JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SECRETARIA DE DESENVOLVIMENTO URBANO E
MEIO AMBIENTE DO ESTADO DE SANTA CATARINA (SDM),
FUNDAÇÃO DO MEIO AMBIENTE (FATMA),
THE FEDERATIVE REPUBLIC OF BRAZIL

THE FEASIBILITY STUDY ON RECUPERATION OF MINED-OUT AREAS IN SOUTH REGION OF SANTA CATARINA STATE, THE FEDERATIVE REPUBLIC OF BRAZIL

MAIN REPORT
SUMMARY

MARCH 1998

MITSUBISHI MATERIALS CORPORATION
CHIYODA-DAMES & MOORE CO., LTD.

JAPAN

CURRENCY EQUIVALENT

Currency Unit	=	Real ($R)
US$1.00	=	R$1.08 (October 1997)

Note: The exchange rate used in this report is US$1.00=R$1.00 because it was the rate prevailing when research and groundwork for this report was done in late 1996 and early 1997.

WEIGHTS AND MEASURES

1 meter (m)	=	3.28 feet (ft)
1 kilometer	=	0.6214 mile (mi)
1 square meter (m^2)	=	10.7639 square feet (ft^2)
1 square kilometer (km^2)	=	0.3861 square mile (mi^2)
1 cubic meter (m^3)	=	35.3147 cubic feet (ft^3)
1 hectare (ha)	=	2.4711 acres (ac)
1 liter	=	0.2642 US gallon (gal)
1 metric ton	=	2,205 pounds (lb)

FISCAL YEAR

January 1 to December 31

PREFACE

In response to a request from the Government of the Federative Republic of Brazil, the Government of Japan decided to conduct the Feasibility Study on the Recuperation of Mined-Out Areas in South Region of Santa Catarina State and entrusted the study to the Japan International Cooperation Agency (JICA)

JICA sent a study team, led by Mr. Yasuo Aida of Mitsubishi Materials Corporation and organized by Mitsubishi Materials Corporation and Chiyoda-Dames & Moore Co., Ltd. to Santa Catarina State in the Federative Republic of Brazil eight times from February 1996 to February 1998.

The team held discussions with the officials concerned of the Government of the Federative Republic of Brazil as well as the State Government of Santa Catarina and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the plan and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Federative Republic of Brazil for their close cooperation throughout the Study.

March 1998

Kimio Fujita

Kimio Fujita
President
Japan International Cooperation Agency

March 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita:

Letter of Transmittal

We are pleased to submit to you the Feasibility Study on Recuperation of Mined-Out Areas in South Region of Santa Catarina State. The report includes the comments and suggestions of concerned authorities of the Government of Japan and your agency. Also included are comments made by FATMA during technical discussions on the draft final report held in Florianópolis, Santa Catarina.

The Study was also carried out with a view to formulating a comprehensive program aimed at ensuring that this severe pollution from coal mining and non-compliance with environmental regulations will not occur again in the future. The report consists of two parts: (i) Summary Report; and (ii) Main Text. The main text includes the following:

- ⇨ Section I. Sector Studies;
- ⇨ Section II. Technical Studies;
- ⇨ Section III. Cost-Benefit Study; and
- ⇨ Section IV. Strategy and Program for Recuperating Mined-Out Areas.

Section I analyzes the coal mining sector and formulates a strengthening program for Fundação do Meio Ambiente (FATMA), the state of Santa Catarina's agency in charge of environmental protection. Section II presents a feasibility-level study on remedying the four designated mined-out sites which are representative of the region's pollution problems and outlines an overall remedial plan, including an environmental measurement and monitoring system for the polluted rivers. Section III describes the environmental damages, quantifies the potential remediation benefits and estimates the remedial cost and the economic merits of the remediation program. Section IV proposes remediation strategy and implementation program.

In light of the very high concern of the affected population to recuperate the polluted areas in the region as shown in our Willingness to Pay Study in Section III, we recommend that the Government of Santa Catarina implement the remediation program proposed in the report as soon as possible.

We wish to take this opportunity to express our sincere gratitude to your agency, the Ministry of Foreign Affairs and the Ministry of International Trade and Industry. We also wish to express our deep gratitude to FATMA, Departamento Natcional da Produção Mineral (DNPM) and many other authorities concerned for the close cooperation and assistance extended to us during our study.

Very truly yours,

相田康雄

Yasuo Aida
JICA Team Leader
The Feasibility Study on Recuperation
of Mined-Out Areas in South Region
of Santa Catarina State

ABBREVIATIONS AND ACRONYMS

AMREC	*Associação dos Municipios da Região Carbonífera,* (Association of Municipalities of the Coal Mining Region)
ARD	Acid Rock Drainage
BOD	Biochemical Oxygen Demand
BOM	US Bureau of Mines
CAEEB	*Companhia Auxiliar de Empresas Elétricas Brasileiras,* (Power Company)
CASAN	*Companhia Catarinense de Águas e Saneamento,* (Santa Catarina's Water and Sanitation Company)
CCC	*Conta de Consuma Combustível,* (A System of Purchasing Fossil Fuel for Power Generation)
CCU	*Companhia Carbonífera de Urussanga,* (Urussanga Coal Mining Company)
CE	*Carvão Energético,* (Calorific Value for Steam Coal: kcal/kg)
CEPAN	*Comissão Executiva do plano do Carvão Nacional,* (Executive Commission of the National Coal Plan)
COD	Chemical Oxygen Demand
CONAMA	*Conselho Nacional do Meio Ambiente,* (National Council for the Environment)
CONSEMA	*Conselho do Meio Ambiente,* (Santa Catarina's Council for the Environment)
CEPCAN	*Comissão do Plano do Carvão Nacional,* (Executive Commission of the National Coal Plan)
CPL	*Carvão Pré-lavado,* (Pre-Washed Coal)
CPRM	*Companhia de Pesquisa de Recursos Minerais,* (Company for Research in Mineral Resources)
CSMA	*Conselho Superior do Meio Ambiente,* (Higher Council for the Environment)
CSN	*Companhia Siderúrgica Nacional,* (National Steel Company)
DO	Dissolved Oxygen
GDP	Gross Domestic Product
DNPM	*Departamento Nacional de Produção Mineral,* (National Department for Mineral Production)
EC	Electrical Conductivity
EIA	*Estudo de Impacto Ambiental,* (Environmental Impact Assessment)
EPAGRI	*Empresa de Pesquisa Agropecuaria e Extensao Rural de Santa Catarina,* (Santa Catarina's Agriculture Secretariat)
FATMA	*FUNDAÇÃO DE MEIO AMBIENTE,* (Santa Catarina's Environment Agency)
FCE	*Formulario de Caraterização do Empreendimento,* (Project Identification Form)
FEPEMA	*Fundo de Proteção Especial ao Meio Ambiente,* (Santa Catarina's Special Fund for Environmental Protection)

FUCRI	*Fundação Educacional de Criciúma,* (Criciúma University)
FUNDEMA	*Fundação Municipal do Meio Ambiente,* (Municipality of Joinville's Environment Agency)
GTZ	Deutche Geselschaft für Technische Zusasammenasbeit
IBAMA	*Instituto Brasiliero do Meio Ambiente e dos Recursos Renováveis* (Brazilian Institute for the Environment and Renewable Resources)
IBRD	International Bank for Reconstruction and Development
ICC	*Indústria Carbonifera Catarinense,* (Coal Mining Company)
INPE	*Instituto Nacional de Pesquisas Espacia,* (National Institute for Space Research)
IPH FRGS	*Instituto de Pesquisas Hidráulicos da Universidade Federal do Rio Grande do Sul*
JICA	Japan International Cooperation Agency
LAVACAP	*Lavador de Capivari,* (Capivari Coal Washing Plant)
MINFRA	*Ministétio de Infra-Estrutura,* (Ministry of Infrastructure)
MME	*Ministério de Minas e Energia,* (Ministry of Mines and Energy)
MIS	Management Information System
MPN	Most Probable Number
MWH	Megawatt/hour
NNP	Net Neutralization Potential
NUPESE	*Núcleo de Pesquisas e Estudos Sócio-Econômicos,* (Unit for Socio-Economic Research and Studies)
NUPEA	*Núcleo de Pesquisas Ambientais* (Unit for Environmental Research)
NGO	Non-Governmental Organization
OB	*Orientação Básica,* (Project Description Document)
ORP	Oxygen Reduction Potential
PATS	Passive Anaerobic Treatment Systems
P-M	Particulate Material
PME	*Programa de Mobilização Energética*
RCA	*Relatório de Controle Ambiental,* (Environmental Control Report)
RIMA	*Relarótio de Impacto Ambiental,* (Environmental Impact Assessment Report)
ROM	Run of Mine
SEMA	*Secretária Especial do Meio Ambiente,* (Special Secretary for the Environment)
SDM	*Secretaria de Estado do DesenvolvimentoUrbano e Meio Ambiente,* (Secretary of Urban Development and the Environment)
SIECESC	*Sindicato das Indústrias de Extração de Carvão do Estado de Santa Catarina,* (Santa Catarina's Coal Mining Industry Union)
SISNAMA	*Sistema Nacional do Meio Ambiente,* (National Environmental Protection System)

SNIEC	*Sindicato Nacional das Indústrias de Extração de Carvão,* (National Coal Mining Industry Union)
SRB	Sulfate Reducing Bacteria
SS	Suspended Solids
TDS	Total Dissolved Solids
TVA	Tennessee Valley Authority
UNESC	*Universidade do Extremo Sul Catarinense* (University of Southern Santa Catarina)
UTE	*Usina Termelétrica,* (Coal-Fired Power Plant)

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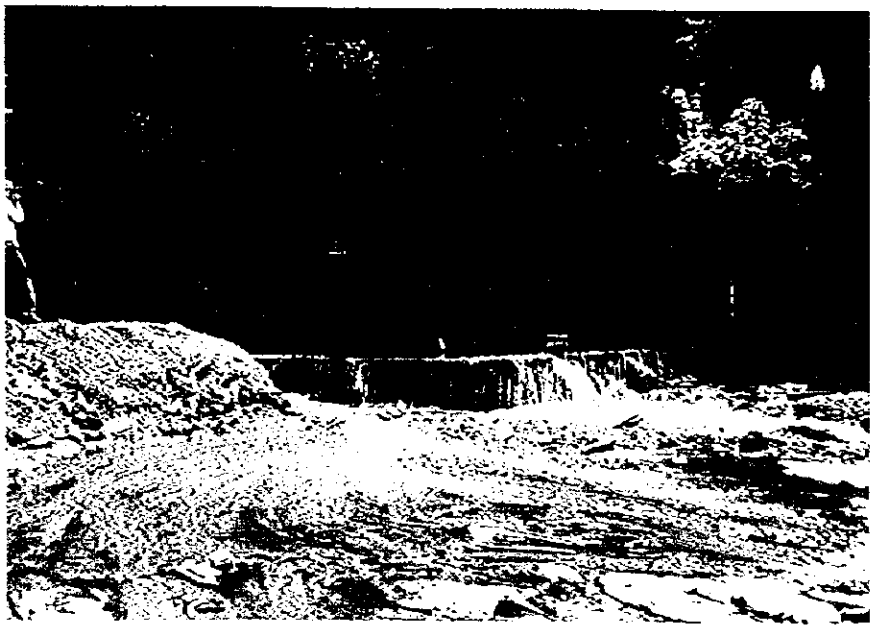
AMÉRICA DO SUL
Localização de SANTA CATARINA
no contexto do MERCOSUL
NICARÁGUA
COSTA RICA
PANAMÁ
TRINIDAD E TOBAGO
VENEZUELA
GUIANA
SURINAME
GUIANA FRANCESA
COLÔMBIA
EQUADOR
PERU
BOLÍVIA
PARAGUAI
ARGENTINA
URUGUAI
BRASIL
AMAZONAS
PARÁ
MARANHÃO
CEARÁ
RIO GRANDE DO NORTE
PARAÍBA
PERNAMBUCO
ALAGOAS
SERGIPE
PIAUÍ
ACRE
RONDÔNIA
TOCANTINS
BAHIA
MATO GROSSO
GOIÁS
MINAS GERAIS
ESPÍRITO SANTO
MATO GROSSO DO SUL
SÃO PAULO
RIO DE JANEIRO
PARANÁ
SANTA CATARINA
RIO GRANDE DO SUL
OCEANO PACÍFICO
OCEANO ATLÂNTICO

Rio Fiorita FS Site

Rio Rocinha FS Site



Rio Carvão FS Site

Capivari FS Site

SUMMARY

OF

FEASIBILITY STUDY ON RECUPERATION OF MINED-OUT AREAS IN SOUTH REGION OF SANTA CATARINA STATE

CHAPTER I. INTRODUCTION

A. BACKGROUND

1.01. Brazil has been mining coal since the late 19th century, originally for railroad fuel, then for power generation from the states of Santa Catarina and Rio Grande do Sul. Together, these two states account for 99% of Brazil's known coal reserves. Although Santa Catarina has less than 10% of the total known reserves, it produced almost as much as its southern neighbor Rio Grande do Sul because the deposits were easier to exploit.

1.02. The quality of the Santa Catarina's coal is relatively poor with a calorific power of between 3700 and 4500 kcal/kg (as compared to 6,400-6,700 for Polish and US coal, respectively). Its coal is also high in ash (between 47% and 58%) and sulfur (1.0%-4.7%) content. Finally, the recovery rate is extremely low, at less than 35%. This means that for every metric ton extracted, only a maximum of 350 kgs of salable coal could be recovered, while the remaining 650 kgs end up as waste.

1.03. Partly because of these characteristics and partly because of vague environmental laws and regulations and weak enforcement until the early 1980s, coal exploitation in Santa Catarina has resulted in an environmental disaster. There was practically no remediation of the mined-out areas, thus making more the 4,700 hectares of good land unusable for any purpose. Compounding the problem is the high level of pyrite contained in the waste which has been leaching through over the years, contaminating most of the southern Santa Catarina region's river basins and groundwater reserves. Many municipalities in the coal mining subregion (*Associação dos Municipios da Região Carbonifera* - AMREC) could not use the water for consumption and had to rely on other water sources in the neighboring municipalities, increasing the cost of living or doing business in the affected area. The pollution of the region's river system also limits the development of agriculture, especially of irrigated rice, prevents its use for recreation or other purposes and gives the region a bad image, constraining the development of its tourism potential. In 1980, the Federal Government decreed the region as the 14th national endangered region, allowing it to obtain special federal assistance to repair the damages done to the environment by past mining activities.

