the quality of which is significantly better than the rest of the reservoir, there are no other costs involved.

COMMUNITY OF SÃO PAULO

The community of São Paulo has been polluting a natural resource, essential for its welfare, through untreated waste disposal.

This action has led to following socio economic costs:

a) Increase of flood risk.

Flood risks have increased during the years due to the extensive urbanization. With the increase of pollution in the Billings system, the flood control efficiency has decreased. (solid waste accumulation impedes the smooth operation of water pumping). The consequences are grave for the city since, a flood not adequately controlled, involves damages of houses and other constructions, as well as traffic accidents, injuries etc.

b) Substitution of the energy produced at Henry Borden.

As seen at the previous section, the pollution at the Billings reservoir has impeded the production of energy at the Henry Borden power plant. In case of inactivation of the Henry Borden, which makes part of the Intelinked System, it must be substituted by another power plant of the same capacity. The cost of a power plant of capacity of 880 MW, US$ 1.760.000.000 would be necessary to invest, an amount which would be distributed to the consumers. This investment is extremely high, taking into consideration that the country is going through a recession period. In addition, Henry Borden is strategically located in the

proximities of São Paulo, in case of a "black out". The cost of the energy not provided come up to US$ 1500/MWh [50].

c) Higher water provision costs

The provision of water for domestic and industrial uses in the city of São Paulo, has been done through the use of basins relatively distant to the city, such as the Piracicaba river, due to the fact that almost all the basins and reservoirs close to the city are polluted, thus not appropriate for noble water uses..

Water transportation from other distant basins has further complications; Firstly the cost of water provision is higher compared to the use of basins close to the city; secondly, this water is not recycled or treated, it is simply returned to the river as sewage! The fact that the water is from other basins brings up questions such as competition of natural resource use and the rights each community has concerning these uses.

One would think that with Billings reservoir cleaner, the water could be used for domestic provision. As seen in Article 46 there are five emergency cases when water pumping to the Billings can be activated. This would have negative consequences on water quality, and its use for domestic provision may no be possible.

d) The fowl smell close to the Pinheiros canal and the Edgard de Souza barricade due to the "foam effect". People living close to these areas have to bear the smell, and their properties have been devaluing continuously.

BENEFITS FOR THE CITY OF SÃO PAULO

The relatively significant environmental improvement could lead to:

-The valorization of real estate close to the reservoir. This is more of a financial benefit for the real estate companies. No data available.

-An increase in the tourist flow to the Billings reservoir which could lead to the increase of recreational activities. No data about tourist flow are available. The increase of recreational activities is an untangible benefit.

MÉDIO TIETÊ

The Médio Tietê basin, after the application of Article 46, has suffered from an increase in water pollution, since it receives all the Tietê flow, and consequently all the sewage from the city of São Paulo.There are 78 cities of the Médio Tietê basin which have been affected negatively by the Operation "Article 46". There are no data about the situation of all the municipalities, apart from some information concerning specific cases.

COSTS

One grave economic consequence of the cities of Médio Tietê is the decrease in the number of tourists. With the pollution, the river has a fowl smell (due to the foam effect) and other activities such as fishing or bathing have been eliminated. For the city of Pirapora there has been a direct economic loss of US$ 120.000/month due to a decrease of 50% of the tourist flux in the city [54]. In Salto the production of a paper-cellulose factory has fallen to 60% since it not possible to work at the night shift due to the appearance of a minute mosquito in

great numbers which interferes with the machinery operation. This mosquito only appears at night[41].

About 15% of the agricultural areas at the city of Salto are located close to the river banks. The water which should be captured from the Tietê river to be used for irrigation is not appropriate due to the high concentrations of toxic substances to the plants such as heavy metals [41].

The river pollution has also created difficulties for the real estate sector due to the devaluation of the estates close to the river [41].

