### 5.2.2 Sediment run-off disaster prevention works

The construction works for sediment run-off disaster prevention works comprise three (3) categories; Sabo dam construction, channel works and groundsill works.

The construction plan for the above major works is as follows:

(1) Sabo dam

Major work items and quantities of Sabo dams are tabulated below.

| Contract Package | Sabo Basin No. | Work Quantity ($m^3$) | |
|---|---|---|---|
| | | Excavation | Concrete |
| Package-A | 2 | 35,200 | 22,000 |
| | 3 | 8,500 | 9,800 |
| | Subtotal | 43,700 | 31,800 |
| Package-B | 7 | 13,900 | 9,400 |
| | 8 | 6,400 | 3,700 |
| | subtotal | 20,300 | 13,100 |
| Package-C | 10 | 600 | 1,100 |
| | 11 | 4,400 | 7,300 |
| | 12 | 3,900 | 4,900 |
| | subtotal | 8,900 | 13,300 |
| | Total | 72,900 | 58,200 |

The total work quantity of excavation was estimated at around 72,900 $m^3$, distributed as follows: 43,700 $m^3$ for Package-A, 20,300 $m^3$ for Package-B, and 8,900 $m^3$ for Package-C. Meanwhile, the total work quantity of concrete was approximately estimated at 58,200 $m^3$, distributed as follows: 31,800 $m^3$ for Package-A, 13,100 $m^3$ for Package-B and 13,300 $m^3$ for Package-C.

Excavation was planned to be carried out by medium class construction equipment owing to limited site conditions. The excavated materials were to be transported to spoil banks which were basically planned in the vicinity of each dam. Hauling distance from dam site to the spoil banks was approximately 1 km on average.

Following the excavation of dam foundation, Sabo dam construction was planned with due consideration for foundation treatment and against expected flood during construction. Temporary construction plant was exclusively designed in each Package for secure concrete supply, which meets design mix proportion.

(2) Channel works

Major work items and quantities of channel works are tabulated below.

| Contract Package | Sabo Basin No. | Work Quantity Length (m) | Work Quantity Excavation ($m^3$) |
|---|---|---|---|
| Package-A | 2 | 530 | 70,800 |
| | 3 | 490 | 31,200 |
| | subtotal | 1,020 | 102,000 |
| Package-B | 7 | 250 | 39,400 |
| | 8 | 440 | 23,200 |
| | subtotal | 690 | 62,600 |
| Package-C | 10 | - | - |
| | 11 | 410 | 12,300 |
| | 12 | 750 | 64,000 |
| | subtotal | 1,160 | 76,300 |
| | Total | 2,870 | 240,900 |

The total channel length was estimated at around 2,870 m, distributed as follows; 1,020 m for Package-A, 690 m for Package-B, and 1,160 m for Package-C. Meanwhile, the total work quantity of excavation was approximately estimated at 240,900 $m^3$, distributed as follows; 102,000 $m^3$ for Package-A, 62,600 $m^3$ for Package-B, and 76,300 $m^3$ for Package-C.

The channel works, which were designed at the downstream of each Sabo dam except for basin No. 10, comprise channel excavation, gravel backsill, concrete block installation, wet masonry and gabion mattress.

(3) Groundsill

Major work items and quantities of groundsill works are tabulated below.

| Contract Package | Sabo Basin No. | Work Quantity | | |
|---|---|---|---|---|
| | | Nos. | Excavation ($m^3$) | Concrete ($m^3$) |
| Package-A | 2 | 4 | 15,700 | 1,210 |
| | 3 | 1 | 120 | 230 |
| | subtotal | 5 | 15,200 | 1,440 |
| Package-B | 7 | 5 | 10,500 | 1,040 |
| | 8 | 4 | 4,000 | 370 |
| | subtotal | 9 | 14,500 | 1,410 |
| Package-C | 10 | - | - | - |
| | 11 | 11 | 15,700 | 1,100 |
| | 12 | 9 | 19,000 | 900 |
| | subtotal | 20 | 34,700 | 2,000 |
| | Total | 34 | 65,020 | 4,850 |

The total groundsills amount to 34 numbers; 5 nos. for Package-A, 9 nos. for Package-B, and 20 nos. for Package-C. The total work quantity of excavation was estimated at around 65,020 $m^3$, distributed as follows; 15,820 $m^3$ for Package-A, 14,500 $m^3$ for Package-B, and 34,700 $m^3$ for Package-C. The total work quantity of concrete was approximately estimated at 4,850 $m^3$, distributed as follows; 1,440 $m^3$ for Package-A, 1,410 $m^3$ for Package-B, and 2,000 $m^3$ for Package-C.

Construction of groundsill with maximum height of 5 m, arranged in each river channel, was planned to be executed together with channel works. Construction works were to be carried out, taking into full account sequence of the works, restricted site conditions, and combination of the equipment.

### 5.2.3 Flood Disaster Prevention Works

The construction works for flood disaster prevention works comprise dike construction, new channel excavation of around 1 km, dredging, and relocation works of road and railway bridges.

The general feature of the priority project of flood disaster prevention works are summarized below:

| Component | Type of Structure | Quantity |
|---|---|---|
| Dike | | 265,000 $m^3$ |
| Excavation | | 334,000 $m^3$ |
| Dredging | | 141,000 $m^3$ |
| Revetment | Wet masonry | 9,800 $m^2$ |
| Culvert | | 1.5m x 1.5m (6 sites)<br>2.0m x 2.5 m(1 site) |
| Intake Weir | Concrete | |
| Parapet Wall | Concrete | |
| Road Bridge | | 40.8 m |
| Railway Bridge | | 130.5 m |

The construction plan for the major works is as follows:

(1) Dike

The dike construction of 265,000 $m^3$ was planned to be carried out in parallel with a new channel excavation and dredging works. Approximately one-third of embankment volume was to be directly hauled from excavation site, whereas around 60% was transported from stock yard where excavated materials were to be treated. Remaining embankment material was planned from borrow pit in the upstream of the Moji river.

(2) Channel excavation

The new channel excavation of the Moji river amounting to 334,000 $m^3$ was planned by combination of conventional excavation and dredging method. The excavation above water level was basically to be performed by medium class construction equipment. Meanwhile, dredging was also planned for excavation below water level and where applicable, to save excavation cost.

Excavation volume of around 100,000 $m^3$ was planned to be directly hauled for dike embankment. Another 100,000 $m^3$ was to be transported to stock yard for material treatment and remaining 134,000 $m^3$ was envisaged to spoil bank.

(3) Dredging

Around 141,000 $m^3$ of channel dredging was basically planned to be carried out using pump suction dredger. The dredged material obtained from the upper sediment of riverbed material was designed to be hauled to stock yard to exert material treatment for dike embankment. On the other hand, the sediment material mainly consisting of silty deposits from the lower portion of the riverbed was planned to spoil bank for future land reclamation.