1.04. Following several attempts during the 1980s, in April 1991, the State Government of Santa Catarina set up a working group to prepare a comprehensive program to recuperate the areas polluted by coal mining and to improve the quality of life in southern Santa Catarina. The program called *Programa de Recuperação da Qualidade de Vida da Região Sul de Santa Catarina* (PROVIDA) envisaged a total investment of US$382 million to (i) repair urgent infrastructure (US$94 million); (ii) develop the road network (US$90 million); (iii) improve drainage and sewerage (US$102 million); and (iv) recuperate mined out areas (US$96 million). The program was approved by the Federal Government in 1992.

1.05. However, finding financing to implement the program proved to be more difficult. At the request of the Brazilian Government, from August to October 1993 JICA (Japan International Cooperation Agency) seconded an expert to FATMA (*Fundação do Meio Ambiente*) to advise on ways to implement the PROVIDA program. The expert recommended that a comprehensive feasibility study be done on PROVIDA and in February 1994 Brazil requested JICA's assistance to carry out such a study. From August 1994 to November 1995, JICA sent a number of missions to prepare the terms of reference of the Study and to agree with the Brazilian authorities on the scope of work. Recognizing that it would not be realistic to tackle all the issues under the PROVIDA program, it was agreed with the Brazilian authorities that the Study should address in priority the remediation of mined-out areas.

B. OBJECTIVES

1.06. The objectives of the Study are two fold. First, (i) conduct a feasibility study on remedying a number of target mined-out sites in southern Santa Catarina; (ii) formulate an overall remediation plan and environmental measurements and monitoring system on the surrounding rivers polluted by coal mining and coal preparation activities; and (iii) transfer relevant technologies to Brazilian counterpart personnel in the course of the Study. Second, facilitate the involvement of bilateral or multilateral lending institutions in the financing of the remediation of mined-out areas. With that second objective in mind, it has been deemed necessary to expand the scope of the work to include improvement of coal mining operations and strengthening of environmental protection in Santa Catarina with a view to formulating a comprehensive program aimed at ensuring that this severe pollution from coal mining and non compliance with environmental regulations will not occur again in the future.

CHAPTER II. THE SECTORAL CONTEXT

A. THE ECONOMIC AND ADMINISTRATIVE SETTING

2.01. Southern Santa Catarina borders the Rio Grande do Sul, Brazil's southernmost state and is located at less than 500 kms from Uruguay. Administratively, the region regroups three associations of municipalities established during the 1970s and early 1980s:

- ◊ AMREC (*Associação dos Municipios da Região Carbonifera* - Association of Municipalities of the Coal Mining Region), created in April 1983, is the most densely populated with 335,155 inhabitants (45% of the region's total population) spread over 212,050 ha (less than 22% of the region's area). AMREC has all the coal mines. Its capital is Criciúma;

- ◊ AMUREL (*Associação dos Municipios da Região de Laguna* - Association of Municipalities of the Lagoon Region), created in August 1970, is the oldest and largest with 463,990 ha, or almost 48% of southern Santa Catarina's territory. It has a population of 318,763 in 1996. AMUREL has no coal mines, but it was home to the largest coal washing plant in southern Santa Catarina (Capivari do Baixo) and to coal mining's most important consumer: Eletrosul's thermal electric complex of Jorge Lacerda. During coal mining's hey days in the early 1980s, its sea port in Imbituba was the main point where coal was shipped out of Santa Catarina to other parts of Brazil; and

- ◊ AMESC (*Associação dos Municipios do Extremo Sul Catarinense* - Association of Municipalities of the Far South Santa Catarina) is the smallest with less than 20% of the region's population. AMESC does not engage in any coal mining activity, but suffers from its consequences through the severe pollution of its main river basin Araranguá.

2.02. Together, these three associations comprise 43 municipalities with a total of 750,000 inhabitants (15% of the state's population according to the 1996 census) distributed over a territory of about 9,700 km^2 (10% of the state's total area). A map of Southern Santa Catarina with its 43 municipalities appears as Figure II-1.

2.03. The region is well endowed with mining and other natural resources. The soil is fertile and the population, mostly from European origin (Italians and Germans), is hard working. The education level is high, with about two thirds of the population having some high school education. The literacy rate approaches 100%. Last but not least, income is well distributed. Southern Santa Catarina can be proud to be ranked third in Santa Catarina (and among the top five regions in Brazil) in terms of income distribution.

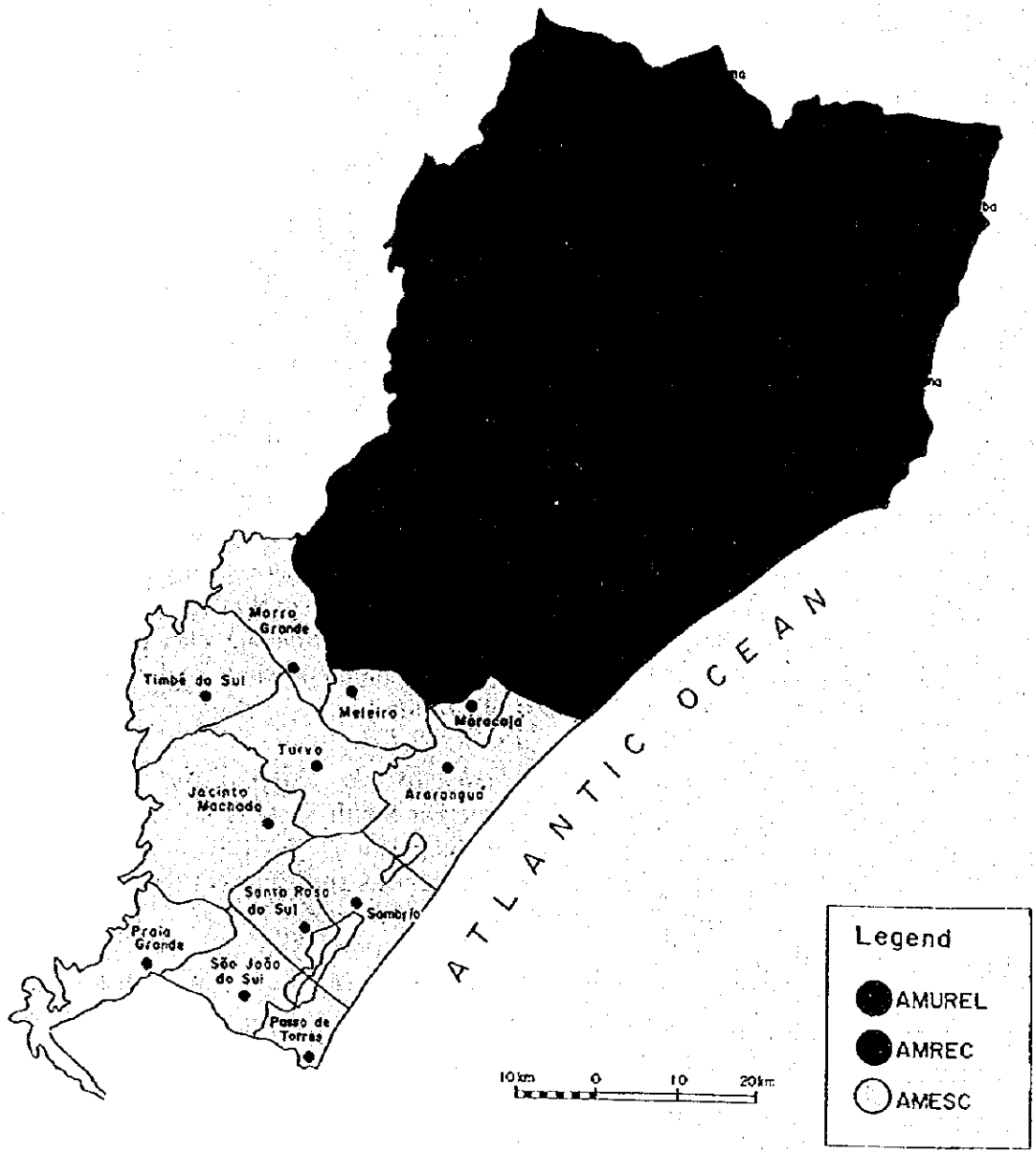


FIGURE II-1 SOUTHERN SANTA CATARINA MAP

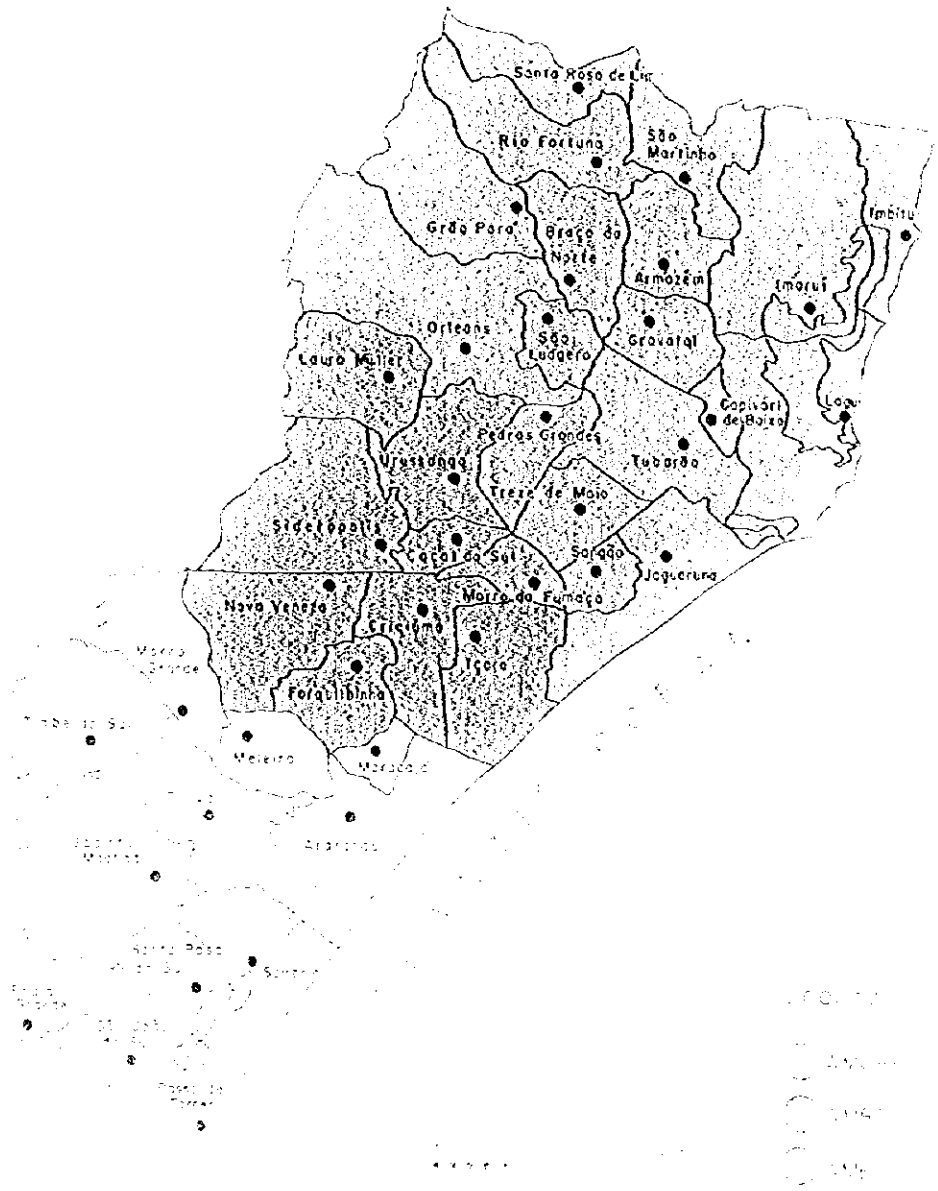


FIGURE II-1 SOUTHERN SANTA CATARINA MAP

2.04. The population, mostly urban (88%), is concentrated in a few relatively large cities. Criciúma, Araranguá and Tubarão, the capitals of the three sub-regions account for more than 42% of the total population. During the 1980s, the region's Figure II-1 Southern Santa Catarina population increased at an annual rage rate of 2.5%, which is about 30% higher than the state's average. AMREC grew the fastest (4.1%), spurred by the expansion of coal mining activities. Since then, population growth has significantly slowed down, averaging 1.2% per year from 1991 to 1996. Again, this was due to the special situation of AMREC whose population stagnated as a result of the crisis hitting the coal sector since 1990. In fact, the population of Lauro Müller, Nova Veneza and Urussanga, three major mining towns, decreased at an average rate of 0.85%, 0.79% and 0.29% per year, respectively.

2.05. The region is reputed for its ceramic tiles and, until the late 1980s, was Brazil's main coal producer, meeting about 75% of the country's coal needs. Other industrial activities include garment manufacturing, plastics, metal working, and furniture making. In the 1980s, industry, including mining, accounted for as much as a third of total value added generated by the region. Since then, its share has decreased to around 20% as a result of the coal mining crisis and difficulties in the ceramic and garment manufacturing sectors.

2.06. Agriculture is important in the region, accounting for as much as 20% of its GDP. The region is a major rice producer and exports agricultural products to other states. It is also well known for cattle raising and pig farming, a profitable but extremely polluting activity. Tourism is still negligible as an economic activity, but there is a large untapped potential, particularly for eco-tourism. Southern Santa Catarina also possesses a rich cultural heritage dating back to the European immigration of the 19th century. Many visit the region as a pilgrimage to learn more about the place where their ancestors lived.

2.07. Despite these assets, southern Santa Catarina is among the poorer regions of the state, with a per-capita income estimated at $3,600/year, as compared to an average of $5,500/year for Santa Catarina as a whole. Economic progress is more expensive than elsewhere because of the high cost of water. As a result of the severe pollution of the main river basins and underground water due to coal exploitation over the last 50 years without regard for the environment, water for human consumption as well as for industrial, agricultural and commercial uses has to be imported.

2.08. The region is also yet to emerge from a deep economic depression brought about by a coal mining crisis when the Federal Government deregulated the sector in 1990, withdrew its price support and subsidies and allowed competition from imported coal and other sources of energy, such as petroleum. From a peak of 5 million tons in 1985, coal production decreased to about 2 million tons in

1994. Many small mining companies were forced to close down and the sector, which employed almost 11,000 workers in the mid-1980s and generated some other 30,000 jobs in related fields, only provided the livelihood for some 3,275 people in 1994. The sector now consists of six companies, some of which are in critical financial condition. A review of the coal sector's past developments and an assessment of its prospects are provided below.