Medical problems have also increased [41], In Salto there has been an increase of 50% of tuberculosis and broncopneumonia cases in the last two years. Apart from the increase in respiratory problems, there is an increase in the occurence of opthalmological and dermatological pathologies. The cases of nausea and headaches have also increased. The mayor of Pirapora has admitted a significant increase in health costs [53]. Further more detailed data are not available.

In this analysis one cannot ommit the social and cultural importance the river has for the population of Médio Tietê. There is a strong connection of the population with their environment, since the river have been providing for their survival, through agricultural and tourism, as well as for their recreational, religious and other traditional activities [42].

The pollution has brought low water quality, and bad smell to the cities (due to the foam effect). Swimming competitions and boat rides cannot make part of the current recreational

activities. Religious processions by boats have been turned into a torturous event since people cannot bear the smell of the river [42].

These activities are very important for the communities of Médio Tietê. Although their value cannot be measured in monetary terms, their disappearance would lead to the loss of their cultural identity.

BENEFITS

There were no benefits for the communities of the Médio Tietê basin from the application of Operation Article 46.

COMMUNITY OF CUBATÃO

COSTS

The community of Cubatão is basically constituted of the workers in the industries of the area. The six industries named above have already threatened to fire their employees the number of which reaches 15.905 [51], in this way creating unemployment to a country in recession, and leaving 64.000 people without financial resources. Apart from the dismantling effects on the municipality of Cubatão, the outcry of such an action would be enormous.

BENEFITS

There are no benefits for the community of Cubatão.

6.5.2 COSTS AND BENEFITS OF THE TIETÊ PROJECT

ASSUMPTION 1: MEETING 100% THE OBJECTIVES OF THE PROJECT

COSTS

INDUSTRIES OF CUBATÃO

To use the water from Henry Borden they would probably have to pay a fee, since they are using a variable resource of the society.

COMMUNITY OF SÃO PAULO

The costs of the Tietê have been seen in the previous section of this chapter. The treatment of domestic organic waste would come up to US$ 2,100.000.000 [48].

COMMUNITIES OF MEDIO TIETÊ

The communities of Médio Tietê have no direct costs in the Tietê project. Indirect costs due to pollution effects of the Upper Tietê to the Médio Tietê which would probably continue after 2005, since the changes are not immediate.

The Tietê project does not mention treatment of heavy metal concentrations already in the river. Heavy metal high concentrations are toxic for agricultural use, one important economic activity of the communities. Also they have a negative effect on the Barra Bonita reservoir, facilitating eutrophication.

COMMUNITY OF CUBATÃO

No costs in the Tietê project.

BENEFITS

ELETROPAULO

ELETROPAULO after the completion of the Tietê project will be able to produce energy at the Henry Borden power plant. As seen before this will depend on the marginal cost of production at 2005, since the cost of energy production at Henry Borden is at US$43,00 /MWh [35].

INDUSTRIES OF CUBATÃO

In 2005 water could be transferred from the Henry Borden to Cubatão, a fact which would lead to the normal functioning of the industries which depend on water flow from Henry Borden.

SABESP

SABESP will be able to use the water of the Billings for domestic provision. Since the Billings is closer to the city of São Paulo the domestic provision unit costs will be lower when compared with the use of more distant resources.

COMMUNITY OF SÃO PAULO

The benefits of the project under assumption 1 are the following:

-Resolution of the sewage treatment problem of the city of São Paulo.

-Potential or probable use of water resources close to São Paulo. This would bring lower domestic water provision costs for the consumers.

-Use of the Henry Borden. No need for substitution for another power plant.

-Flood control system. With the deject treatment, solid waste accumulation will not be a cause for lower efficiency of the turbines at the elevatory stations, and for their high breakdown probability.

-Recreational activities at the Tietê and Billings involves tourism . This could be assumed as intangible benefits.

-Real estate valorization of the proximities of the reservoir.

-View a clean Tietê river, and the lack of fowl smell; This is an untangible benefit.

COMMUNITIES OF MÉDIO TIETÊ

The communities of Médio Tietê can continue with their traditional economic activities, such as tourism. The cultural religious and recreational events will be practiced.