(4) Relocation of existing bridge construction

The existing road bridges and Federal railway (RFFSA) were planned to be relocated in the early stage of construction works. Both relocation works were designed with due care for local traffic and consideration during construction and for future permanent use.

### 5.3 Cost Estimate

#### 5.3.1 Unit cost revised

The unit costs for major works were revised based on the basic data such as labor wage, material and equipment cost. These figures were obtained with a little difference from unit costs estimated in the master plan stage. The unit costs revised are indicated in Table 20.

#### 5.3.2 Construction cost for priority project

The construction cost for the priority project was estimated based on the preliminary design and construction plan. The basic assumptions and conditions adopted for the cost estimate are basically the same as that of master plan stage as follows:

a) price level --- the end of June 1990
b) official exchange rate --- US$ 1.0 = Cr$ 60 = ¥ 150
c) currency of cost estimate --- foreign and local currency
d) labor wage, materials and equipment cost
e) constitution of capital cost

The construction costs for the priority projects in the financial basis were estimated for the sediment run-off and flood disaster prevention works. The summary of financial cost for the sediment run-off disaster prevention works was estimated at US$ 25.7 million as presented in Table 21. The direct and indirect costs were estimated at US$ 17.0 million and US$ 8.7 million, respectively.

The financial cost for the flood disaster prevention works of the Moji river was estimated at US$ 11.4 million as shown in Table 22. The direct and indirect costs were estimated at US$ 7.4 million and US$ 4.0 million, respectively. The financial cost for the priority projects is tabulated in Table 22 altogether.

Total construction cost for the sediment run-off and flood disaster prevention works, therefore, was estimated to amount to US$ 37.1 million; direct cost of US$ 24,4 million and indirect cost of US$ 12.7 million.

**Construction Cost for Priority Project**

(Unit : million US$)

| Item | Sediment Disaster | | | Flood Disaster Prevention Works Moji River | | |
|---|---|---|---|---|---|---|
| | F/C | L/C | TOTAL | F/C | L/C | TOTAL |
| I Preparatory Work (5-15% of II) | 1.0 | 1.2 | 2.2 | 0.2 | 0.1 | 0.3 |
| II Construction Cost | 7.0 | 7.8 | 14.8 | 4.0 | 3.1 | 7.1 |
| III Compensation Cost | | 0.1 | 0.1 | | 0.2 | 0.2 |
| IV Administration Cost (5% of I + II) | | 0.9 | 0.9 | | 0.4 | 0.4 |
| V Engineering Service (10% of I + II) | 1.4 | 0.3 | 1.7 | 0.6 | 0.1 | 0.7 |
| VI Physical Contingency (15% of I+II+III+IV+V) | 1.4 | 1.5 | 2.9 | 0.7 | 0.6 | 1.3 |
| VII Price Contingency (F/C 3%, L/C 3%) | 1.5 | 1.6 | 3.1 | 0.8 | 0.6 | 1.4 |
| Total | 12.3 | 13.4 | 25.7 | 6.3 | 5.1 | 11.4 |

(Unit : million US$)

| Works | Construction Cost | | |
|---|---|---|---|
| | Direct | Indirect | Total |
| (1) Sediment run-off disaster prevention works | 17.0 | 8.7 | 25.7 |
| Basin 2 | 6.0 | 3.0 | 9.0 |
| " 3 | 2.7 | 1.3 | 4.0 |
| " 7 | 2.7 | 1.4 | 4.1 |
| " 8 | 1.1 | 0.8 | 1.9 |
| " 10 | 0.3 | 0.1 | 0.4 |
| " 11 | 2.2 | 1.1 | 3.3 |
| " 12 | 2.0 | 1.0 | 3.0 |
| (2) Flood desaster prevention works | 7.4 | 4.0 | 11.4 |
| Total | 24.4 | 12.7 | 37.1 |

## 5.4 Project Economic Evaluation

### 5.4.1 Economic cost

The constitution and concept of the economic cost for the priority project was assumed to be the same as applied in the master plan. Hence, the financial cost was converted into the economic costs by adjustment based on the conditions and assumptions.

The economic cost for the sediment run-off disaster prevention works was estimated at US$ 20.0 million comprising US$ 15.1 million for direct cost, US$ 0.02 million for compensation cost, US$ 0.8 million for administration cost, US$ 1.5 million for engineering services and US$ 2.6 million for physical contingency.

The economic cost for the flood disaster prevention works in the Moji river basin was estimated at US$ 9.0 million comprising US$ 6.8 million for direct cost, US$ 0.06 million for compensation cost, US$ 0.3 million for administration cost, US$ 0.7 million for engineering services, and US$ 1.2 million for physical contingency.

Operation and maintenance(O&M) costs are incurred annually during the project life after completion of construction. The rate of 1.0 % of the construction cost was assumed to be O&M cost for the sediment run-off disaster prevention works and 0.5 % of that for the flood disaster prevention works. From the above, O & M costs for the sediment run-off and flood disaster prevention works were estimated at US$ 0.15 million and US$ 0.03 million annually.

The economic cost of the priority project is summarised below.

**Economic Cost of Priority Project**

(Unit: million US$)

| Works | Economic Cost | | |
|---|---|---|---|
| | Direct | Indirect | Total |
| (1) Sediment run-off disaster prevention works | 15.1 | 4.9 | 20.0 |
| Basin 2 | 5.4 | 1.7 | 7.1 |
| " 3 | 2.3 | 0.8 | 3.1 |
| " 7 | 2.4 | 0.8 | 3.2 |
| " 8 | 1.1 | 0.3 | 1.4 |
| " 10 | 0.2 | 0.1 | 0.3 |
| " 11 | 1.9 | 0.6 | 2.5 |
| " 12 | 1.8 | 0.6 | 2.4 |
| (2) Flood disaster prevention works | 6.8 | 2.2 | 9.0 |
| Total | 21.9 | 7.1 | 29.0 |

5.4.2 Economic benefit

The economic benefits were estimated as the reduction in damages or losses to damageable properties, which will be brought about by implementation of the designed disaster prevention works. With the design scale of about a 25-year return period for the sediment run-off disaster prevention works for the proposed project selected among the master plan stage, the benefits were considered to be commensurate with the reducible amount of annual mean sediment run-off damages corresponding to the design scale.

Meanwhile, the benefit of the flood protection works of the Moji river basin consisting of channel excavation and flood dike construction with the design scale of 10-year return period was estimated on the basis of the effect of reduction in annual mean flood damages to assets and properties in and around the flood protection areas. In addition, the benefit was also estimated on the basis of conceivable socio-economic projections up to the year 2020 in the study area.