B. SANTA CATARINA'S COAL MINING SECTOR

1. Importance of Coal in Brazil's Energy Supply

2.09. Coal has traditionally played a secondary but crucial role in Brazil's energy equation. Because of the country's immense hydraulic potential and the enormous investments already made to develop it, hydroelectricity will continue to be the main source of power. However, the role of coal is likely to remain important in the foreseeable future for the following reasons:

a) most of Brazil's hydraulic potential is located in the Amazon region, far from the country's major consumption centers of the south and south east;

b) the cost of hydropower projects is high and most of the investment is concentrated in the first years of execution, making it necessary to mobilize large amounts of resources in short periods;

c) the environmental impact of hydroelectric projects, particularly those involving major dam construction, has become more apparent and adds substantially to the investment cost; and

d) finally, the construction period of a hydroelectric complex is very long.

2.10. In Brazil, coal is found mainly in the states of Rio Grande do Sul and Santa Catarina. Together, these two states account for 99% of the 32.3 billion tons of known reserves. During the coal boom period of the late 1980s, production almost reached nine million tons. Although Santa Catarina has less than 10% of the total known reserves, it produced almost as much as its southern neighbor Rio Grande do Sul because the deposits were easier to exploit. Since then, Santa Catarina's production has hovered around 1.9 million tons, or about 40% of Brazil's total coal production.

2.11. Both states produce mainly steam coal with a relatively low calorific power of between 3,700 and 4,500[1] kcal/kg (as compared to 6,400 and 6,700 for Polish and US coal, respectively). Brazilian coal is also high in ash (between 47% and 58%) and sulfur (1.0%-4.7%) content. Finally, extraction

[1] Santa Catarina also produced coke with 17% of ash and 1.7% sulfur, but following the liberalization of the sector in 1991, production ceased because of competition from cheaper imported coke (mostly from China).

conditions are difficult given the location, disposition and shape of the deposits. All these problems make that Brazilian coal is only competitive under relatively favorable conditions of price and demand.

2.12. At present, thermal generation only accounts for 5% of Brazil's power production. However, Eletrobras expects that percentage to increase to 15% by the year 2015, as a result of continued high power demand fueled by the country's strong economic growth. Thermal generation is also expected to continue playing an important role as an alternative source of power, relieving the system during peak periods or during crises.

2.13. The need to maintain a viable thermal power sector is most evidenced by the *Conta de Consuma Combustivel* (CCC), a system whereby public utilities companies make mandatory contributions into an account managed by Eletrobras which uses the funds to help power generation companies purchase fossil combustibles (coal or oil) for their thermal plants. The rationale is to ensure the continued availability of thermal generation in Brazil as an insurance against crises of the hydrosystem.

2. Brazil's Emerging Coal Mining Policy

2.14. Until the wave of market policy reforms with its accompanying deregulation and privatization measures hit Brazil in the early 1990s, the country's coal mining policy was characterized by direct involvement of the Federal Government in all the phases of activity of the sector, from research and exploration to production and commercialization.

2.15. The 1990 Federal Deregulation Program (Decree No. 99.179) established the legal basis for the Government's disengagement and, in 1995, the Ministry of Mines and Energy with the collaboration of representatives of the coal industry, issued the following twelve guiding principles for the formulation of a national coal mining policy:

1. Government should not interfere in coal mining exploration and commercialization;

2. Price subsidies to coal's alternative fuels (such as petroleum) should be avoided;

3. Technology development programs should be introduced to improve open pit and underground mining;

4. Government should support the development of clean technologies for coal burning;

5. Resolution No. 08/90 of December 6, 1990 on licensing of mining activities should be improved but without reducing the environmental protection

requirements;

6. Workers' contracts should be consistent with the requirements of the legislation concerning safety and hygiene on mining work;

7. Implementation of the planned investments in coal-fired thermoelectric plants and the coverage of coal production and sales by the *Conta de Consuma de Combustível* will continue to be conditioned on criteria of optimization of the electric system;

8. Ministry of Mines and Energy (MME) will request that the Ministry of Science and Technology given priority to programs aimed at developing the production, beneficiation and utilization of coal;

9. MME will support requests from the coal industry for financing of, and/or fiscal incentives for, actions aimed at improving its productivity;

10. MME will study the possibility of promoting coal-fired thermal generation in the Mercrosul countries;

11. MME will support the Santa Catarina state's efforts to mobilize external resources for the recuperation of mined-out areas; and

12. MME will consider the inclusion of coal-fired thermal generation in the regulation of the electric sector as well as in the IPP (Independent Power Production) sector.

2.16. The Government disengaged itself from coal production and commercialization as stated, but did not keep its commitment to discontinue subsidizing diesel oil prices, a direct competitor of coal as an industrial fuel, because of the impact of such a measure on inflation. As a result, many coal mining companies are in difficult financial situation[2].

2.17. In October 1997, the Federal Government decided to privatize power generation in Brazil. Although there would certainly be provisions to ensure that the new private owners would use local coal for the next few years, Santa Catarina's coal mining industry would need to improve its efficiency rapidly to survive in the long run. Currently, Brazilian thermoelectric plants rely for about two thirds on domestic coal and will continue to do so, provided that it is competitive with imported coal. This is a challenge that Santa Catarina's coal sector should meet.

[2] In 1995, for example, they sold coal CE-4500 to Eletrosul at R$39.8/ton and coal for industrial use, such as CE-5200 and CE-5400 at about R$30/ton, while, according to a study carried out by the *Fundação Getúlio Vargas*, the average production cost of SIECESC's members was R$37.3. Including taxes and normal profit margin, they should have sold their coal at R$46.5 to remain profitable.

a challenge that Santa Catarina's coal sector should meet.

3. *Importance of Coal in Santa Catarina's Economy*

2.18. Coal mining has played a dominant role in the economy of southern Santa Catarina, particularly in the 1970s when it represented up to 30% of the region's GDP. During the 1980s, the economy became more diversified with emerging industries such as ceramics, garment manufacturing, plastics and furniture making accounting for an increasing share of the region's production. However, coal mining remains important because of its indirect effects on the rest of the economy. Using national accounts input-output tables, a study by the Fundação Getúlio Vargas (*O Carão Nacional na Industriá Brasileira*) estimated that coal mining has a multiplier effect of 3.49 on the economy of southern Santa Catarina, i.e., the total impact of coal mining on the economy is 3.49 times its direct impact. Applying this coefficient to GDP figures shows that coal mining represented between 28.7% and 33.3% of southern Santa Catarina's economy in the 1980s. Even in the depressed years of the early 1990s, the sector still contributed between 20.4% to 25.6% to the region's GDP. Recent research by FUCRI (*Fundação Educational de Criciúma*) indicated that in Lauro Müller and Siderópolis, two municipalities in the coal mining area (AMREC) which have not succeeded in diversifying their economy, coal mining still accounts for 85% and 73% of industrial production, while in the rest of AMREC, it averages 10%

2.19. In terms of employment, in its prosperous days, coal mining employed nearly 11,000 workers and provided the main livelihood for more than 66,000 people. Its total impact is even larger, however, if account is taken of related activities, such as transportation (both rail and road), shipping, handling and, commercialization and other services. Assuming that these activities are at least as labor intensive as mining (which is a safe assumption), the total employment impact of coal mining could be estimated at 38,000 jobs which supported more than 220,000 people.

4. *Prospects*

2.20. Coal prospects as an viable source of energy -- particularly for thermal generation -- depends, to a large extent, on the resolution of environmental problems associated with its use. While the environmental problems resulting from the extraction and washing of coal can be easily remedied through the application of relatively simple technologies, the control of P-M (particulate materials), SO_x and NO_x emissions in the production of energy requires the use of more advanced technologies recently developed in Europe and the US where coal accounts for more than 50% of the fuel used in electricity production. Japan is also using such technologies.

2.21. At present, available technologies include those (i) allowing coal burning in the pre- or post-combustion phases; (ii) affecting the coal combustion process itself; and (iii) transforming coal into a liquid or gasified fuel.

2.22. In the pre-combustion phase, the technology aims at eliminating impurities, such as pyrite contained in the mineral, thus preventing the emissions of polluting gases during the burning process. Technologies that act directly on the combustion process itself are used more both in conventional and advanced processes. The main ones are described below:

(i) Thermoelectric Plants with Pulverized Coal Burner

1. Conventional combustion with low emission of NO_x using ROM (Run of Mine) coal;
2. Conventional combustion with pre-combustion coal desulfurization and low emission of No_x
3. Conventional combustion of ROM coal with low No_x emission and desulfurization of combustion gases.

(ii) Thermoelectric Plants with Atmospheric Fluidized Bed Combustion

(iii) Thermoelectric Plants with Topping Cycle

1. Fluidized combustion at high pressure
2. Gasification and fluidized combustion in topping cycle

2.23. Among processes considered the cleanest and most popular is the fluidized bed combustion system. It is also the most suitable to Brazilian coal. The process works as follows: through adequate temperature, the coal is maintained in suspension in the furnace by air injection through an appropriate distributor located at the bottom of the burner. The desulfurization operation is done in a simple way through a reaction in the bed, producing sulfite of calcium which is extracted together with ashes.

2.24. The fluidized bed functions at controlled temperatures below the fusion point of ashes (about 850°), thus avoiding the formation and deposit of slags close to the inside parts of the burner, guaranteeing a perfect burning of the fuel. Given its low temperature, it reduces No_x emissions. The wide application of this new technology for thermal generation is due to its aptitude to burn cleanly bad quality fuels, i.e., those with high humidity, ash and sulfur content. There are plants currently using this process effectively and staying within established emissions limits. Table II-1 below compares the generation costs of a thermal unit of 125 MW, using four different processes.

TABLE II-1

GENERATION COST OF A THERMAL UNIT OF 125 MW

Generation Process	CE 1800 Waste	CE 3300 Candiota	CE 3300 Bonito	CE 3700 B. Jacui	CE 6500 Colômbia
	Generation Cost ($ Thousand/kw)				
Pulverized Coal	—	46.7	51.6	55.1	56.9
Pulverized Coal with Desulfurization	—	58.6	63.6	67.2	69.1
Topping Cycle with Gasification	—	—	—	69.8	71.4
Atmospheric Fluidized Bed	46.6	53.8	58.8	62.4	64.2

Source: Eletrobras
NB: CE = Carvão Energético (kcal/kg)

2.25. In Santa Catarina, the coal most suitable for fluidized bed combustion is that of the Bonito seam (CE-3300 or CE-2800). The pulverized coal process is cheaper but is considered inadequate because it results in high emissions of large PM after combustion. The adoption of the fluidized bed combustion technology constitutes a breakthrough with regard to the compatibility between the economics of thermal generation and the requirements of air pollution control.

(b) Brazil's Mineral Reserves Potential

2.26. According to MINFRA (*Ministerio de Infraestrutura*) 1990 National Energy Survey, coal accounts for two thirds of Brazil's non-renewable resources. In energy terms, this is equivalent to ten times identified petroleum reserves, three times that of nuclear energy and ten times that of bituminous schist and makes coal credible as a reliable source for electric energy generation. Eletrobrás' 2015 Plan seriously consider this scenario and recommends more research, studies and investments in thermoelectric plants to make a smooth transition from a predominantly hydroelectric program to a hydro-thermal system in the future.

2.27. Table II-2 below taken from Eletrobras' 2015 Plan shows the thermoelectric potential of Brazil, while Table II-3 projects the installation of 14 additional thermoelectric units of 125 MW each in Santa Catarina based on the likely exploitation of the Bonito seam (CE-4500 for the existing plant and ROM-2800 for the new units using AFBC (Atmospheric Fluidized Bed Combustion) process. It is therefore estimated that Santa Catarina will generate 2,582 MW by 2015 and would use 14.7 million tons of coal/year, which is equivalent to 7.3 times the current annual production.

TABLE II-2

COAL-FIRED THERMOELECTRIC POTENTIAL IN BRAZIL
(IN MW)

	Existing	Planned	Potential		
			Measured/Indicated	Inferred	Total Potential
R.G.Sul	538	700	27,200	29,500	56,700
S.C	482	350	1,750	450	2,200
Paraná	20	—	260	—	260
TOTAL	1,040	1,050	29,210	29,950	59,160

TABLE II-3

PLANNED THERMOELECTRICITY EXPANSION IN SANTA CATARINA
(Coal: Thousand tons)

	1996	2000	2005	2010	2015
Jorge Lacerda					
- MW/h	482	832	832	832	832
- CE-4500	1,320	2,900	2,900	2,900	2,900
NEW TEU*					
- MW/h	—	(2) 250	(3) 375	(3) 375	(6) 750
- ROM-2800	—	1,686	2,530	2,530	5,060
TOTAL					
- W M/h	482	1,082	1,457	1,832	2,582
- Coal	1,320	4,586	7,116	9,646	14,706

Source: Eletrobras - Year 2015 Plan and SIECESC (*Sindicato da Industria da Extração de Varvão do Estado de Santa Catarina*)
* Thermoelectric Unit (using Atmospheric Fluidized bed Combustion)

5. *Technical Characteristics of Mining Operations*

2.28. Both surface and underground mining are used in Santa Catarina. Until the early 1980s, surface mining predominated, but now only accounts for 15% of the coal produced as most of the areas available for open cast mining have been mined out. This type of mining was done in flat areas in the vicinity of rivers where the overburden rarely exceeded 30 m in height. At the beginning, overburden was entirely extracted by shovels after blasting. Then, the dragline method was introduced. All waste materials were dumped on the spot. The method used was strip mining without any reclamation and was responsible for the destruction of thousands of hectares of fertile land. Open cast mining is now practically done by only one company (Treviso).

2.29. Underground mining takes place in the eastern part of the Paraná basin which is formed by gondwanic sequence. The coal field is approximately 60 kms long and 20 kms wide. The geological structure is relatively simple on the south side, but more intricate on the northeast part of the coal basin.

Given the structure of the deposits, heavy mechanization is not always feasible.

(a) Mining and Extraction Methods

2.30. The mining method generally used is "rooms and pillars without pillar extraction." The extraction methods adopted are "conventional equipment" (full mechanization) and semi-mechanization with bobcats. Five out of the six mines in operation use bobcats and the last one uses conventional equipment. The Fontanella mine owned by Metropolitana will start production with LHD (Loading, Hauling and Dumping) instead of using loaders and shuttle cars.

2.31. The conventional equipment appears to be a more productive and economical method and is well adapted to the extraction conditions existing in the Barro Branco seam. However, it requires good organization and technical expertise in the company because it involves a more complex production process.

2.32. The semi-mechanized method with bobcats contributed to a productivity improvement in mines which were so far operating manually. However, this is only a first step toward a full mechanization of mining operations, which was not achieved in many companies due to the lack of investment funds and the difficulty of mastering the problems related to the mechanization method.

2.33. The productivity obtained in mechanized mines reach 250 tons per hour worked, against 120 t/h in semi-mechanized ones. In 1986, labor productivity was 6.2 to 9.9 tons of ROM coal per man-shift in mechanized mines and 2.6 to 7.1 tons of ROM coal per man-shift in semi-mechanized ones.