COMMUNITIES OF CUBATÃO

No threats for unepmloyment for the Cubatão community. This will bring security to the population.

6.5.3 TIETÊ PROJECT: ASSUMPTION 2: THE PARALIZATION OF THE PROJECT AT THE COMPLETION OF PHASE 1. (END OF 1994)

COSTS

ELETROPAULO, INDUSTRIES OF CUBATÃO, SABESP.

If only 50% of the domestic sewage is treated, the costs for ELETROPAULO, the Industries of Cubatao and SABESP will probably be the same as in the case : Operation Article 46. This is due to the fact that even with 50% less sewage the Tietê river still continues to be highly polluted. Therefore pumping to the Billings probably will not be activated, except for in emergency cases.

COMMUNITY OF SÃO PAULO

Apart from the costs of the community already mentioned in OPERATION ARTICLE 46, there will be an additional US$ 1,55 billion of the loans from the international organizations which would have to be paid back.

COMMUNITIES OF MÉDIO TIETÊ AND CUBATÃO

The same costs as in OPERATION ARTICLE 46.

BENEFITS

The benefits for all entities involved would be the same as OPERATION ARTICLE 46.

6.5.4 DISCUSSION OF THE RESULTS

From the analysis seen above we can conclude that is economically and socially favorable to complete the Tietê project, within the already set timeframe and efficiency.

This conclusion is based on the following facts:

a) The costs of the Tietê project are lower than the costs of the interruption of pumping to the Billings reservoir.

b) The interruption of pumping to the Billings, first it will not resolve the environmental degradation of the Billings reservoir, since pumping could be activated due to the five defined emergency cases, and second it will aggravate the environmental and socioeconomic conditions in Médio Tietê and Cubatão, as well as of the community of São Paulo.

c) The interruption of pumping caused conflicts between three communities; the city of SãoPaulo and the communities of Tietê, the city of São Paulo and the city of Cubatão. The resolution of these conflicts could only come through the attack of the real problem; LACK OF SEWAGE TREATMENT.

6.6 FURTHER RECOMMENDATIONS

6.6.1 NEED FOR THOROUGH AND ACCURATE DATA

There is need for a more accurate and thorough estimation of the socioeconomic impacts of the interruption of pumping to the Billings reservoir as well as the data and perspectives concerning the Tietê project.

In particular, information for the estimation of socioeconomic costs concerning the communities of Médio Tietê, including estimation of health costs, losses from tourism and agriculture and other production means, are necessary.

As far as the Billings system is concerned, the number of people affected from the fowl smell, living to the proximities of the reservoir, the tourist flow lost during the years of its environmental degradation and further costs related to its environmental imrpovement should be estimated.

Its is also necessary to examine other parallel projects such as sewage waste disposal of the cities of Médio Tietê and removal of homeless people from the margins of the Billings.

6.6.2 NEED FOR VALUATION OF ENVIRONMENTAL COSTS AND BENEFITS

In principal, economic analyses are to take into account all costs and benefits of a project. With regard to environmental impacts, there have been two basic problems [54]. First environmental impacts are often difficult to measure in physical terms [54]. Second, even when impacts can be measured in physical terms, valuation in monetary terms can be difficult. (Munasinghe 1991)

Environmental effects should be included in the economic analyses of projects, since in this way decisionmaking is improved towards a more efficient use of natural resources.
Several approaches and techniques have been developed, for their valuation, from the World Bank and other agencies.

6.7 GOVERNMENT ACTIONS

The entity responsible for taking actions concerning Operational regime of the Tietê river is the Environmental Secretariat of the State of São Paulo.

In the last 5-6 years the government of São Paulo showed a strong interest in resolving the environmental degradation of the Billings reservoir, through the creation of Article 46 in 1989 and its application in 1992. Also the government created the Executive Comittee responsible for the "communication" of the entities involved in the Billings system, that is ELETROPAULO, the Industries of Cubatão, DAEE, CONSORCIO INTERMUNICIPAL ABC, CETESB, and non-governmental organizations. In the last one and a half years a representative of the communities of Médio Tietê has been participating. This committee has no executive power, it serves as a counseling group to the Environmental Secretariat. During the last four months there have not been any regular meetings.