(1) Sediment run-off damages

Most of the target properties which would be vulnerable to the sediment run-off disaster were identified as the industrial establishments located in the foot of Serra do Mar. Large scale petrochemical refinery establishments, in particular, are the most serious targets, followed by the substation facilities and state highway.

Taking into account the identification of damageable properties above, the sediment run-off damage was estimated for each establishment. Damageable properties of respective industrial establishments were estimated on the basis of depreciable assets and inventory stocks, which were basically valuated from the sector-wise asset holdings in the state, and value of production of each establishment, adjusted by the price index. Damage rates to properties was assumed to be 50% for buildings, equipment and installations, and 80% for moveables, vehicles and inventory stocks.

Probable sediment run-off damages and annual damages were estimated for 7 Sabo subbasins of the selected priority project under the present conditions below.

**Probable Sediment Run-off Damages and Annual Damages**

(Unit: US$ million)

| Sabo Subbasin | Return Period 5 | 25 | 50 | 100 | Annual Damage (*) |
|---|---|---|---|---|---|
| 2 | 1.2 | 6.0 | 7.0 | 7.7 | 0.7 |
| 3 | 0.3 | 4.6 | 6.2 | 8.1 | 0.4 |
| 7 | 1.9 | 3.6 | 4.6 | 6.3 | 0.6 |
| 8 | 0.7 | 0.8 | 1.1 | 1.4 | 0.2 |
| 10 | 0.1 | 0.6 | 1.4 | 1.9 | 0.1 |
| 11 | 1.4 | 2.2 | 2.7 | 3.1 | 0.4 |
| 12 | 1.0 | 3.0 | 8.6 | 11.4 | 0.4 |

Note: (*) Annual damage with the design scale of approximately 25-year return period.

1 US$ = 60 Cr$

(2) Flood Damage

Damageable properties in the flood protection area of the Moji river basin were identified from the topographic maps, aerial photographs and field investigation, by using a mesh survey with a grid of 500m interval squares. The potential flood damage was then estimated as the product of three(3) components: number of properties by type, unit value of each property and damage rate corresponding to the inundation depth.

In the flood protection area of around 8.0 $km^2$ in Moji river basin, the following damageable properties were identified: 250 residences, 10 small scale commerce and services shops, and nine(9) major industrial establishments.

Probable flood damages and annual damages were estimated for the Moji river basin as a reduction in damages and losses with river improvement works designed for a 10-year return period and without the project, as summarized below.

**Probable Flood Damages and Annual Damages**

(Unit: US$ million)

| Basin | Return Period | | | | | | Annual Damage |
|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 50 | 100 | |
| Moji | 0.9 | 1.5 | 2.0 | 2.1 | 2.4 | 2.5 | 1.0 |

Note: Annual damage with the design scale of 10-year return period.
1 US$ = 60 Cr$

### 5.4.3 Economic evaluation

An economic evaluation was carried out to ascertain the economic viability of the proposed projects by comparing the economic costs and benefits. The Economic Internal Rate of Return (EIRR) was applied as a criterion for economic evaluation.

Based on the cost stream disbursed in accordance with the construction schedule, and the benefit flow to be accrued from the proposed project, the EIRR was separately calculated for the sediment run-off disaster prevention works and the Moji river improvement works.

Overall economic evaluation of the Sabo works, consisting of 7 Sabo sub-basins, showed an EIRR of 18.2%. Of the above, sub-basin No.7, 10, 11 and 12 were analyzed to exhibit quite high economic return of more than 20%. On the other hand, the Moji river improvement works showed an EIRR of 11.1%.

The economic analysis of the priority project is summarized below.

Economic Evaluation of Proposed Projects

| Works/Sabo Sub-basin | EIRR (%) |
|---|---|
| Sabo Works | |
| 2 | 13.3 |
| 3 | 17.8 |
| 7 | 23.5 |
| 8 | 16.8 |
| 10 | 30.1 |
| 11 | 21.2 |
| 12 | 22.3 |
| Total | 18.2 |
| River Improvement Works | 11.1 |

## 5.5 Environmental Impact Assessment

The checklist method was applied as the basic tool for identification of impacts which may be caused by the selected priority projects.

The four(4) effects, such as state park, soil erosion, water quality deterioration and damages on forest are expected to be mainly caused during the construction of stage of the priority projects.

The environmental effects caused by the priority projects are considered mainly during the construction stage. However, those magnitudes are not expected so serious, it is considered that the priority projects are acceptable through the viewpoint of the environment.

The environmental effects of the priority projects will be generally limited to the construction stage. However, the magnitude are expected to be small, because the impacts are tentative and effective countermeasures will be taken during construction of the projects.

## 5.6 Project justification

Based upon the results of the economic evaluation above, the proposed projects for the sediment run-off prevention works with a design scale of an about 25-year return period could be justified. Moreover, taking into account unmeasurable social impacts and intangible damage which could be caused by sediment run-off disasters, these proposed projects were judged to be highly viable for implementation.

With regard to the proposed project for flood protection works in the Moji river basin, major industrial establishments are at high risk of repeated frequent inundation by overflowing from the Moji river and its tributaries. If future land use in the Moji river basin is taken into consideration, the probable flood damage will be significantly higher than that of the present projection. If the above situation and economic evaluation are taken into account, the flood protection works of the Moji river basin will be seen to be as highly justified as the proposed project with a design scale of a 10-year return period.

## VI. RECOMMENDATION

1. The proposed priority project for the sediment run-off and flood disaster prevention works is strongly recommended to be implemented at the earliest possible time because of eminent social request from high potential of disaster, as shown that the project is technically feasible and economically viable with high economic return.

2. It is well known that the forest restoration plan is very important to protect industrial establishments and inhabitants from sediment run-off and flood disasters. Therefore, basic study on the relationship between vegetation changes and air pollution, and monitoring on the aeroplantation should be carried out in continuous and effective methods as applied presently.

In considering uncertainty and difficulty in predicting accurate time and location of occurrence for the sediment run-off disasters, the present civil defense plan and forest restoration program are also strongly requested to be continued as effective countermeasures which are complementary to the proposed priority project in order to restore forest in Serra do Mar.

3. Prior to the detailed design and during the construction, it is also recommended that geotechnical investigations for bearing capacity of foundation, cutting slope stability and bank materials should be carried out because of complex geological conditions in the project area of the priority project.

4. Other projects in the Master plan especially diversion tunnel works including open channel through the marsh area, which were not selected as the priority project, could seem to cause relatively serious impact on mangrove and its neighboring environment. From the above, detailed environmental impact assessment should be undertaken before the project is implemented.