(b) Drainage and Effluent Disposal

2.34. All active mines today, with the exception of CBCA's (*Companhia Brasilera Carbonifera de Araranguá*) No. 3 mine, which started production in 1990, have experienced land subsidence because of pillar extraction. Through these collapsed areas, large amounts of water get in the underground, polluting aquifers. The quantity of water drained by the mines varies significantly from mine to mine, depending on the size of the area already mined and the extent of the pillar extraction in each mine. It ranges from 2,000 m^3/day to 9,400[3].

2.35. Part of the drained water is used in coal washing, part of it in dust suppression, and the rest (a large part) is pumped from the mining face to local pump stations (often located within the underground working area itself) and from there collectively to the main pump station and, finally, to the ground.

[3] The Nova Próspera mine reaches 15,000 m^3/day.

2.36. The quality of the drained water is monitored on a monthly basis by the companies as stipulated in the Environmental Operating Permits (*Licenças Ambientais de Operação*) delivered by FATMA. The table 4 below shows the range of values obtained directly from the companies:

TABLE II-4

MINE WATER: ENVIRONMENTAL STANDARDS AND ACTUAL SITUATION

	Values Observed			Standards
pH	2.44	to	5.52	6.0 to 9.0
Solid waste (mg/l)	1925	to	1965	- a/
Acid (mg/l $CaCO_3$)	102	to	905	-
Sulfate (mg/l)	1056	to	1126	1.0
Fe (mg/l)	36.87	to	89.82	15.0
Mn (mg/l)	5.11	to	5.83	1.0 b/
Cu (mg/l)	0.059	to	0.19	0.5
Zn (mg/l)	0.00	to	2.85	1.0
Pb (mg/l)	0.00	to	0.00	0.5

a/ Sedimentable solid up to 1.0 ml/l in assay of one hour using the "Imhoff cone" method
b/ Mn^{+2} soluble

(c) Coal Washing

2.37. For a long time, coal washing was considered a secondary activity in the extraction process. Coal production was concentrated on CPL (*carvão pre-lavado* - pre-washed coal), which was sent to the preparation plant at Capivari for washing and separation between metallurgical coal and steam coal. Coal fines recuperation only started in 1973. For more than 50 years, this product was discharged improperly polluting most of the region's river system.

2.38. At present, washing is a major activity since the loss of this product in the production process reduces profitability. Many enterprises specialize in only washing old coal waste generated by mining companies. They get enough coal out of the waste to make it a profitable activity.

2.39. The washing technique used in Santa Catarina is gravimetric separation by jigs. The region has small washers with a capacity of 100 to 200 t/h made of wood, which are copies of the original McNally, as well as larger ones (500 to 600 t/h) made with steel and supplied by KOPEX, a Polish manufacturing company. These plants are all Baüm jigs. There is also a Batac jig of German technology supplied by Humdbolt -Wedag with a capacity of 500 t/h operating in the CBCA mine.

(d) Products and Recovery Rates

2.40. Following the abolition of the requirement for the Brazilian steel industry to use local coal,

mining companies switched to the production of the CE 4500 coal with 42% ash for use by the Jorge Lacerda thermoelectric power plant in Capivari de Baixo. This represents the main product of the region's mines. Other products include coal with ash content between 32% and 35% (CE 5200) which are sold to the cement, ceramic and food industries.

TABLE II-5

RECOVERY RATES AND ASH CONTENT

	t/h	Recovery (%)	Ash Content (%)
Coarse Coal			
Feed	3500	100.0	64
Waste R1	1166	33.3	81
Waste R2	808	23.1	81
Fines	424	12.1	58
CE 4500	1102	31.5	42
Fine Coal			
Feed	424	12.1	58
Waste	126	3.6	--
Mixes	56	1.6	45
Recirculated	161	4.6	--
Products	81	2.3	--

6. *Environmental Aspects of Coal Mining Operations*

(a) Solid Waste Disposal

2.41. Mining companies dispose of solid wastes by stacking them in piles and dumping them in mined out areas, or in flat areas near washing plants. The regulation and control of waste dump areas as well as the methods of disposal, reclamation and revegetation have been defined in 1984 by ZETA and International Engineering SA, two consulting firms contracted by the mining companies. The work was done to comply with SEMA' s regulations (*Secretária Especial do Meio Ambiente*) concerning disposal of solid waste and treatment of effluents.

2.42. However, implementation of the recommendations was inadequate. Some important measures were dropped, such as: (i) the obligation to treat the water leaching through the waste piles (deep drainage); (ii) the use of clay for impermeabilization; and (iii) the requirement to compact layers of waste with compactors. The regulation with regard to surface drainage was significantly simplified. On the other hand, the placement of waste in piles and the requirement to bench it every 10 m high were respected. In some cases, waste with clay recuperated from decantation ponds is used to make waterproof between lifts of waste, in substitution for clay. Compactation of waste piles is only done to facilitate the traffic of trucks which transport materials for the dump area. The slope angle of the waste

piles is not defined. Some companies shape the slope at less than 24° by bulldozers. Others leave it at the natural disposition angle (about 40°). The disposal method is called "*ponta de aterro*".

2.43. The final treatment consists of recovering taluses with clay. In some places, grass is planted; in others, taluses are simply covered with top soil containing roots and seeds, providing for spontaneous revegetation. Some companies plant eucalyptus trees on the taluses to reduce erosion. However, DNPM (*Departamento Nacional da Produção Mineral*) is now advising companies not to plant eucalyptus as their deep root systems tend to destroy impermeable clay layers. Steps or channels in concrete or made with sand are built to allow evacuation of rain water to the main drainage system.

2.44. In principle, inspection of waste disposal is the responsibility of the engineer of the washing plant with the assistance of the company's environmental staff. However, no environmental specialists have ever been employed in any of the mining companies. Control is rare and only focuses on drainage aspects. There is practically no control or monitoring of the structure or stability of the waste piles.

(b) Effluent Disposal

2.45. Water from coal washing and storage, waste piles (generated by rain), as well as underground mining activities is sent to the decantation pond near the preparation plant. The various uses in the mine (washing activities, dust suppression during drilling, etc.) could not absorb all that water and the excess, which varies from company to company and ranges from 40 to more than 600 m^3/h, is discharged mostly untreated, contributing to the severe pollution of the region's rivers, particularly the Urussanga and Araranguá river basins.

2.46. The quality of the wastewater discharged into the ground and river system is monitored regularly by the mining companies as stipulated in the Environmental Operating Permit.

TABLE II-6

WASHING PLANT EFFLUENT DISCHARGE: ENVIRONMENTAL STANDARDS AND ACTUAL SITUATION

	Observed Values	Standards
pH	2.940 - 3.390	6.0 - 9.0
Solid Waste (mg/l)	3.457 - 4.895	-*
Acid (mg/l $CaCO_3$)	452.2 - 1.470	-
Sulfate (mg/l)	2.159 - 3.044	1.0
Fe (mg/l)	108.1 - 311.6	15.0
Mn (mg/l)	11.16 - 16.86	1.0**
Cu (mg/l)	0.054 - 0.120	0.5
Pb (mg/l)	0.000 - 3.429	0.5
Zn (mg/l)	0.000 - 9.220	1.0

*Sedimentable solid up to 1.0 ml/l in assay of one hour using the Imhoff cone method.
**Mn^{+2} soluble.

2.47. The wastewater from the washing plants is channeled to the decantation pond for fine coal recuperation. Solid wastes in the water are settled before the water is discharged into the river system. In some cases, the decantation ponds function as filters where the water permeates leaving only the solid waste in the ponds. Some companies dispose of the solid materials remaining in the decantation ponds by dragging them together with coarse waste. Others cover the materials in the ponds with clay for revegetation and build new ponds for use. However, given the difficulty to find space for waste disposal, companies now tend to drag existing decantation ponds.

7. *Economic Aspects of Mining Operations*

2.48. Given its geological characteristics (especially the high ash content), Santa Catarina's coal must be consumed near the mines. The sulfur content of the ROM coal has a maximum value of 4.5% in the Barro Branco seam and 6.0% in the Bonito seam. Submitted to washing the ash content is reduced from 62% to between 35% and 42%, while total sulfur content decreased from 4.5% to between 1.8% and 2.5%. With these characteristics, the region's coal is mainly used in power plants and in the cellulose, food and petrochemical industries. Secondary uses include gasification in the ceramics industry and as an energy source in cement plants.

(a) Principal Consumers

2.49. The region's coal is mainly used for power generation at Eletrosul's Jorge Lacerda thermoelectric complex located in Capivari de Baixo. The plant has an installed capacity of 482 MW and consumes about 1,320,000 tons of CE 4500 per year. This represents about 65% of coal sales in 1995. Indeed, thermoelectric generation represents a viable alternative for the sustainable development of the coal sector. Prospects for the growth of steam coal consumption are good with the start-up operation in early 1997 of Jorge Lacerda IV, a power generation plant with a capacity of 350 MW, which may consume up to 125,000 tons of CE 4500 per month. Another possibility is a stronger energy demand, which will gradually increase capacity utilization at existing power plants, currently operating at 40%. At 80% capacity utilization, coal consumption would increase from the present 120,000 tons per month to more than 170,000 tons per month.

2.50. Coal's other uses have tended to diminish over the past few years. The cement industry, which consumed 45% of the coal production in 1991, only accounted for 19% in 1995. The ceramics and food industries maintained their shares of around 3.7-3.8%, but the coke industry reduced its consumption of Santa Catarina's coal from 7.1% in 1991 to about 1.3% in 1995 as a result of stronger competition from imported coke, mainly from China. Total coal consumption, which reached 2.7 million tons in 1991, decreased to about 2.0 million per year since 1992.

(b) Environmental Aspects of Thermal Generation

2.51. As a result of its high ash content, low calorific value, high sulfur content, and above all, its low beneficiation efficiency, the region's coal faces major difficulties to compete with other available sources of energy. High ash and sulfur content present major problems. Besides increasing transportation costs, ash generates problems in terms of dust emissions and waste disposal. Sulfur, for its part, constitutes an important limiting factor due to more and more restrictive emissions regulations from environmental authorities. Finally, the low beneficiation rate (about 30% at the Barro Branco seam) makes productivity improvements at mine level a sine qua none condition for the economic and financial viability of the sector. At present, the mining sector is operating at an average capacity utilization rate of 50%-60%. An increase in that rate to 80%-90% would result in a cost reduction of between 15% to 25%.

2.52. The Bonito seam has a higher beneficiation rate (about 50%) and presents therefore better prospects. However, the factors influencing extraction, including geological characteristics are still insufficiently known and need to be further studied.

2.53. Another bright prospect for Santa Catarina's coal is the possibility of using the coal without washing in fluidized bed combustion technology. This is being studied by Metropolitana, CELESC (*Centrais Eletricas de Santa Catarina*), and the municipality.

2.54. In conclusion, the viability of the coal mining sector in Santa Catarina depends on the following factors:

- ◊ Productivity improvement at the mine and reduction of administrative costs;
- ◊ Economies of scale through higher capacity utilization;
- ◊ Consumption of high ash content coal near the mine;
- ◊ Development of clean burning technology of high ash and sulfur content coal, such as the fluodized bed combustion method;
- ◊ Higher beneficiation rate through development of the Bonito seam;
- ◊ Improvement of the sector investment capacity; and
- ◊ Adaptation of production and utilization processes to environmental and health requirements.

8. Conclusions and Recommendations

2.55. Prospects for coal mining are relatively good. As a result of continued strong economic growth in Brazil, energy demand is expected to remain high. Eletrosul has expanded its thermal electric complex at Jorge Lacerda by adding a forth unit, while its 20-year Development Plan (1995-2015) foresees the construction in Santa Catarina of 14 new units with a total installed capacity of 1750

MW during 2000-2015. As a result, coal demand is expected to increase eleven-fold from 1.3 million tons in 1996 to 14.7 million in 2015. World Bank projections also foresee a strengthening of coal prices, which are expected to reach US$49/ton (US coal) in 2005, up from their present low level of US$36.9/ton.

2.56. Given the favorable price trends and some restructuring[4], continued coal mining in Santa Catarina could be an economically viable proposition. Under certain conditions, the sector would be able to compete with import and meet Eletrosul's demand for coal. However, without a marked improvement of mining and environmental regulations and a substantial strengthening of public agencies responsible for monitoring mining activity and enforcement of environmental protection, this expected increase in mining activity is likely to result in an environmental disaster. The region is already classified as a national endangered area by a 1980 Federal Decree, which allows it to obtain special Government assistance to repair the damages done to the environment from past mining exploitation.

2.57. In order to permit the sector to meet Brazil's demand for steam coal, while protecting the environment, it is recommended that the Brazilian authorities act on the following fronts simultaneously:

(I) Improving the Policy Framework

2.58. Brazil's coal mining policy as formulated by a commission composed of representatives of the Ministry of Mining and Energy (MME), DNPM, Eletrobras and coal mining companies, including SNIEC (*Sindicato Nacional da Industria de Exploitação do Carvão) and* SIECESC, clearly defines the roles of the private sector and the Government in the sector. Coal exploration, production and commercialization should be entirely left to the initiative of the private sector without interference (or subsidies) from the Government. The public sector should limit its role in the sector to promoting efficient and cleaner production technologies, ensuring workers' safety and protecting the environment. These principles are sound and should lead to an efficient exploitation of Brazil's coal mining resources.

2.59. As part of its commitment, the Government disengaged itself from coal production and marketing. It abolished CAEEB (*Companhia Auxiliar de Empresas Elétricas Brasilieras*), which was responsible for the commercialization of all the coal produced in Brazil, leaving prices to be freely set between mining companies and coal users. It abolished CSN (*Companhia Siderúrgica Nacional)* and privatized its subsidiary Carbonifera Prospera, signaling the public sector's total withdrawal from coal production.

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[4] Average production cost of Santa Catarina's coal mining companies is high as a result of the large number of companies in the sector, which prevents economies of scale. There appears to be inefficiencies in individual companies, as well. Some restructuring is bound to occur as less efficient companies are squeezed by tight prices and competition.

2.60. However, the Government continued to subsidy diesel oil prices, a direct competitor of coal as an industrial fuel, because of its impact on inflation. This measure tends to depress coal prices and many mining companies have difficulty in competing and are incurring losses. Some have stopped operating. While removing fuel price subsidies may negatively affect the viability of certain activities, it is recommended that the Government undertake a comprehensive study on the topic with a view to improving long-term energy pricing in Brazil.

(2) Improving the Legal Framework

2.61. Mining (both research and exploitation) is regulated by the Federal Government. The basic legislation is the 1967 Mining Code which covers all mining activities. There is no specific legislation for coal mining, despite its special characteristics and environmental impact. Given the expected substantial expansion of coal mining production in the coming years, it would seem advisable to introduce specific legislation to better regulate this activity.