The action the government took in 1992 to interrupt water pumping to the Billings reservoir, having as objective the improvement of environmental quality of the same, had strong negative environmental and socioeconomic concequences for the communities of Médio Tietê and Cubatão as well as for the city of São Paulo. The decision was taken after past experiences such as those of 1983 when the operation "Saneamento" was applied and the cities of Médio complained, resulting finally in 1984 to operation "Balanceada".

The first question which comes up is the one about competition of natural resource use and the rights of each community concerning these uses. The proper state government has shown unjustified preferences for a certain community and natural resource, that is the community of São Paulo and the Billings reservoir respectively, without taking into

consideration that the cause of the problem, the pollution of the Tietê river had not been resolved.

The second question concerns the proper objectives of this action. The government of São Paulo justified its action by saying that Billings is necessary for future domestic water provision. There were no studies done estimating the recuperation capacity of the reservoir, and the possibilty of its use for domestic water provision. The bed of the reservoir has high concentrations of heavy metals. In addition there are the five emergency cases during which pumping could be activated. There were no environmental impact evaluations concerning the application of the five items of Article 46.

From 1984 until October 5 1992, the temporary solution was Operation " Balanceada", which allowed activity in the Médio System, and the Billings. If we take into account that the two systems were already under environmental stress, since the pollution from the Upper Tietê zone had reached extremely high levels, what was the need for the change of the operational regime if the project Tietê had not yet been completed.

Even if the decision of interruption of pumping is only temporary, until the completion of the Tietê project, there do not seem to be any advantages of transferring pollution from one sub-system (Billings) to the other (Médio Tietê).

During the last four years the Executive Committee has made suggestions concerning the operational regime of the river Tietê and the Billings in such a way that would give temporary solutions somewhat satisfactory to all the entities and communities involved. These suggestions had no effect on the government's decision. In this way the proper

existence of the Executive Committee is questioned since it has no influence on governemnt's actions.

6.8 COMMUNICATION BETWEEN THE ENTITIES INVOLVED

From personal interviews and other documents concerning meetings and declarations of the entities involved in the situation, a lack of an integrated perspective was observed.
This could be justified if it is taken into consideration that each entity would emphasize the importance of its own problems. However, the lack of an integrated approach had negative consequences for decisionmaking process since it was and continues to be a cause of delay for any coordinated action.

6.9 CONCLUSIONS

It is observed that there is lack of sufficient information and understanding of the physical, biological and social impacts of the latest government action, that is the interruption of pumping to the Billings reservoir.

There have been observed:

.The lack of studies of economic analysis taking into consideration environmental costs.

.The lack of government actions aiming at the welfare of all the communities involved in the system Upper Tietê.

.The lack of organization and funding of the cities of Médio Tietê to make their problem known to the public, outside their cities. This leads to an unequal presentation of the problem to the public, which could be a form of pressure to the government to take actions.

.The lack of an integrated approach to the problem, since on one hand the entities involved have a fragmented, personified view of the situation, and on the other, their communication with the government body responsible is almost non-existant.

As Mohan Munasinghe [54] (1991) points out, the identification of sustainable development options requires:

1. Good understanding of the physical, biological and social impacts of environemntal degradation.
2. Precise estimates of the economic value of damage to the environment, to improve the design of policies and projects, and to arrive at environmentally sound decisions;
3. Development of policy tools and strengthening of human resources and institutions to implement viable strategies and manage natural resources on a sustainable basis.