# TABLES

**TABLE 1 LIST OF MEMBERS OF THE COORDINATING BODY AND THE COUNTERPART AGENCY**

| | Member | Agency |
|---|---|---|
| (1) Coordinating Body | | |
| (General) | - Ana Lùcia Segamarchi | SMA |
| | - Cèlia Castello | CETESB |
| | - Marcia Jungmann Cardoso | SMA |
| | - Cèlia Albuquerque | CETESB |
| (Technical) | - Roque Monteleone Neto | SMA |
| | - Sussumu Niyama | IPT |
| (2) Counterpart Agency | | |
| | - Sussumu Niyama | IPT |
| | - Celso Carvalho dos Santos | |
| | - Marco Antonio Palermo | DAEE |
| | - Dorcas Florêncio Domingues | |
| | - Paulo Tetuia Hasegawa | CETESB |
| | - Sergio Luiz Pompèia | |
| | - Mizue Kirizawa | IBt |
| | - Marcia Inês M. S. Lopes | |

TABLE 2 LIST OF MEMBERS OF THE ADVISORY COMMITTE AND JICA COORDINATOR

| Name | Position and Agency |
|---|---|
| **(1) Advisory Committee** | |
| - Mr. H. Kobayashi (Chairman) | Senior Officer for Engineering Affairs, Slope Conservation Division, Sediment Control Department, River Bureau, Ministry of Construction, Japan |
| - Mr. H. Ohno | Senior Officer of River Division, Kinki Regional Construction Bureau, Ministry of Construction, Japan |
| - Mr. K. Okuda | Deputy Director of River Planning Division, Chubu Regional Construction Bureau, Ministry of Construction, Japan |
| **(2) JICA Coordinator** | |
| - Mr. H. Takama | Japan International Cooperation Agency (JICA Tokyo) |
| - Mr. K. Noritake | Japan International Cooperation Agency (JICA Tokyo) |
| - Mr. S. Murata | Japan International Cooperation Agency (JICA Tokyo) |
| - Mr. Y. Hongo | Japan International Cooperation Agency (JICA Brazilia) |
| - Mr. M. Habu | Japan International Cooperation Agency (JICA São Paulo) |
| - Mr. H. Sasaki | Japan International Cooperation Agency (JICA São Paulo) |

TABLE 3 LIST OF MEMBERS OF THE STUDY TEAM

| Name | Position and Assignment |
|---|---|
| M. Ooishi | Team Leader |
| Y. Tomida | Co-Leader/<br>Sediment runoff Disaster Prevention |
| T. Nobe | Flood Disaster Prevention |
| N. Jituhiro | Sediment Hydaulics |
| Y. Kato | Hydrology |
| T. Shibatani | Topography, Geology |
| K. Narita | Vegetation, Soil |
| K. Ishizuka | Topographic Survey |
| Y. Shimano | Construction Plan and Design |
| M. Watanuki | Socio-economy, Disaster Investigation |
| Y. Iwai | Environment |

## TABLE 4 POPULATION GROWTH AND LABOR FORCE

| Item | Population | | | | Average Annual Growth Rate (%) | | |
|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990(87) | '60-'70 | '70-'80 | '80-90(87) |
| **(1) BRAZIL** | | | | | | | |
| 1. Population | 70,070,457 | 93,139,037 | 119,002,706 | 150,367,841 | 2.89 | 2.48 | 2.37 |
| 2. Male | 35,055,457 | 46,331,343 | 59,123,361 | 74,992,111 | 2.83 | 2.47 | 2.41 |
| 3. Female | 35,015,000 | 46,807,694 | 59,879,345 | 75,375,730 | 2.95 | 2.49 | 2.33 |
| 4. Urban | 31,303,034 | 52,084,984 | 80,436,409 | 112,743,732 | 5.22 | 4.44 | 3.43 |
| 5. Rural | 38,767,423 | 41,054,053 | 38,566,297 | 37,624,109 | 0.57 | -0.63 | -0.25 |
| 6. Economically Active | 48,740,564 | 65,683,745 | 87,677,224 | (104,311,844 ) | 3.03 | 2.93 | 2.51 |
| 7. Labor Force | 22,750,100 | 29,557,224 | 43,235,712 | ( 59,542,958 ) | 2.65 | 3.88 | 4.68 |
| 8. Labor Force Participation(%) | 46.7 | 45.0 | 49.3 | 57.1 | -0.37 | 0.92 | 2.12 |
| **(2) Sao Paulo** | | | | | | | |
| 1. Population | 12,809,231 | 17,771,948 | 25,040,772 | ( 31,124,350 ) | 3.33 | 3.49 | 3.16 |
| 2. Male | 6,480,421 | 8,931,360 | 12,519,890 | ( 15,416,521 ) | 3.26 | 3.49 | 3.02 |
| 3. Female | 6,328,810 | 8,840,588 | 12,520,882 | ( 15,707,829 ) | 3.40 | 3.54 | 3.29 |
| 4. Urban | 8,019,743 | 14,276,239 | 22,196,378 | ( 28,202,067 ) | 5.94 | 4.51 | 3.48 |
| 5. Rural | 4,789,488 | 3,495,709 | 2,844,334 | ( 2,922,283 ) | -3.20 | -2.08 | 0.27 |
| 6. Economically Active | 9,308,538 | 13,334,701 | 19,327,707 | ( 24,231,757 ) | 3.66 | 3.78 | 3.28 |
| 7. Labor Force | 4,517,600 | 6,372,842 | 10,411,726 | ( 14,249,629 ) | 3.50 | 5.03 | 4.58 |
| 8. Labor Force Participation(%) | 48.5 | 47.8 | 53.9 | 58.8 | -0.15 | 1.21 | 1.25 |
| **(3) Cubatao** | | | | | | | |
| 1. Population | 25,166 | 51,009 | 79,162 | 105,547 | 7.32 | 4.49 | 2.92 |
| 2. Male | - | 27,342 | 43,208 | 58,950 | - | 4.68 | 3.16 |
| 3. Female | - | 23,667 | 35,954 | 46,597 | - | 4.27 | 2.63 |
| 4. Urban | - | 37,255 | 78,569 | 105,547 | - | 7.75 | 3.00 |
| 5. Rural | - | 13,754 | 593 | 0 | - | -36.94 | - |
| 6. Economically Active | - | 35,598 | 59,177 | ( 76,571 ) | - | 5.21 | 3.75 |
| 7. Labor Force | - | 15,822 | 31,576 | - | - | 7.15 | - |
| 8. Labor Force Participation(%) | - | 44.5 | 53.4 | - | - | 1.86 | - |

Source : Anuario Estatistico do Brasil 1989: IBGE
Estatisticas Historicas do Brasil 1988: IBGE
Anuario Estatistico do Estado de Sao Paulo 1988: IBGE
Boletim Informativo de Cubatao: P.M.C
Secretaria de Ciencia, Tecnologia e Desenvolvimento Economico

Remark : *1 Quated in 1990 are projected population.
*2 Figures in parentheses are projected data in 1987.
*3 Economically active population is defined as persons aged 10 years and over.
*4 (7)/(6)