(3) Improving Health and Safety Norms

2.62. Working conditions in Santa Catarina's underground mines are unhealthy and unsafe. Noise, temperature and dust levels often exceed maximum acceptable limits. Most companies do not possess equipment and safety procedures considered mandatory in other countries, such as rescue teams, self rescuer for carbon monoxide, self-contained breathing apparatus for rescue teams, explosion proof electric equipment, etc.

2.63. Existing laws are also flawed with inconsistencies, being extremely restrictive in some areas and completely lax in others. For example, the velocity of air flow is defined, but not the minimum supply of fresh air; or the limitation of SiO_2 dust content in air for inhalation is stipulated, but there is no description of dust explosivity or inflammability. There is an urgent need to strengthen existing legislation to protect the health and safety of coal mining workers, while improving the attractiveness of this activity.

(4) Improving Environmental Regulation

2.64. Existing environmental laws, both at the federal and state levels, are basically sound. They spell out in some detail the environmental obligations of the mining companies, as well as the procedures for EIAs and public consultation and participation, which are adequate. However, regulations are generally lacking to implement the laws, particularly with regard to land reclamation and reject disposal.

2.65. In 1984, to comply with SEMA's directives, Santa Catarina's mining companies contracted

two consulting firms to help define the regulation and control of waste dumps, as well as the methods of disposal, reclamation and re-vegetation. However, very little was put in practice, least translated into regulations. Some of the more important measures which were not implemented include: (i) the obligation to treat the water leaching through the waste piles; (ii) the use of clay for impermeabilization; and (iii) the requirement to compact layers of waste with compactors. These should now be revived and, if necessary, updated with a view to translating them into regulations.

2.66. Regulations concerning effluent discharge are generally adequate but not complied with by mining companies. They argue that the surrounding environment is so polluted with pH levels in the river bodies as low as 2-3 that there is no need to neutralize mining water before discharge as required by law. This emphasized the need to repair the mistakes of the past without which there would not be any substantial progress in environmental improvement of coal mining activity.

(5) Strengthening the Regulatory and Enforcement Agencies

2.67. Being an activity regulated by the Federal Government, coal mining falls under the supervision of both DNPM (technical aspects) and FATMA (environmental aspects). Both agencies have competent and dedicated staff, but they are overworked and underpaid. DNPM maintains a strong presence in Santa Catarina with a staff of 32, of whom 18 are university graduates. However, most of them are in the capital, Florianópolis. Its southern region's office located in Criciúma (where all the coal mines are) has only four professionals (two Geologists and two assistants) seconded by CRPM. to do the inspection and monitoring of coal mining companies. The situation is similar for FATMA which has a staff of 212 but only 17 in the southern region (Criciúma and Tubarão). Strengthening of DNPM and FATMA's regional offices is a *sine qua none* condition for progress in environmental protection in southern Santa Catarina. A technical and financial program aimed at strengthening FATMA has been prepared for discussion with, and approval by, the Brazilian authorities. It is recommended that a similar effort be done for DNPM.

2.68. Another important issue which needs to be resolved is a clear understanding and delineation of responsibilities between the two agencies with regard to monitoring of coal mining activity. Legally, both agencies are responsible, but in practice DNPM does most of the work on an *ad hoc* basis and puts the emphasis on the technical and mining aspects rather than on environmental considerations. The two agencies should agree on a periodic program for monitoring coal mining companies with clear division of work so that environmental issues are not neglected. Another alternative would be for FATMA to delegate responsibility for environmental monitoring of mining companies to DNPM so that the latter is totally in charge of all the monitoring work, including environmental aspects. This solution makes sense from a technical point of view. It also avoids duplication of work which would inevitably arise

when two agencies inspect a same company with different objectives. Finally, it releases FATMA's overworked staff from a technical task for which they may not be well prepared. FATMA will retain all its prerogatives with regard to EIAs and environmental licensing of mining companies.

(6) Improving the Mining Companies' Operation

2.69. In parallel to strengthening the regulatory and environmental enforcement agencies, there is a need to improve the capacity of mining companies to conduct their operations in an efficient and environmentally sound way. The review of mining operations in this chapter shows that all the companies operate with valid environmental licenses but are generally not complying with environmental regulations. Some companies try to reduce the environmental impact of their operations by restricting truck traffic at night, watering roads to reduce dust formation, and covering trucks to prevent spilling. However, they do not generally dispose of rejects properly and their discharged effluent has pH values two to three times lower than the norms (2.9-3.4 compared to the norms of 6.0-9.0) and heavy metal content often exceeding FATMA standards by more than ten times.

2.70. In neighboring state Rio Grande do Sul where environmental norms and standards are similar to those in Santa Catarina, mining companies have no difficulty to comply. Some are doing a wonderful job reclaiming the land disturbed by open pit mining, returning the areas to their original pre-mining state. Effluent standards are generally met. Some companies even neutralize wastewater for reuse in the mine or in the washing station, discharging very little into the ground and river bodies.

2.71. There is no reason why Santa Catarina's mining companies could not comply with environmental regulations. Most companies have the technical capability to do so. They are not doing it partly because the surrounding environment is already polluted and it is not in their corporate culture to do it, partly because they are not under pressure to do it, and partly because this involves extra work and adds to the production cost.

2.72. It will take time to change this situation, particularly given the tight financial situation which most companies are in. Since the number of companies in the sector is relatively small[5], it is recommended that Santa Catarina's authorities develop specific programs adapted to the needs of the individual companies and negotiate with each of them a plan to bring them to compliance over a given period of time. If needed, technical and financial assistance from the state would be available to help the mining companies carry out the improvement program for which they have signed off.

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[5] There are at present six operating companies

C. *COAL MINING'S INSTITUTIONAL AND LEGAL FRAMEWORK*

2.73. Coal mining falls under the Ministry of Mines and Energy, which is responsible for: (i) geology and mineral resources; (ii) hydraulic regime and sources of hydraulic energy; (iii) petroleum industry, electricity and nuclear energy; and (iv) mining and steel industry. The Ministry mainly relies on DNPM to carry out these tasks.

1. Departamento Nacional da Produção Mineral - DNPM

2.74. DNPM is located in MME and is directly responsible for all types of mining in Brazil. It functions as an autonomous agency (Law No. 8.876 of May 2, 1994) and is responsible for (i) promoting the planning and development of the exploration and exploitation of mineral resources: (ii) supervising geological research and monitoring mining operation in all the national territory according to the Mining Code, Mineral Water Code and related regulation and legislation; and (iii) ensuring compliance with the mining code and related legislation and regulations.

2.75. In particular, the Department is responsible for:

⇒ Granting licenses for the exploration and exploitation of mineral resources;
⇒ Analyzing developments of the Brazilian (and international) mining sector and maintaining statistical data and information on the production and trade of mining products;
⇒ Monitoring the research, extraction, washing, and commercialization of mineral products. DNPM can impose sanctions and penalties for non-conformity to the dispositions of the mining legislation;
⇒ Enforcing compliance with environmental regulations, as well as hygienic and safety norms, together with public organisms responsible for these matters;
⇒ Supporting the development of small-scale mining enterprises;
⇒ Establishing areas and defining conditions for the constitution of individual or small mining companies; and
⇒ Issuing supplementary norms and, together with responsible organisms, enforcing compliance with environmental, safety and hygienic regulations.

2.76. DNPM has a legal personality and is administratively and financially autonomous. Its present structure dates from September 1993 when Congress adopted a national program for mining development. Besides entrusting DNPM with an autonomous framework, the program transformed CPRM (*Companhia de Pesquisa de Recursos Minerais*) into a public enterprise, amended the mining code, created a national program of basic geological surveys (*Programa de Levetamentos Geológicos Básicos do Brasil*) and established a working group to formulate a multiannual plan for the development of the mining sector in Brazil.

2.77. DNPM's resources mainly come from the federal budget. However, it also raises revenues from fines to mining companies, contributions foreseen in the mining legislation, sales of publications, inspections and supervision, donations, subsidies and other income established by law, regulations and contracts.

2.78. In the 1990 administrative reform DNPM lost most of its regional offices, the functions of which were transferred to the Mining Division of the Ministry of Infrastructure, now recreated as the Ministry of Mines and Energy. However, DNPM still maintains a strong presence in Santa Catarina. That office has a staff of 32, of whom 18 university graduates (12 geologists and 2 mining engineers). Its work program is enormous, consisting of the supervision and monitoring of 350 extraction concessions, 300 licensing, 1,300 research permits and 3,800 research requests. The office needs to be closer to its clients, as well as state and municipal organisms involved in mining exploitation, and develop a training and incentives program (including career planning) to improve the productivity of its staff. The southern region office located in Criciuma has four professionals (two Geologists and two assistants) seconded by CPRM.

2. *The Mining Code*

2.79 The present Mining Code was enacted by a Law-Decree No. 227 of February 28, 1967 which updated the old mining code of 1940. The Code covers all mining activities. There is no special code for coal mining.

2.80. The Code stipulates that "the Union [the Federal Government] is responsible for managing the country's natural resources and the industry dealing with the production, commercialization and distribution of mineral products.

2.81. To operate a mine in Brazil, a company must obtain an authorization delivered by the MME through DNPM (Articles 80 and 84 of the Mining code). Before extraction, a company must submit a research project to MME which will grant an exploration permit on the basis of DNPM's recommendation. Following exploration and verification of the existence of minerals in technical and economical conditions justifying exploitation, if the company decides to proceed with the exploitation phase, it needs to obtain an extraction permit, which is granted after review by DNPM of the proposal submitted by the company. If the exploitation request is accepted, the extraction permit is granted with a document signed by the President of the Republic according to Articles 36-59 of the Mining Code. The concession has no time limit and is free (i.e., no annual fees nor taxes). The company must, however, agree to DNPM's monitoring of its activities and must conform to the reporting requirements as stipulated by law. The company must also abide by the environmental regulations stipulated by the

Federal Government, as well as the state and municipality in which it operates.

2.82. DNPM is entrusted by law with the necessary power to monitor all mining activities in Brazil. However, it needs more technical and human resources to efficiently play the role for which it was created.

3. Sindicato da Industria da Extração de Carvão do Estado de Santa Catarina - SIECESC

2.83. Created to coordinate the actions of the individual mining companies and represent and defend the interests of the mining industry, SIECESC has become the official channel of communication between the industry and the authorities. It also represents the Santa Catarina mining companies in price negotiations with ELETROSUL and other coal users.

2.84 SIECESC has been very active in promoting the importance of coal in thermal generation and helping its members adopt cleaner technologies and introduce environmental protection measures in their operations.

2.85. Since the coal mining crisis in 1990, SIECESC has lost some of its importance as many companies closed down under competition from cheaper import coal. The sector is now reduced to six companies with a total direct labor force of 3,500, as compared to almost 11,000 in the mid-1980s. The future of Santa Catarina's coal lays in the adoption by Eletrosul of clean combustion technologies of high ash and sulfur content coal and SIECESC's main task will be to help promote these technologies in Brazil.

4. Sociedade de Assistência aos Trabalhadores do Carvão - SATC

2.86. Created in 1959 to assist mining workers, SATC provides training in coal mining techniques through its technical school and gives high school level classes to the workers' children. It is managed by SIECESC. The entity also has a lab and makes coal quality analyses for mining companies sending their production to Eletrosul in Tubarão and monitors the quality of water in washing plants for SIECESC members.

D. Environmental Regulation of Coal Mining

1. The Institutions

2.87. In Brazil, enforcement of environmental regulations is the responsibility of state and local governments. The federal environmental agencies mainly issue norms and regulations, which are often

supplemented by state directives according to their own environmental policy. In the case of coal mining, since it is a federal responsibility, both federal and state agencies are involved in the regulation and control of that activity. The main ones are described below. For more details, please refer to Section I of Main Text.

(a) Federal Institutions

2.88. Brazil's basic environmental legislation is the law No. 6938 of August 31, 1981 (referred to as the *Ley do Meio Ambiente)*. That law defines Brazil's environmental policy, establishes the national environmental system - SISNAMA (*Sistema Nacional do Meio Ambiente*) and allocates responsibilities for environmental protection among the three spheres of government (federal, state and municipal). At the federal level, the institutions forming SISNAMA are the following:

(i) *Conselho Superior do Meio Ambiente - CSMA.* The council advises the President of the Republic on the formulation of national policies and federal guidelines concerning the environment and the management of natural resources.

(ii) *Conselho Nacional do Meio Ambiente* CONAMA is the executive support of CSMA. CONAMA prepares federal environmental policy directives, drafts norms and regulations and issues resolutions and implementation guidelines to clarify or apply environmental laws.

(iii) *Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal e a Secretaria do Meio Ambiente da Presidência da República* The Ministry is responsible for providing support to CONAMA's Executive Secretariat and its Technical Committees.

(iv) *Instituto Brasileiro de Meio Ambiente e dos Recursos Naturais Renováveis* IBAMA is the executor of the Government's environment policy. It is established as an autonomous entity by law No. 7735 of February 22, 1989.

(v) *Fundo Nacional de Meio Ambiente* Created to finance projects promoting the rational and sustainable use of natural resources, the fund gets its resources fromthe federal budget, donations and other resources defined by law. It is managed by the Office of the Presidency's Secretaria of the Environment under directives fixed by the Council of the Government.

(b) State Institutions

2.89. At the state level, environmental policy and management are usually defined by state laws. In Santa Catarina, the law No. 5793 of October 15, 1980 sets the objectives and priorities of the state's environmental policy and establishes the institutional framework under which it will be carry out. The law created FATMA and entrusted it with the responsibility of executing the state's environmental policy. FATMA is discussed in a separate report. The other major environmental institutions are briefly described below:

(i) *Secretaria do Estado do Devolvimento Urbano e Meio Ambiente* SDM is in charge of coordinating, formulating, and implementating programs and projects supporting ecological sustainability. It is also responsible for integrating the State Government's environmental actions with those of the Federal Government and the municipalities through its specialized organisms.

(ii) *Conselho de Meio Ambiente* CONSEMA is a consultative body whose main objective is to direct the environmental policy of the Santa Catarina state. CONSEMA is located in SDM.

(iii) *Fundo Especial de Proteção ao Meio Ambiente* Created to receive fines and other penalties imposed by FATMA to enterprises and other predators for damages to the environment, FATMA is administered by SDM.

(c) Municipal Institutions

2.90. It is at the municipal level that community pressures demanding solutions to environmental problems are first felt. However, it is also there that the institutions are the weakest. Among Brazil's four thousands municipalities, only a few have agencies or departments specifically assigned to work on environmental issues.