As seen from the environmental and socioeconomic analyses presented in the last two chapters, the pollution of the Billings reservoir and the river Tietê, had been caused by the direct disposal of untreated domestic and industrial organic waste. In order to find solutions of the environemntal and socioeconomic negative impacts caused, it is more than necessary a complete and accurate analysis of those impacts, as well as their internalization to the economic analysis. In this way decisionmaking could be done on an environmentally sound basis and thus limit depletion to the minimum necessary.

To promote communication and cooperation, a Committee with a more active participation in the decisionmaking process should be formulated. It will be constituted by all the entities involved in the system, with regular monthly meetings. The Committe will be the only body which could suggest action plans to the government, which should be examined by the appropriate authorities before approval or diapproval. In this way the representation of the entities involved would be equal, leading to a more balanced decisionmaking process.

CHAPTER 7 : CONCLUSIONS

7.1 INTRODUCTION

The concept of sustainable development has emerged in front of the failures of current development paradigms which had as objective the creation of wealth through inustrialization. Their failure had been attributed in four domains; distribution, employment, self realiance and human costs.

The concept of SD has been accepted by many, a necessary prerequisite for collaboration in both national and international levels. A serious effort for integration of environment and development has been taking place, a very important step for improving today's conditions. There has been a shift from the economic development emphasis on industrialization and export sectors, towards social development sectors such as education and human resource development. The integration of population considerations beyond just numbers, like composition characteristics and distribution have started to enter environment and development plans, both on short term and long term basis.

However, due to the novelty of the concept there exist obstacles in relation with its operationality and clear definitions of development and sustainability as well as of the linkages between the environment and the developmental process.

The studies of the Aral Sea and the Billings aimed to show how the concept is applied in real-life cases and to make suggestions concerning the operationality of the concept. As a first step the linkages between the development process and the environment have been identified.

7.2 COMPARISON BETWEEN THE TWO CASES

7.2.1 LACK OF INTEGRATED APPROACH TO THE PROBLEMS

In the two cases it seems quite clear that there exists a vicious circle between wrong steps in the development process and environemntal degradation showing the importance of an integrated approach of the two provided by the concept of SD.

The lack of this integrated perspective in both cases is reflected from government actions. In the case of the Aral the only interest of the govenment was economic growth through cotton culture expansion. The capacity of the Aral basin to assimilate such a growth pattern was not analysed or not taken into consideration. In the case of the Billings the lack of an integrated perspective has been seen in two levels. First, the entities involved in the Billings problem have taken a personified position without first making an effort to see the entire frame of the problem. Second, the government has not conducted **any** study of the environemntal, economic and social concequences of the Billings situation which takes into account the entities and communities involved. In addition, the actions taken, had acentuated negative consequences in other regions such as the Médio Tietê basin, and the Cubatão community.

7.2.2 THE MEANING OF SUSTAINABILITY

One of the great obstacles related to the operationality of the concept of SD is the meaning of sustainability. As seen in Chapter 2 many authors define sustainability as a dynamic state of optimum use of resources both human and environmental. In these terms sustainability could be understood as an ideal concept. However, including parameters of completely different natures is a difficult and risky process leading to questionable and controversial

conclusions. A functional definition of sustainability was found to be necessary so that the concept of SD become operational.

The differences in spatial and temporal dimensions of the concept can be seen through the two case studies. First the definition of short, mid and long term actions have different durations. This can be seen in the following table:

Table 7.1-Differences of duration of short, mid and long term actions.

ACTIONS	ARAL SEA*	BILLINGS RESERVOIR**
short-term	0-2 years	0-0.5 years
mid-term	2-10 years	0.5-1.5 years
long-term	10-15 years	3-10 years

Source:* Reference no 19

**Deducted by various sources of information about the Billings.

The effectiveness of short , mid and long term actions differs in the studies; In the case of the Aral Sea if the actions were taken there would be gradual progress in the system not only environmental, but economic and social. The range of these measures goes from improvement of living conditions and health of the basin population to changing the strategy of development of economic and productive forces in the region. To achieve sustainability several gradual steps are necessary and a considerable amount of time.