## TABLE 5 GROSS DOMESTIC PRODUCT

| Year | Gross domestic Product | | | | Gross Domestic Product per Capita | | | |
|---|---|---|---|---|---|---|---|---|
| | Current Price (Cr$ 1,000) | Constant Price at 1980(Cr$1,000) | Annual Growth Rate (%) | Current Prie (US$ million) | Current Price (Cr$) | Constant Price at 1980(Cr$) | Annual Growth Rate (%) | Current Price (US$) |
| 1970 | 194 | 5,419 | - | 34,034 | 0.002 | 0.057 | - | 355.18 |
| 1971 | 258 | 6,037 | 11.3 | 39,529 | 0.003 | 0.061 | 8.7 | 402.43 |
| 1972 | 347 | 6,754 | 11.9 | 45,704 | 0.003 | 0.067 | 9.3 | 454.21 |
| 1973 | 512 | 7,698 | 14.0 | 55,329 | 0.005 | 0.074 | 11.3 | 536.91 |
| 1974 | 745 | 8,326 | 8.2 | 66,403 | 0.007 | 0.079 | 5.7 | 629.32 |
| 1975 | 1,050 | 8,756 | 5.2 | 76,219 | 0.01 | 0.081 | 2.7 | 705.52 |
| 1976 | 1,634 | 9,654 | 10.3 | 88,896 | 0.01 | 0.087 | 7.6 | 803.78 |
| 1977 | 2,493 | 10,130 | 4.9 | 99,342 | 0.02 | 0.089 | 2.5 | 877.53 |
| 1978 | 3,617 | 10,634 | 5.0 | 112,205 | 0.03 | 0.092 | 2.5 | 968.46 |
| 1979 | 5,961 | 11,352 | 6.8 | 133,338 | 0.05 | 0.096 | 4.3 | 1,124.71 |
| 1980 | 12,402 | 12,402 | 9.2 | 165,264 | 0.10 | 0.102 | 6.8 | 1,362.60 |
| 1981 | 24,654 | 11,859 | -4.4 | 174,334 | 0.20 | 0.096 | -6.6 | 1,405.15 |
| 1982 | 51,025 | 11,939 | 0.7 | 186,311 | 0.40 | 0.094 | -1.6 | 1,468.35 |
| 1983 | 118,927 | 11,531 | -3.4 | 185,737 | 0,92 | 0.089 | -5.6 | 1,431.32 |
| 1984 | 393,647 | 12,111 | 5.0 | 203,505 | 2.97 | 0.091 | 2.8 | 1,534.05 |
| 1985 | 1,413,312 | 13,111 | 8.3 | 228,137 | 10.43 | 0.097 | 6.0 | 1,682.87 |
| 1986 | 3,708,949 | 14,099 | 7.5 | 250,123 | 26.78 | 0.102 | 5.3 | 1,806.03 |
| 1987 | 11,899,911 | 14,611 | 3.6 | 268,663 | 84.13 | 0.103 | 1.5 | 1,899.32 |
| 1988 | 91,952,490 | 14,613 | 0.0 | 279,492 | 636.67 | 0.101 | -2.0 | 1,935.16 |
| 1989* | 1,366,421,000 | 15,139 | 3.6 | 303,452 | 9,270.00 | 0.103 | 1.5 | 2,058.64 |

Source: Anuario Estatistico do Brazil, 1989 : IBGE
Relatorio, 1989: Banco Central do Brasil
Remarhs: * Provisional estimate by IBGE

TABLE

# TABLE 6 NUMBER OF MANUFACTURING ESTABLISHMENTS AND PRODUCTION VALUE

(Unit: Cr$)

| Type of Industrial Sub-sector | Sao Paulo | | | | Cubatao | | | | Share of Cubatao to Sao Paulo (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1975 | | 1980 | | 1975 | | 1980 | | | |
| | Nos. | Amount | Nos. | Amount | Nos. | Amount | Nos. | Amount | 1975 | 1980 |
| Mining | 778 | 930 | 871 | 7,519 | 8 | 155 | 4 | 59 | 16.7 | 0.8 |
| Non-metal products | 6,823 | 14,297 | 8,147 | 158,693 | 8 | 206 | 7 | 1,832 | 1.4 | 1.1 |
| Metallurgy | 6,433 | 56,075 | 6,251 | 679,102 | 5 | 4,222 | 7 | 91,085 | 7.5 | 13.4 |
| Machinery | 4,824 | 43,534 | 5,516 | 497,404 | 10 | 327 | 18 | 6,270 | 0.8 | 1.3 |
| Electric & communication products | 1,752 | 29,326 | 2,110 | 331,434 | 1 | - | - | - | - | - |
| Vehicles | 1,794 | 57,473 | 1,504 | 563,288 | 1 | - | - | - | - | - |
| Timber | 2,281 | 3,444 | 1,860 | 36,427 | 1 | - | 1 | - | - | - |
| Furniture | 3,540 | 6,405 | 3,081 | 65,579 | 1 | - | - | - | - | - |
| Paper | 821 | 11,249 | 892 | 145,099 | 1 | - | 1 | - | - | - |
| Rubber | 495 | 10,423 | 514 | 112,415 | 1 | - | - | - | - | - |
| Leather | 347 | 1,078 | 357 | 13,145 | - | - | - | - | - | - |
| Chemistry | 1,536 | 65,218 | 1,553 | 906,593 | 42 | 10,175 | 44 | 191,270 | 15.6 | 21.1 |
| Medicine | 237 | 7,894 | 222 | 68,715 | - | - | - | - | - | - |
| Soap & Perfume | 328 | 5,231 | 309 | 53,735 | - | - | - | - | - | - |
| Plastic products | 1,412 | 8,836 | 1,721 | 117,695 | - | - | - | - | - | - |
| Textile | 3,458 | 29,034 | 3,194 | 320,038 | 2 | 2 | - | - | - | - |
| Clothing | 5,425 | 13,855 | 6,747 | 172,228 | - | - | 2 | - | - | - |
| Food products | 11,038 | 49,122 | 10,540 | 533,039 | 23 | 13 | 25 | 133 | - | - |
| Beverage | 646 | 3,875 | 575 | 34,839 | - | - | - | - | - | - |
| Tobacco | 8 | 1,389 | 6 | 8,668 | - | - | - | - | - | - |
| Printing | 2,782 | 8,660 | 3,263 | 77,427 | 3 | - | 2 | - | - | - |
| Others | 6,117 | 11,788 | 7,066 | 155,941 | 24 | 525 | 26 | 7,503 | 4.5 | 4.8 |
| Total | 60,378 | 439,138 | 62,426 | 5.059,027 | 131 | 15,625 | 126 | 298,152 | 3.6 | 5.9 |