2.91. In southern Santa Catarina, besides Criciúma, no municipality has an adequately staffed environmental department. The municipality of Siderópolis, for example, has only one person in charge of the environment, while environmental problems are enormous. There is an urgent need to strengthen municipalities in environmental management at least to deal with the following environmental issues which could not be delegated to the states:

⇒ *Land Use Planning.* Only municipal authorities can decide the use of its territory and define the areas which will be reserved for parks, ecological protection and recreation uses and those where commercial and industrial activities are permitted. Although the Constitution requires a master plan for municipalities over 20,000 people, very few such municipalities have.

⇒ *Environmental Impact Assessment (Relatórios de Impacto Ambiental - RIMA).* This is another area where the municipality has to get involved as projects requiring EIA generally have significant impact on the population living in the project area.

⇒ *Control and monitoring of pollution.* Control and monitoring of activities with potential negative impact on the environment and the quality of life are also responsibilities that municipal authorities can not be delegated.

⇒ *Mining Exploitation.* Given its significant negative environmental impact on the community and the need to ensure that the exploiting company recuperate the mined-out areas as described in its approved project, the involvement of the municipality is indispensable.

2. *The Regulations*

2.92. The main legal texts regulating mining activity from an environmental point of view are the following:

⇒ *CONAMA Resolution No. 01 of January 23, 1986 and Federal Decree No. 97.632 of April 10, 1989* which spell out in detail the environmental obligations of mining companies as stated in the article 2 of the 1981 Environmental Law. The decree requires new mining companies to prepare and submit for approval to the appropriate environmental authorities (i) an Environmental Impact Assessment (*Estudio de Impacto Ambiental - EIA*) and the corresponding report (*Relatorio de Impacto Ambiental - RIMA*); and (ii) a plan for recuperating the areas which have been polluted by mining activity. Existing companies are requested to submit that plan within 180 days. The CONAMA resolution enumerates the activities for which an EIA is necessary, establishes the criteria and norms for its preparation and defines the minimum technical requirements of the EIA. However, state and municipal authorities can supplement and/or establish their own norms. This is a potential area of conflict and/or duplication and confusion. Generally, state and municipal authorities only adapt the federal norms to suit their local situation;

⇒ *CONAMA Resolution No. 09 of December 3, 1987* which makes mandatory public consultation and participation (*Audiência Pública*) in the EIA process whenever deemed necessary by the environmental authority or requested by a public entity or by more than 50 citizens. The local environmental authority is responsible for organizing and conducting the consultation.

⇒ *CONAMA Resolution No. 09 of December 6, 1990* which spells out the licensing requirements (*Licenciamento*) for all mining research and extraction (with the exception of quarries for extraction of construction materials). Three types of licensing exist, depending on the phase of activity: (i) *Licença Prévia* (LP) delivered at the research phase following approval of the EIA; (ii) *Licença de Instalação* (LI) required by DNPM when it grants the extraction concession following submission by the mining company of its Environmental Control Program (*Plano de Controle Ambiental* - PCA); and (iii) *Licença de Operação* (LO) delivered by the environmental authority when the concession and the PCA are approved. In practice, this Resolution establishes a good operational articulation between the technical work linked to mining licensing for which DNPM is responsible and the environmental considerations for which FATMA must ensure compliance.

3. *The Enforcement*

2.93. In Santa Catarina, FATMA is responsible for enforcing environmental regulations. It mainly focuses on environmental licensing and EIA to monitor and control the activity of the mining sector and other potentially polluting industries. FATMA's work and effectiveness are discussed below:

E. FUNDAÇÃO DO MEIO AMBIENTE (FATMA)

1. *Main Objectives*

2.94. FATMA's main objectives are as follows:

a) enforce environmental regulations in Santa Catarina;

b) manage the environmental licensing system and ensure that polluters carry out the agreed preventive measures. The emphasis is put on solid waste (urban, industrial and hospital) coming from the following sources: (i) industries classified in the list of activities potentially polluting, such as coal mining, and pig farming; (ii) hotels and camping; (iii) hospitals and clinics; and (iv) public water sanitation systems;

c) maintain the cleanliness of the state's beaches and enforce water quality standards;

d) monitor fisheries activities on behalf of the federal government;

e) execute programs aimed at creating parks and forestry reserves;

f) carry out special projects, including scientific and technological research for the defense and ecological conservation; and

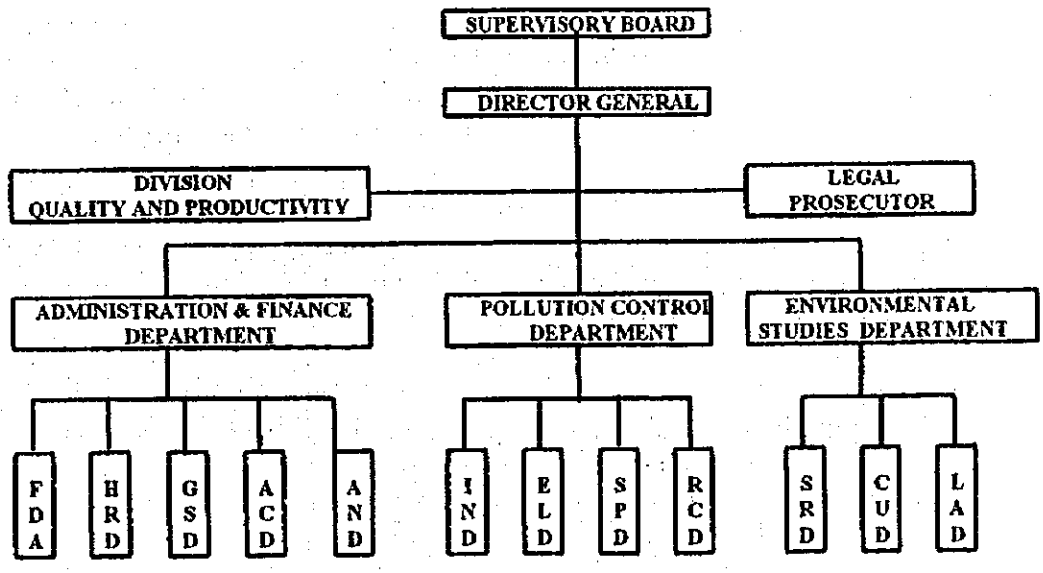
g) participate in the analysis of the state's natural resources potentiality with a view to promote their rational exploitation.

2. *Organization and Staffing*

2.95. FATMA is organized in three main departments (Exhibit 1): (i) Administrative and Financial; (ii) Pollution Control (industrial, rural and urban); and (iii) Environmental Studies. There are also eight regional offices, which carry out most of the monitoring and enforcement work.

EXHIBIT 1

FATMA'S ORGANIZATIONAL STRUCTURE



FDA: Finance and Administration Division
HRD: Human Resources Management Division
GSD: General Services Division
ACD: Accounting Division
AND: Administration and Cadastre Division
IND: Inspection Division
ELD: Environmental Licensing Division
SPD: Special Projects Division
RCD: Regional Coordination Division
SRD: Studies and Research Division
CUD: Conservation Units Division
LAD: Lab Analysis Division

2.96. FATMA has a total of 212 staff, of whom 16 work exclusively for the GTZ (Deutche Geselschaft für Technische Zusasammenasbeit) project, 13 are seconded to FATMA from other organizations, 13 are on leave of absence status and 13 seconded to FATMA from other agencies. FATMA staff exhibits the following particularities:

⇒ Excluding the 13 staff on leave of absence and the 16 recruited to work exclusively on the GTZ project, out of the remaining 183 staff, only 59 (32%) are in the regional offices where most of the enforcement work is done. The remainder 124 (or about two thirds) are in the Florianópolis headquarters.

⇒ Ninety of FATMA's total active staff of 183 (i.e., about 50%) are environmental control technicians[7] and essentially work on environmental licensing, leaving only 93 (including support staff) to work on other activities, such as inspection, enforcement of environmental regulations, research, etc.

3. Operations and Main Tasks

(a) Environmental Licensing

2.97. FATMA's major task is environmental licensing, which is required by law (No. 5793 of October 15, 1980) for all "new and expansion enterprises whose activities are included in the list of activities considered potentially harmful to the environment". To obtain the required environmental licensing, an enterprise goes through the following steps:

- **First step**: Completion of the FCE (*Formulário de Caracterização do Empreendimento* - Project Identification Form) which contains the basic information on the project such as: description of the project, localization, type of activity, production, inputs used, etc. The FCE is reviewed by FATMA which should approve it and recommend the project for the second step of the process;

- **Second step**: Preparation of the OB (*Orientaçao Básica*), which includes: identification of the promoter, description of the project to be licensed, type of licensing, completion of administrative procedures (documents required by the municipality, authorization of DNPM, publication of the licensing request as per CONAMA resolution 006/82 of January 24, 1986, etc.), environmental impact assessment (EIA), if required and a pollution control plan to be prepared according to FATMA's guidelines. Coal mining projects involving extraction, beneficiation and use of coal should also submit an Instruçao Normativa IN 01 which describes in detail (i) geological and geotechnical surveys done to help assess the risks of groundwater pollution; (ii) surface water drainage system to be used in the project;

[7] The number and professional categories of the 90 environmental technicians are as follows: 13 biologists, 11 geographers, 8 civil engineers, 6 biochemists, 6 industrial chemistry specialists, 5 sanitary engineers, 5 chemists, 4 agronomists, 4 administrators, 4 lawyers, 3 forestry specialists, 2 surveyors, 2 librarians, 2 accountants, 2 pedagogues, 2 chemical engineers, 2 mechanical engineers, 2 architects, one veterinarian 2 economists, one sociologist, one editor, one oceanographer, and one artistic education specialist.

(iii) proposals to collect, remove and treat underground mining water; and (iv) transport and disposal of wastes.

- **Third step**: Granting of the environmental licensing. It is done by FATMA following a careful review of the request and related documentation (including EIA) and inspections and site visits to the project area. The inspection and control by FATMA do not exclude those of the municipality or other state and federal organisms. The licensing is always subject to the enterprise realizing the project according to an agreed timetable and that environmental conditions are complied with.

2.98. While environmental licensing is undoubtedly important, it should not occupy half of its staff to the detriment of other equally important tasks, such as control of urban pollution. There is also a need to strengthen FATMA's representation in the regions where most of the monitoring and enforcement of compliance to the requirements of the environmental licensing is done.

(b) Environmental Impact Assessment

2.99. EIA is required by the 1988 Brazilian Constitution for any civil work or economic activity with potential harmful effects on the environment. The EIA must be done and approved before the authorization to start construction or activity is given. The EIA must be public, involving public consultation and participation in the process. This public consultation and participation process should not, however, violate the industrial and commercial secrets that the project sponsor companies are entitled to keep. Brazil's EIA system presents the following characteristics:

- **Nature**: EIA is a legal instrument of Brazil's national environmental policy. As such, the EIA process must end with a decision whether the project should be approved or rejected;

- **Responsibilities**: CONAMA is responsible for setting the norms and criteria for the licensing of potentially polluting activities. However, state and municipal authorities can supplement and/or establish their own norms. This is a potential area of conflict and/or duplication and confusion. Generally, state and municipal authorities only adapt the federal norms to suit their particular local situation;

- **Scope**: CONAMA resolution No. 001/86 specifies activities for which an EIA is required, e.g., major infrastructure projects, such as dam or road construction, hazardous waste disposal facility and mining projects. An EIA must include, inter alia, the following elements, which are then summarized in a report called RIMA (Relatório de Impacto Ambiental):

  ⇨ Comprehensive survey of existing scientific literature and adequate legal reference, field work and investigation, and detailed lab analysis;

- ⇨ Definition of the geographical limits of the project's direct and indirect impacts. In any case it should include the whole river basin where the project is located;

- ⇨ Compatibility and consistency of the project with Government's plans and programs (CONAMA Resolution No. 001/86);

- ⇨ Ex-ante study of the project area (before establishment of the project) covering the physical, biological (the natural ecosystems) and socio-economical (environmental diagnostic of the area) aspects (Decree No. 88-351/83 and Art. No. 6 of the Resolution 001/86). An initial description of the project site is an important element to objectively assess the merits of the project by comparing the "with" and "without" project situations;

- ⇨ Identification and evaluation of all the possible impacts (positive and negative; direct and indirect; short, medium and long terms, temporary and permanent, their degree of reversibility as well as their cumulative or synergetic characteristics;

- ⇨ Description of proposed measures aimed at correcting or mitigating the negative impact on the environment. CONAMA Resolution No. 0011/85 stipulates that the EIA should spell out the remedy measures, including a description of the control equipment and effluent treatment systems, together with an evaluation of their efficiency;

- ⇨ Inclusion of proposed compensatory measures;

- ⇨ Inclusion of disaster prevention measures;

- ⇨ Estimation of the social costs and benefits. It is extremely important from a social point of view to identify the winners and losers (the segments of the population which are going to benefits and those which are going to lose as a result of the project);

- **EIA Team**: The EIA should be done by a multidisciplinary team independent from the project sponsor. The team will be technically responsible for the conclusions of the work.

- **Public Participation**: The public can follow, or assist in, the work of the EIA team to the extent that its participation does not affect the industrial secret to which the sponsor company is entitled to protect. In addition, the RIMA should be extensively advertised and published in the State Official Journal, as well as in a major regional or local newspaper. Access to EIAs is a constitutional right of the Brazilian citizen. The EIA is prepared in two phases. At the Comment Phase, any person, institution, environmental association, or public ministry can make written comments to the team on the work being carried out.. At the Public Audience Phase, the preliminary results of the EIA are presented to the public in a meeting organized by FATMA. The comments (officially recorded) will be used by

FATMA, together with the RIMA, to make a decision with regard to the project. The public audience is the last step in the EIA process.

2.100. FATMA only requests EIA with consultations with the affected communities in public audiences for large projects. It is also FATMA's policy to require EIA for all coal mining projects irrespective of their size.

(c) Monitoring and Enforcement of Regulations on Polluting Activities

2.101. In Santa Catarina, the main sources of pollution are (i) industrial and municipal solid wastes; (ii) pig and chicken farming; and (iii) hazardous wastes (petroleum by products and hospital wastes). In the southern region of the state, the main source of pollution by far is coal mining extraction and beneficiation.

2.102. The major environmental problems associated with coal mining include: (i) improper effluent disposal; (ii) improper accumulation, transport, utilization and/or disposal of solid mining wastes; (iii) air pollution; (iv) damages to forests and vegetation; (v) noise pollution; (vi) installation and operation of equipment without FATMA authorization; and (vii) non-immediate communication to FATMA of accidents with potential damages to the environment.