The case of the Billings reservoir is quite different. From what has been seen in Chapters 4, 5 and 6, the pollution to the reservoir is indirect through water pumping from the Tietê river. Therefore there are no other solutions apart from the treatment of the sewage of the city of São Paulo. Short or mid-term solutions do not lead to the sustainability of the system, since

if pumping to the Billings is interrupted the region of the Médio Tietê basin is polluted and if pumping continues the proper reservoir is degraded. In this way the long term solution is the only one sustainable, depending on the duration of the project Tietê as well as on its success.

The next issue concerning sustainability is the predictability of the systems under study. It is supported by some authors that the predictability of the systems is essential to the decisions taken leading to the recovery of these systems. Although high level knowledge of the factors involved in the system are more than necessary, the full knowledge of them is quite impossible and not essential.

The Aral sea is a complex system to be analysed. As seen in the diagnostic report done by UNEP there are numbers concerning salt and water balance of the basin which are estimated with a significant error margin. This implies that further more detailed studies are needed for more accurate results. However due to the obvious catastrophic impacts should implementation of actions should have already be taken.

In the Billings case, predictability of the system is higher than the former case since the system is man-made and less complex . In addition, through the alternation of operations during the last 15 years the impacts have been studied more thoroughly. Although need for more data is essential, actions should have been taken, based on the results already existing from the past experience.

We can conclude that sustainability is an achievable goal within a certain time period . This depends on the degree of knowledge of the system under study and of its proper characteristics. Through studies which integrate environmental degradation with its anthropogenic causes reflected through the development process, it is possible to take

measures which lead to the recovery of the systems. Each system is a separate case of study with sustainability having differing dimensions.

7.2.3 THE DECISION MAKING PROCESS

According to Tatsuro Kunugi [18], "sustainable development can only be achieved through a broad participatory process involving all layers of societies, both in public and private sectors". In the two studies analysed there were not observed any indications of a decision making system similar to that described by T. Kunugi.

In the case of the Aral sea, the only interest of the government was the growth of the economy through the cultivation of cotton. Projects developed by scientists, which one could think that they could have had a positive effect towards the improvement of the conditions of the basin, were financed by the proper ministries in this way serving only their own interests. This led to the misinformation of the population and to actions not beneficial to the both the population and the environment.

In the case of the Billings there has been observed an unequal representation of the environmental groups supporting the interruption of pumping to the Billings and the communities of Médio Tietê; This could be seen clearly from the number of articles in the daily newspapers where the ones describing the position of the envionemntal groups outnumbered the ones describing the problems of Médio Tietê.

7.3 RECOMMENDATIONS

In this thesis it was shown that there are strong relationships between environment and development through the analysis of the Aral Sea and the Billings reservoir. The meaning of sustainability was analysed showing that it is indeed an achievable objective. For the concept of sustainable development become operational there are some essential prerequisites:

1) The integrated perspective of the problems under study. This is achieved through studies which encompass environmental, economic and social factors. In the case of the Aral sea the diagnostic report of UNEP was the first serious effort on this issue aiming to give this perspective. In the case of the Billings reservoir, there was no integrated study which included all the parties involved in the problem.

2) The necessity of the introduction of environmental costs to project evaluation. This implies the quantification of these costs. Several methodologies are being developed today, although they have not implemented in a large scale yet.

3) A reformulation of the institutional basis; in the Aral sea we have seen that only this year there has been a serious effort of the countries involved to resolve the situation, after pressuring of the World Bank. The situation which involves the Billings is still unresolved with the government taking sporadic and unjustified actions. There was a delay in attacking the root of the problem in the first place . Committees or institutions independent of govenments should conduct studies which could have active participation in the decision making process.

The concept of sustainable development is applicable internationally due to its flexibility since in it there are embedded the proper characteristics of each system under study. It integrates environmental and developmental issues in this way it is more adjusted to today's needs than current development paradigms. The paradigm of SD could be operational through formulation of methodologies which integrate environmental and developmental issues. This integration is essential to the decisionmaking process.

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