Source: Censo Industrial, 1975: IBGE
Censo Industrial, 1980: IBGE

# TABLE 7 ESTIMATED PROBABLE DISCHARGES

PRESENT CHANNEL CONDITION

| Return Period (Year) | | 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| CUBATAO RIVER SYSTEM (Feb.24.1971 Flood Type, 2DAY-Rainfall=301.8mm) | | | | | | | |
| Probable Rainfall (mm) | | 206 | 282 | 331 | 394 | 441 | 488 |
| Scale factor of total rainfall | | 0.683 | 0.934 | 1.100 | 1.309 | 1.465 | 1.617 |
| Probable Discharges at Major Points (m3/s) | | | | | | | |
| -River Mouth | (29) | 916 | 1301 | 1555 | 1876 | 2121 | 2366 |
| -After Pereque | (28) | 915 | 1302 | 1552 | 1877 | 2128 | 2376 |
| -Pereque River | (27) | 212 | 321 | 382 | 460 | 519 | 581 |
| -Before Pereque | (20) | 724 | 1033 | 1231 | 1489 | 1690 | 1890 |
| - " | (19) | 748 | 1056 | 1258 | 1530 | 1743 | 1956 |
| -Anchieta Bridge | (17) | 586 | 878 | 1070 | 1330 | 1534 | 1739 |
| -Imigrantes Brg. | (14) | 537 | 828 | 1022 | 1289 | 1498 | 1708 |
| -After Piloes | (10) | 570 | 868 | 1062 | 1320 | 1521 | 1725 |
| -Piloes River | ( 9) | 173 | 282 | 356 | 455 | 532 | 609 |
| -Before Piroes | ( 4) | 397 | 586 | 706 | 865 | 1018 | 1172 |

| MOJI RIVER (Jan.22.1985 Flood Type, 2DAY-Rainfall=286.5mm) | | 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| Probable Rainfall (mm) | | 182 | 250 | 295 | 351 | 393 | 435 |
| Scale factor of total Rainfall | | 0.639 | 0.873 | 1.030 | 1.229 | 1.375 | 1.568 |
| Probable Discharges at Major Points (m3/s) | | | | | | | |
| -River Mouth | (49) | 243 | 367 | 453 | 568 | 652 | 714 |
| -After Piacag. | (48) | 278 | 429 | 536 | 683 | 806 | 866 |
| -Piacaguera R. | (44) | 79 | 128 | 168 | 227 | 274 | 292 |
| -Before Piacag. | (41) | 234 | 365 | 461 | 585 | 675 | 737 |
| -After Indio R. | (38) | 240 | 376 | 489 | 644 | 762 | 819 |
| -Indio River | (34) | 28 | 44 | 58 | 79 | 95 | 101 |
| -Before Indio | (33) | 220 | 346 | 451 | 595 | 706 | 759 |
| -Intake Weir | (30) | 240 | 421 | 570 | 788 | 965 | 1040 |

IMPROVED CONDITION OF EXISTING CHANNEL

| Return Period (Year) | | 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| CUBATAO RIVER SYSTEM (Feb.24.1971 Flood Type, 2DAY-Rainfall=301.8mm) | | | | | | | |
| Probable Rainfall (mm) | | 206 | 282 | 331 | 394 | 441 | 488 |
| Scale factor of total rainfall | | 0.683 | 0.934 | 1.100 | 1.309 | 1.465 | 1.617 |
| Probable Discharges at Major Points (m3/s) | | | | | | | |
| -River Mouth | (29) | 920 | 1346 | 1617 | 1970 | 2242 | 2515 |
| -After Pereque | (28) | 915 | 1326 | 1589 | 1933 | 2199 | 2467 |
| -Pereque River | (27) | 209 | 324 | 395 | 488 | 558 | 627 |
| -Before Pereque | (20) | 724 | 1058 | 1270 | 1549 | 1767 | 1988 |
| - " | (19) | 751 | 1069 | 1278 | 1556 | 1774 | 1993 |
| -Anchieta Bridge | (17) | 589 | 891 | 1090 | 1356 | 1565 | 1776 |
| -Imigrantes Brg. | (14) | 537 | 827 | 1022 | 1279 | 1482 | 1687 |
| -After Piloes | (10) | 570 | 868 | 1062 | 1320 | 1521 | 1725 |
| -Piloes River | ( 9) | 173 | 282 | 356 | 455 | 532 | 609 |
| -Before Piroes | ( 4) | 397 | 586 | 706 | 865 | 1018 | 1172 |

| MOJI RIVER (Jan.22.1985 Flood Type, 2DAY-Rainfall=286.5mm) | | 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| Probable Rainfall (mm) | | 182 | 250 | 295 | 351 | 393 | 435 |
| Scale factor of total Rainfall | | 0.639 | 0.873 | 1.030 | 1.229 | 1.375 | 1.568 |
| Probable Discharges at Major Points (m3/s) | | | | | | | |
| -River Mouth | (49) | 213 | 345 | 438 | 551 | 658 | 706 |
| -After Piacag. | (48) | 273 | 443 | 578 | 759 | 897 | 949 |
| -Piacaguera R. | (44) | 79 | 128 | 168 | 227 | 274 | 292 |
| -Before Piacag. | (41) | 228 | 378 | 503 | 676 | 810 | 864 |
| -After Indio R. | (38) | 231 | 377 | 487 | 632 | 740 | 778 |
| -Indio River | (34) | 28 | 44 | 58 | 79 | 95 | 101 |
| -Before Indio | (33) | 218 | 359 | 466 | 609 | 716 | 755 |
| -Intake Weir | (30 | 240 | 421 | 570 | 788 | 965 | 1040 |

# TABLE 8 PAST MAJOR SLOPE FAILURES

Area: Unit (10E-2 Km2)