2.103. In enforcing compliance with environmental regulations, FATMA can impose the following penalties:

- Warning when the infraction is a first offense, is light and does not have a potential risk on public health;
- Fines when the polluter has not corrected the infraction noted in the warning, did not remedy to the situation within the time period specified ,or when there is a risk to public health. The fines can be light (when there is no damages to the fauna, flora or to materials); serious (when there is negative impact on public health or damages to the fauna, flora or other natural resources) and very serious (when there is risk to human life). The fines vary from R$8.35 to R$338.5 per day for light fines; R$164.5 to R$677.2 for serious fines; and R$420.8 to R$1,025.3 for very serious fines. Payment of the fines does not exempt the polluter from remedying to the situation;
- Restriction of financing when the predator does not pay the fines, or when he recidivates for the third time in three years;
- Closure of the activity when there is a serious risk to public health if the activity continues;
- Seizure or destruction of the work or construction when the construction has been

made without authorization or done in violation of the agreement or norms stipulated in the approved project.

- Environmental remediation. The obligation for the predator to remedy to the situation can be imposed on top of a fine.

2.104. In 1995, FATMA gave 171 warnings and 49 fines. The sanctions are executed by administrative order, with recourse to police force if necessary to execute the seizure or destruction decisions. Legal recourse is used when the fines have not been paid after a given period.

2.105. FATMA believes it cannot effectively monitor coal mining pollution in the present organizational structure and suggests the creation of a special unit entirely devoted to the control of the sector activities, including environmental licensing. The unit would have six staff (five technicians and a trainee), three vehicles and adequate computing and lab equipment. Its resources would come from the licensing of mining activities.

(d) Special Projects

(i) Clean Beach Program

2.106. FATMA has developed a program aimed at preserving the quality of the beaches which is one of the most valuable natural asset of the state. Through FATMA's labs at headquarters in Florianópolis and in Criciúma (FUCRI), the program analyses the quality of water in the main beaches and classifies them into four categories using criteria defined in CONAMA resolution No. 20 of June 18, 1985: Excellent, Very Good, Satisfactory and Inadequate. The results are also published in newspapers throughout the state to inform the population about the real situation of the beaches. This indeed provides a strong incentive to the municipalities to act and protect one of their main sources of income (tourism).

(ii) Mata-Atlântica Project

2.107. The project aims at protecting the remaining Floresta Atlântica of the Santa Catarina state, thus consolidating the biosphere reserve of the state through its zoning and monitoring, the establishment of state preservation units, and the introduction of an integrated inspection system, environmental education and scientific research programs. The project is, however, stalled.

2.108. FATMA is also entrusted with a number of projects financed by foreign donors, such as the Management of Water Resources in Santa Catarina Project (financed by GTZ) whose main objective is to improve its capacity to control industrial pollution through a strengthening of its technical and legal bases for managing water resources, or the World Bank-financed Micro-Basin Project, which aims at

recuperating and preserving the productive capacity of soils and reduce rural pollution, thus increasing productivity and income of small producers in the micro-basins. The project aims at encouraging the adoption of adequate practices of soil and water management and redefine the use of the land according to its agrosylvopastoral aptitude.

4. Financial resources

2.109. FATMA's resources mainly come from budgetary allocations by the state. For 1996, its allocation was set at R$ 6.4 million for the following expenses: staff compensation, maintenance, purchase of equipment and investments. However, the resources must be appropriated monthly by the Treasury of the state. At present, the rate of appropriation amounts to about R$30,000 per month, while FATMA's expenses (theoretically covered by the budget) exceed $R100,000.

2.110. To compensate for the budgetary shortfalls, FATMA uses the funds coming from environmental licensing and other services it provides (such as RIMA and lab analyses) available in the state environmental fund (FEPEMA). This, however, barely allows it to meet indispensable expenses, such as staff compensation and operating costs. FATMA's financial situation must be addressed urgently.

5. Main Issues

2.111. FATMA faces a number of important issues which hamper its efficiency. They are described below:

⇒ *Institutional Problems* resulting from (i) lack of coordination among the different agencies, institutions and associations involved in environmental protection: FATMA, IBAMA, DNPM, municipalities, other state and federal agencies and NGOs; (ii) large number of laws, decrees, and resolutions which make their interpretation and application difficult; and (iii) overlapping responsibility among regulatory and enforcing agencies;

⇒ *Organizational Problems* as evidenced by an imbalance between the number of staff at headquarters and in the regional offices where most of the regulatory and enforcement work is done. There appears also to be a need for more decentralization of staff and authority to the regional offices;

⇒ *Operational Problems*. Policies and procedures are not uniform, resulting in different treatments for similar situations within the institution. It is also urgent to update the MIS (Management Information System) to facilitate exchange of information within the institution. Finally, many regional offices lack the basic equipment (e.g., labs, vehicles) to properly do their work;

⇒ *Management Problems*: Work planning seems to be insufficient. There is, for example, no system to evaluate the impact of the work and no basic guidelines nor

prioritization of issues, resulting in the institution reacting to problems rather than addressing issues;

⇒ *Human Resources Problems*: Staff is insufficient in number and of poor quality. At all levels, they appear overworked and unmotivated. Training to increase staff technical expertise is a high priority. Also, there seems to be a need to improve compensation and strengthen career planning; and

⇒ *Financial Problems*: Budgetary appropriations issues should be solved urgently. FATMA needs adequate financial resources to function.

6. *Proposed Strengthening Program*

2.112. The following strengthening program has been prepared with the assistance of FATMA's Criciúma regional office for consideration by the Santa Catarina's authorities. While it covers the institution as a whole, the emphasis is on the southern regional office where coal mining is located.

2.113. As discussed in Section 5 above, FATMA's problems are numerous. Some are due to its own internal organization and management; others result from the state of Santa Catarina's legal and institutional setup for environmental protection and budgetary practices. They are beyond FATMA's control but need nevertheless to be addressed as they impact on FATMA's performance.

(1) Defining FATMA's Role and Responsibilities and Improving Inter-Agency Coordination

2.114. It is proposed that a working group, chaired by SDM and composed of representatives of FATMA, CONSEMA, DNPM, associations of municipalities, IBAMA and other federal agencies, be established to review existing laws and decrees with a view to clearly delineate the roles of these different agencies in environmental protection. Particular emphasis should be placed on defining the responsibilities of FATMA, DNPM, and the municipalities in monitoring coal mining activity and in enforcing environmental regulations to that sector.

2.115. Following that work, FATMA, DNPM, and AMREC (Associação dos Municipios da Região Carbonífera), the Association of Municipalities in the Coal Mining Region would enter into an agreement to coordinate their activities with regard to monitoring and control of coal mining pollution. While FATMA' strengthening is being addressed in this report, it also recommended that resources be made available to help improve the municipalities' and DNPM's enforcement capability.

(2) Strengthening Work Planning and Programming

2.116. Being the state of Santa Catarina's environmental agency, FATMA's responsibilities are

enormous. There is therefore a need to plan to set priorities and efficiently allocate scarce staff resources[8]. FATMA should introduce systematic work planning and programming at the institution's main levels. It is recommended that regional offices, divisions (*Gerências*) and departments (*Diretorias*) prepare annual work programs which would be discussed and agreed with top management. Progress in achieving the agreed work programs would be an important element in the assessment of managers' performance.

2.117. The divisions/departments' work programs would be integrated to form the institution's overall work program. FATMA could also use these work programs as inputs to prepare annual "business plans" for discussion and agreement with SDM on the institution's priority tasks and expected performance during the year. In many other countries, institutions similar to FATMA with important responsibilities and little resources have successfully used this approach to agree on priority works with their governing authorities and avoid excessive pressure and conflicting demands on their time and resources. Rigorous planning could also help cope better with crises which inevitably arise when dealing with environmental protection.

(3) Improving Internal Policies and Procedures

2.118. FATMA's internal policies and procedures are not uniform and, at times, contradictory. A working group should be established within FATMA to review the institution's policies and practices with a view to standardizing them. It is also recommended that an Operations Manual be prepared to guide staff in their work and avoid inconsistent practices.

(4) Strengthening Regional Offices

2.119. As discussed in Section 2 above (Organization and Staffing), most of the enforcement of environmental regulations falls on the eight regional offices; but they lack both personnel and equipment to do the work efficiently. At present, only about one third of FATMA's staff is in the regional offices; the remainder two thirds work in the Florianópolis headquarters. It is recommended that FATMA review the amount of work carried out at headquarters and in the regional offices with a view to better allocating available staff resources. A preliminary analysis shows that the current proportions could easily be reversed, i.e., two thirds of the staff in the regional offices and one third at headquarters.

2.120. In addition to staff transfers, the regional offices should have the necessary resources and

[8] Section V (Operations and Main Tasks) shows that about 50% of FATMA staff work mainly on environmental licensing. While this task is undoubtedly important, it should not be done at the expense of other equally important activities, such as enforcement of environmental regulations or monitoring of water quality.

authority to efficiently carry out their enforcement responsibilities. For this reason, the regional coordination division should report directly to the Director General. That Division could also provide technical support to the regional coordinators in specific areas where their expertise is lacking, such as legal matters, prosecution of polluters,, special test analyses, etc.

2.121. In the southern regional office which, in addition to other tasks, has the responsibility of enforcing environmental regulations on coal mining companies, the Regional Coordinator proposes the creation of a special unit entirely devoted to the monitoring and control of coal mining activities (para. 2.105 above). This proposal merits to be studied further in the context of this comprehensive effort to strengthen FATMA.

(5) Putting Staff Development First

2.122. As a public service agency, FATMA's main asset is the quality of its staff. As mentioned in Section 5 (Main Issues), staff appears overworked and unmotivated. To remedy the situation, FATMA should take the following actions:

⇒ Introduce a comprehensive training program to upgrade the skills of its staff, particularly the technical ones;

⇒ Assess existing recruitment and personnel management policies with a view to improving staff career development prospects;

⇒ Review existing salary structures with a view to introducing financial incentives to retain and motivate valuable staff. There may be a need to reform the whole compensation policy to link more closely work categories and pay. FATMA may also want to consider introducing a bonus system, which has worked well in similar organizations.

(6) Promoting FATMA's Image

2.123. Like many environmental agencies in other countries, FATMA's work is little known to the general public, which often views it as a nuisance or an obstacle to economic development. The measures proposed above to strengthen the institution, particularly the improvement in the technical expertise of FATMA staff, will go a long way in improving the image of the institution. However, FATMA may consider launching a public relations campaign to disseminate its successes and to obtain support for its work from the population.

(7) Increasing Financial Resources

2.124. FATMA's budget is inadequate for it to carry out its work properly. In 1996, FATMA was allocated a budget of $R6.4 million (about US$6.3 million), but appropriations were slow and insufficient to cover all of FATMA's priority needs. Regional offices lack the basic equipment (vehicles, labs and other monitoring devices) to properly inspect potentially polluting industries. Staff are poorly paid and, as a result, moral is low.

2.125. Under the proposed Santa Catarina Environmental and Coal Mining Management Improvement Project for which a loan from bilateral or multilateral lending institutions is being requested, the following actions would be financed to strengthen FATMA:

⇒ Capital expenditures to strengthen and modernize FATMA's work equipment (vehicles, labs, computers, etc.);

⇒ Technical assistance to help FATMA carry out the strengthening measures outlined above, including reviewing its organizational structure, improving its internal policies and procedures, formulating a comprehensive training program for its staff, reforming its compensation policy, and launching a public relations program to improve its image with the general public (a to f above);

⇒ Establishment of a MIS to accelerate the flow of information within the institution and to improve communication with the regional offices; and

⇒ Creation of a fund to recruit short-term experts in areas where FATMA lacks expertise or finance special tests and analyses.

2.126. The external loan cannot, however, finance recurrent expenditures, such as staff salaries, FATMA's maintenance and operating costs without which the institution will not be able to function properly. It is therefore imperative that the Government of Santa Catarina agree to increase FATMA's budget. Appropriations problems will also need to be solved. These will represent the Brazilian contribution to the financing of the project. It is proposed that a SDM/FATMA working group be established to look into this budget issue and make recommendations on ways and means to provide FATMA with adequate financial resources to fulfill the functions for which it was created.

CHAPTER III. TECHNICAL EVALUATION OF RECUPERATION OF MINED-OUT AREAS

A. *INTRODUCTION*

3.01. To understand the southern Santa Catarina's pollution problems, photogrammetric mapping by aerial photographs, covering more than 600 km^2, was carried out. For the feasibility-level study (FS) sites, the Team made 1:1,000 scale maps and, for overall remediation areas, 1:20,000 scale maps. More than 100 points on the region's rivers were selected in the overall remediation areas and in the FS sites for water quality monitoring, including three unmanned water quality monitoring stations which were newly built as part of the Study. Periodic monitoring at each point was continued for a year.

3.02. Three alternatives for each of the four FS sites were developed by creating three distinct groupings of remedial actions with respect to their effectiveness in reducing acid and metal loadings to surface waters. Alternative 1 represents the remedial alternative expected to provide the greatest improvement in water quality at each site, whereas Alternative 3 is expected to result in the lowest level of water quality improvement. These alternatives are then evaluated with respect to the following three criteria: (i) effectiveness,(ii) implementability, and (iii) cost.

3.03. Based on the results of the FS sites studies, overall remedial actions were determined. Since the overall remediation is only done up to a pre-feasibility study level, individual pollution sources as well as waste dumps in the whole study area have not been fully identified. Overall remedial cost was therefore estimated by extrapolating the findings of the FS sites study, i.e., classifying overall waste dumps into several patterns with similar characteristics in terms of remedial actions using factors such as waste type, topographical type and "with river" or "without river" condition.

3.04. Finally, to evaluate an overall remedial plan, three scenarios of water quality simulation were tested for the three river basins: Tubarão, Araranguá, and Urussanga.

- ⇨ Scenario I: This scenario illustrates the extent of mitigation under ideal conditions, i.e., (a) the whole area would be remedied using a wet/dry cover system and wetland treatment method; and (b) effluent discharge from all active areas would comply with Brazilian effluent standards;

- ⇨ Scenario II: This scenario is identical to scenario I except that the quality of effluent from active areas remains low, i.e., not in compliance with Brazilian norms; and

- ⇨ Scenario III: This scenario is the reverse of scenario II, i.e., operators would comply with Brazilian norms, but there is no land remediation at all.

B. CHARACTERISTICS OF POLLUTION

1. Description of FS Sites

3.05. The FS sites are located north and west of the City of Criciúma, Santa Catarina (Figure III-1). This area was mined extensively for coal in the 1970s resulting in acidification of numerous streams at the headwaters of three river basins. The affected river basins include the Rio Tubarão, Rio Urussanga and Rio Araranguá which has two major affected tributaries, i.e. the Rio Mae Luzia and Rio Sangão.