| Division Name | 1962 Nos. | 1962 Area | 1971 Nos. | 1971 Area | 1976 Nos. | 1976 Area | 1980 Nos. | 1980 Area | 1985 Nos. | 1985 Area | 1988 Nos. | 1988 Area | 1962-1989 Nos. | 1962-1989 Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MOJI RIVER BASIN | | | | | | | | | | | | | | |
| MR-1 | 3 | 0.98 | 100 (1) | 34.07 | 77 (6) | 21.25 | 45 (9) | 12.21 | 302 (29) | 61.05 | 26 (2) | 5.13 | 664 | 161.7 |
| MR-2 | 7 | 1.1 | 7 (1) | 3.79 | 43 (3) | 12.82 | 16 (4) | 3.42 | 57 (9) | 12.45 | 10 (2) | 1.75 | 155 | 39.34 |
| MR-3 | 2 | 0.49 | 13 (0) | 2.67 | 88 (1) | 19.9 | 31 (7) | 10.5 | 136 (10) | 27.23 | 40 (10) | 5.86 | 342 | 73.06 |
| MR-4 | 0 | 0 | 0 | 0 | 2 (0) | 0.73 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0.73 |
| MR-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 (0) | 1.22 | 0 | 0 | 18 | 1.22 |
| ML-1 | 9 | 2.56 | 38 (0) | 16.85 | 7 (1) | 18.8 | 10 (8) | 8.42 | 118 (16) | 35.29 | 12 (8) | 2.56 | 252 | 109.74 |
| Sub-Total | 21 | 5.13 | 158 (2) | 57.38 | 217 (11) | 73.5 | 102 (28) | 34.55 | 621 (64) | 137.24 | 88 (22) | 15.30 | 1433 | 385.79 |
| CUBATAO RIVER BASIN | | | | | | | | | | | | | | |
| CR-1 | 4 | 0.2 | 20 (0) | 3.33 | 16 (3) | 2.92 | 0 | 0 | 1 (0) | 0.73 | 0 | 0 | 43 | 5.86 |
| CR-2 | 0 | 0 | 12 (0) | 1.88 | 10 (0) | 1.88 | 2 (0) | 1.56 | 1 (0) | 0.73 | 2 (0) | 1.59 | 26 | 3.79 |
| CR-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 (0) | 2.13 | 0 | 0 | 4 | 2.56 |
| CL-1 | 1 | 0.1 | 4 (0) | 0.38 | 0 | 0 | 8 (0) | 1.46 | 3 (0) | 0.79 | 2 (0) | 1.59 | 21 | 2.81 |
| CL-2 | 3 | 0.2 | 1 (0) | 0.1 | 1 (0) | 0.16 | 5 (0) | 1.04 | 6 (0) | 2.13 | 11 (1) | 3.79 | 32 | 8.18 |
| CL-3 | 5 | 0.33 | 3 (0) | 0.31 | 2 (0) | 0.16 | 4 (0) | 3.25 | 16 (1) | 3.05 | 21 (1) | 4.5 | 64 | 8.01 |
| CL-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 (0) | 1.59 | 24 (0) | 3.3 | 45 | 8.15 |
| CL-5 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (0) | 1.71 | 26 (0) | 3.42 | 14 (1) | 1.71 | 68 | 11.63 |
| CL-6 | 0 | 0 | 4 (0) | 1.47 | 1 (0) | 0.73 | 1 (0) | 1.22 | 44 (1) | 7.2 | 14 (1) | 2.32 | 114 | 23.05 |
| CL-7 | 6 | 1.59 | 16 (0) | 5.74 | 56 (1) | 15.26 | 63 (10) | 13.8 | 172 (15) | 34.19 | 39 (4) | 5.37 | 446 | 96.23 |
| CL-8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 (0) | 1.10 | 0 | 0 | 8 | 1.47 |
| Sub-Total | 19 | 2.42 | 60 (0) | 13.21 | 86 (4) | 21.11 | 85 (10) | 24.04 | 282 (17) | 55.96 | 127 (8) | 24.17 | 871 | 171.74 |
| Total | 40 | 7.55 | 218 (2) | 70.59 | 303 (15) | 94.61 | 187 (38) | 58.59 | 903 (81) | 193.2 | 215 (30) | 39.47 | 2304 | 557.53 |

Note: ( ) Shows number of slope failures that occured again at the same places compared with previous aerial photographs interpretation results.

## TABLE 9 SEDIMENT YIELD OF SABO SUB-BASIN

| Number of Sabo Sub-Basin | Catchment Area (km2) | Sediment Yield of Slope Failures (10^3m3) | | | | Sediment Yield of Torrent Deposit (10^3m3) | | | | Potential Sediment Yield | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1/5 | 1/25 | 1/50 | 1/100 | 1/5 | 1/25 | 1/50 | 1/100 | 1/5 | 1/25 | 1/50 | 1/100 |
| 1 | 2.39 | 66.3 | 112.9 | 132.3 | 151.4 | 35.1 | 44.2 | 46.8 | 47.2 | 101.4 | 157.1 | 179.1 | 198.6 |
| 2 | 3.79 | 105.1 | 179.1 | 209.9 | 240.1 | 67.6 | 85.8 | 91.4 | 91.8 | 172.7 | 264.9 | 301.3 | 331.9 |
| 3 | 1.29 | 35.8 | 61.0 | 71.4 | 81.7 | 20.6 | 26.1 | 27.6 | 27.7 | 56.4 | 87.1 | 99.0 | 109.4 |
| 4 | 8.42 | 121.4 | 228.7 | 273.5 | 317.7 | 253.0 | 328.0 | 353.9 | 362.7 | 374.4 | 556.7 | 627.4 | 680.4 |
| 5 | 0.90 | 13.0 | 24.4 | 29.2 | 34.0 | 10.9 | 13.5 | 14.3 | 14.5 | 23.9 | 37.9 | 43.5 | 48.5 |
| 6 | 1.73 | 24.9 | 47.0 | 56.2 | 65.3 | 31.1 | 39.0 | 41.4 | 41.7 | 56.0 | 86.0 | 97.6 | 107.0 |
| 7 | 2.64 | 38.1 | 71.7 | 85.7 | 99.6 | 50.5 | 62.9 | 66.5 | 67.0 | 88.6 | 134.6 | 152.2 | 166.6 |
| 8 | 0.41 | 4.2 | 7.8 | 9.3 | 10.8 | 3.5 | 4.3 | 4.5 | 4.5 | 7.7 | 12.1 | 13.8 | 15.3 |
| 9 | 0.17 | 7.4 | 13.9 | 16.6 | 19.3 | 6.3 | 7.9 | 8.3 | 8.4 | 13.7 | 21.8 | 24.9 | 27.7 |
| 10 | 1.26 | 12.8 | 21.0 | 28.7 | 33.3 | 15.0 | 16.6 | 19.7 | 19.8 | 27.8 | 42.6 | 48.4 | 53.1 |
| 11 | 0.62 | 6.3 | 11.8 | 14.1 | 16.4 | 8.4 | 10.5 | 11.1 | 11.1 | 14.7 | 22.3 | 25.2 | 27.5 |
| 12 | 1.11 | 11.3 | 21.1 | 25.3 | 29.4 | 13.2 | 16.2 | 17.2 | 17.4 | 24.5 | 37.3 | 42.5 | 46.8 |