3.06. Four FS sites have been selected by JICA and are representative of the different types of conditions requiring remediation throughout the region. They are as follows:

- ⇨ Fiorita FS Site: An example of an abandoned open-pit mine using dragline methods in the Rio Ararangua basin, located upstream in the municipality of Siderópolis;
- ⇨ Rocinha FS Site: An example of an extensive valley fill deposit of coarse rejects from coal washing in the Rio Tubarão basin, located upstream in the municipality of Lauro Muller;
- ⇨ Carvão FS Site: An example of ARD flow from an abandoned underground mine discharging to the Rio Urussanga basin, located upstream in the municipality of Urussanga; and
- ⇨ Capivari FS Site: An example of a large settling pond for an abandoned coal washing facility at the Eletrosul Power Station in the Rio Tubarão basin, located downstream in the municipality of Capivari de Baixo.

2. Description of Overall Areas

(a) Waste Dumps Survey

3.07. Almost all waste dumps have been surveyed to understand the Southern Santa Catarina's pollution problems and all findings have been compiled into a database. Parameters used for the description of waste dumps are as follows:

- ⇨ Rank (map, aerophotography and others) indicates accuracy and source material;
- ⇨ Waste type (washing reject, overburden waste and water) indicates waste material;
- ⇨ Topographical type (flat, slope, heap. saw, pond, road and river bank) indicates shape and condition of waste dumps;
- ⇨ Area type (mountain top, mountain area, flat area and along river) indicates topographical situation surrounding waste dumps; and

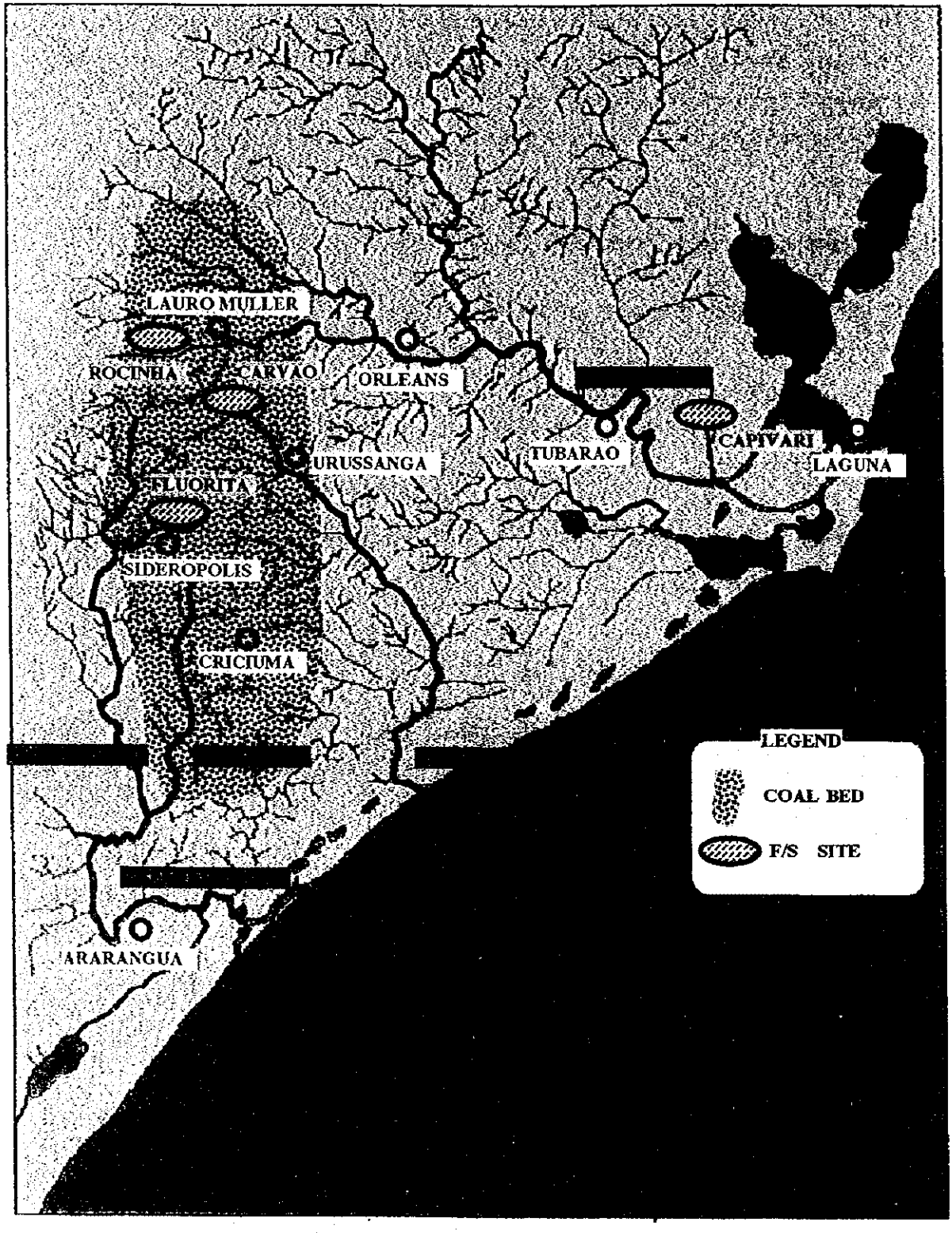


FIGURE III-1 STUDY SITE LOCATION MAP

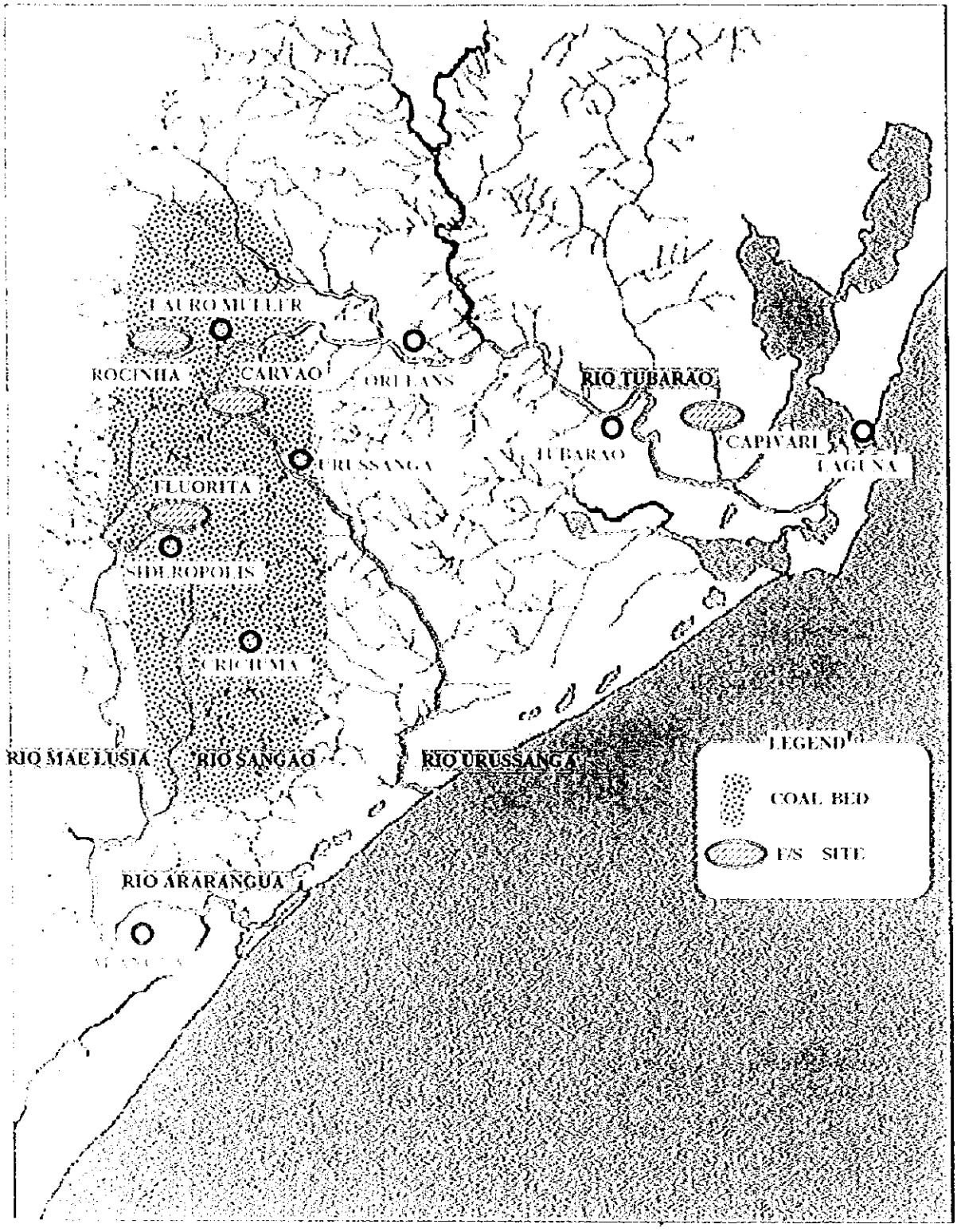


FIGURE III-1 STUDY SITE LOCATION MAP

TABLE III-1

SUMMARY OF WASTE DUMPS

Area (ha)

Municiparity	Waste type	Topo type	River	Abandoned Area	Active Area	Inactive Area	Total
Capivari de Baixo	Black Shale	Flat	No river	80	-	-	80
	Water	Pond	No river	80	-	-	80
	Sub-total			160	-	-	160
Criciuma	Black Shale	Flat	No river	87	-	-	87
			River flow	582.2	163	93.9	839.1
		Slope	No river	12	-	-	12
			River flow	58	-	-	58
	White Waste	Flat	No river	39	-	-	39
			River flow	29.5	-	-	29.5
	Sub-total			807.7	163	93.9	1064.6
Forquilhinha	Black Shale	Flat	River flow	165.5	191.2	-	356.7
	Water	Pond(flatBS)	River flow	-	28	-	28
	Sub-total			165.5	219.2	-	384.7
Icara	Black Shale	Flat	River flow	36	8.8	-	44.8
Lauro Muller	Black Shale	Flat	No river	11.4	-	-	11.4
			River flow	42.7	56.8	-	99.5
		Heap	No river	8	-	-	8
			River flow	32.2	-	-	32.2
		River Bank	River flow	-	27.8	-	27.8
		Slope	No river	-	8	-	8
			River flow	-	-	16.8	16.8
	Water	Pond	River flow	-	0.5	0.8	1.3
		Pond(flatBS)	River flow	0.5	3	-	3.5
	White Waste	Flat	No river	8	-	-	8
		Heap	No river	115.1	8.8	-	123.9
			River flow	128.5	-	-	128.5
		Saw	No river	5	-	-	5
			River flow	71.8	64.4	18	154.2
	Sub-total			423.2	169.3	35.6	628.1
Sideropolis	Black Shale	Flat	No river	18	191	-	209
	Black Shale		River flow	8.5	-	-	8.5
	Water	Pond	River flow	15	-	-	15
		Pond(flatBS)	River flow	-	1	-	1
		Pond(saw)	No river	25	-	-	25
		Pond(saw)	River flow	61	-	-	61
	White Waste	Flat	River flow	10	-	-	10
		Saw	No river	113	-	-	113
			River flow	628.4	-	-	628.4
	Sub-total			878.9	192	-	1070.9
Treviso	Black Shale	Flat	No river	-	120.8	-	120.8
			River flow	28.8	-	-	28.8
	Water	Pond(flatBS)	No river	-	8	-	8
		Pond(flatBS)	River flow	6	-	-	6
		Pond(saw)	River flow	-	2	6	8
	White Waste	Saw	No river	50	-	-	50
			River flow	47	108.2	104.6	259.8
	Sub-total			131.8	239	110.6	481.4
Urussanga	Black Shale	Flat	No river	20.8	-	-	20.8
			River flow	31.5	157.2	-	188.7
		Slope	River flow	-	-	36.7	36.7
	Water	Pond(flatBS)	River flow	-	4	-	4
		Pond(saw)	No river	-	1	-	1
		Pond(saw)	River flow	3.5	-	-	3.5
		Pond(slopeBS)	River flow	-	-	1.5	1.5
	White Waste	Flat	River flow	19	-	-	19
		Heap	No river	7	-	-	7
		Saw	No river	322.8	-	-	322.8
			River flow	284.3	-	-	284.3
	Sub-total			688.9	162.2	38.2	889.3
Grand Total				3,292.0	1153.5	278.3	4723.8

⇨ Other parameters include area's name, municipality, the river and river basin to which a waste dump belongs, original polluter, current land owner, type of operation (mining, washing and coke manufacturing), operation status (active, inactive and abandoned), waste zone (ha) and waste volume (1,000 m3).

3.08. Table III-1 above presents summary of overall waste dumps with parameters: municipality, waste type, topo type and operation status. Figures III-2 (1/2) and (2/2) illustrate distribution of wastes in the region.

(b) Water Quality

3.09. The current conditions of the three polluted rivers are summarized in Table III-2 below.

TABLE III-2

CONDITIONS OF THE THREE POLLUTED RIVERS

Parameters	Undisturbed Area[a/]	Disturbed Area[b/]	Brazilian Norms[c/]
pH	6 to 7	2 to 4	6 to 9
Iron (mg/l)	less than 4	10 to 190	5
Sulfate (mg/l)	8 to 25	100 to 2,000	250
Aluminum (mg/l)	less than 0.5	10 to 100	0.1

a/ Upstream beyond active or abandoned mined-out areas.
b/ Downstream of active or abandoned mined-out areas.
c/ Brazilian water quality standard class four. The State of Santa Catarina does not specify those parameter requirements for ambiente standard.

3.10. Concentrations of lead, chromium, and manganese exhibit the same pattern as sulfate, iron, and aluminum i.e., their values in the disturbed areas (active and abandoned) exceed the Brazilian standard (lead: 0.05 mg/l, chromium: Cr^{3+} 0.5 mg/l, manganese: 0.5 mg/l). Rio Sangão is the worst of all the rivers. The concentrations of zinc and copper also increase near the disturbed area. However, the concentrations of both substances are less than the Brazilian standard (zinc: 5 mg/l, copper: 0.5 mg/l). Arsenic, cadmium, and mercury are not detected in most of the monitoring points. The heavy metal concentrations in sediment increase near the disturbed area. However, the concentrations of those substances are within the range of natural soil averages.

3. Active Areas

3.11. Operating coal mines and washing plants were inspected by the Team to study their environmental protection control activities and also to evaluate the adequacy of the ZETA/IESA report, in which guidelines for the design of acid rock drainage prevention and control systems have been established by consulting firms contracted by the mining companies in the State of Santa Catarina. The findings are summarized below.