## TABLE 10 DESIGN SEDIMENT RUN-OFF DISCHARGE

| Sabo Sub-basin | Design Sediment Run-off Discharge | | | |
|---|---|---|---|---|
| | 1/5 | 1/25 | 1/50 | 1/100 |
| 1(2.39) | 0 | 0 | 0 | 0 |
| 2(3.79) | 77,600 | 124,200 | 142,900 | 159,400 |
| 3(1.29) | 56,400 | 87,100 | 99,000 | 109,400 |
| 4(8.42) | 72,900 | 119,800 | 139,900 | 158,700 |
| 5(0.90) | 19,100 | 30,200 | 34,600 | 38,700 |
| 6(1.73) | 38,400 | 62,100 | 71,600 | 80,100 |
| 7(2.64) | 83,000 | 130,500 | 149,800 | 166,600 |
| 8(0.41) | 7,500 | 11,800 | 13,600 | 15,200 |
| 9(0.17) | 13,700 | 21,800 | 24,900 | 27,700 |
| 10(1.26) | 18,700 | 29,400 | 33,700 | 37,700 |
| 11(0.62) | 13,000 | 20,400 | 23,400 | 26,100 |
| 12(1.11) | 24,500 | 37,300 | 42,500 | 46,800 |

Note ; ( ) means Sabo sub-basin area in km2

# TABLE 11 DIMENSION OF STRUCTURAL MEASURES

(Unit:m3)

| Sub-basin No. | Sediment Run-off Discharge | Eristence Structural Measures | | | | Design Sediment Run-off Discharge | Proposed Structural Measures (Sabo-dam) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | Total | | 1st | 2nd | 3rd | 4th | 5th | 6th | Total |
| 1 | 155,500 | (H=8) 24,800 | (H=10) 138,200 | (H=10) 44,200 | 207,200 | 0 | (H-10)* 7,400 | | | | | | 7,400 |
| 2 | 159,400 | (H=4) 70,000 | | | | 159,400 | (H-7) 124,800 | (H=10)* 16,200 | (H=10)* 19,300 | | | | 160,300 |
| 3 | 109,400 | (H=4) 82,000 | | | | 109,400 | (H=10) 85,800 | (H=10)* 28,500 | | | | | 114,300 |
| 4 | 158,700 | | | | | 158,700 | (H=8) 120,000 | (H=10)* 45,000 | | | | | 165,000 |
| 5 | 38,700 | | | | | 38,700 | (H=10) 38,100 | (H=5)* 2,300 | | | | | 40,400 |
| 6 | 80,100 | | | | | 80,100 | (H=10) 36,700 | (H=10) 41,600 | (H=10)* 2,400 | | | | 80,700 |
| 7 | 166,600 | | | | | 166,600 | (H=10) 44,600 | (H=10) 20,300 | (H=10) 35,700 | (H=10) 49,500 | (H=10)* 8,500 | (H=10)* 8,600 | 167,200 |
| 8 | 15,200 | | | | | 15,200 | (H=7) 12,000 | (H=10)* 3,600 | | | | | 15,600 |
| 9 | 27,700 | | | | | 27,700 | (H=10) 21,800 | (H=10)* 3,600 | (H=10)* 3,300 | | | | 28,700 |
| 10 | 37,700 | | | | | 37,700 | (H=8) 34,000 | (H=10)* 4,000 | | | | | 38,000 |
| 11 | 26,100 | | | | | 26,100 | (H=10) 20,000 | (H=10) 6,000 | (H=10)* 2,000 | | | | 28,000 |
| 12 | 46,800 | | | | | 46,800 | (H=9) 37,800 | (H=10) 5,500 | (H=10)* 4,500 | | | | 47,800 |

Note ; * : means control amount

## TABLE 12 FINANCIAL COST FOR SEDIMENT DISASTER PREVENTION WORKS

| Item | Unit | Quantity | Foreign Currency Unit Cost | Foreign Currency Amount (1,000US$) | Local Currency Unit Cost | Local Currency Amount (1,000US$) | Total (1,000US$) |
|---|---|---|---|---|---|---|---|
| I. Preparatory Works (15% of II) | | | | 2,879 | | 3,102 | 5,980 |
| II. Construction Cost | | | | | | | |
| II.1 Sabo dam (32 sites) | m3 | 179,600 | 95.0 | 17,062 | 95.0 | 17,062 | 34,124 |
| II.2 Channel works (11 sites) | m2 | 70,800 | 15.0 | 1,062 | 35.0 | 2,478 | 3,540 |
| II.3 Groundsill (2 Nos.) | m3 | 1,700 | 90.0 | 153 | 90.0 | 153 | 306 |
| II.4 Miscellaneous (5% of Total II.1 - II.3) | | | | 914 | | 985 | 1,899 |
| Total of II | | | | 19,191 | | 20,678 | 39,869 |
| III. Compensation Cost | | | | | | | |
| III.1 Residence | Nos. | 12 | | | 400 | 5 | 5 |
| III.2 Residential Area | m2 | 960 | | | 2.5 | 2 | 2 |
| III.3 Non-Residential Area | m2 | 11,200 | | | 0.7 | 8 | 8 |
| III.4 Factory Area | m2 | 132,700 | | | 1.3 | 173 | 173 |
| Total of III | | | | | | 188 | 188 |
| IV. Administration Cost (5% of I + II) | | | | | | 2,292 | 2,292 |
| V. Engineering Service (10% of I + II) | | | | 3,668 | | 917 | 4,585 |
| VI. Physical Contingency (15% of I + II + III + IV + V) | | | | 3,861 | | 4,076 | 7,937 |
| VII. Price Contingency (F/C 3%, L/C 3%) | | | | 6,901 | | 7,289 | 14,190 |
| Total | | | | 36,499 | | 38,542 | 75,041 |

# TABLE 13 SUMMARY OF FINANCIAL COST (EXCLUDING PRICE CONTINGENCY) FOR SEDIMENT DISASTER PREVENTION WORKS IN EACH BASIN

Unit : 1,000 US$

| Item | Basin 1 | | | Basin 2 | | | Basin 3 | | | Basin 4 | | | Basin 5 | | | Basin 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL |
| I Preparatory Work (15% of II) | 51 | 81 | 132 | 429 | 456 | 885 | 222 | 240 | 462 | 343 | 373 | 717 | 148 | 162 | 311 | 249 | 284 | 533 |
| II Construction Cost | 341 | 542 | 883 | 2,860 | 3,043 | 5,903 | 1,479 | 1,603 | 3,082 | 2,289 | 2,489 | 4,778 | 989 | 1,083 | 2,072 | 1,661 | 1,894 | 3,555 |
| III Compensation Cost | | 28 | 28 | | 11 | 11 | | 10 | 10 | | 47 | 47 | | 15 | 15 | | 35 | 35 |
| IV Administration Cost (5% of I + II) | | 51 | 51 | | 339 | 339 | | 177 | 177 | | 275 | 275 | | 119 | 119 | | 204 | 204 |
| V Engineering Service (10% of I + II) | 81 | 20 | 102 | 543 | 136 | 679 | 284 | 71 | 354 | 440 | 110 | 549 | 191 | 48 | 238 | 327 | 82 | 409 |
| VI Physical Contingency (15% of I+II+III+IV+V) | 71 | 108 | 179 | 575 | 598 | 1,173 | 298 | 315 | 613 | 461 | 494 | 955 | 199 | 214 | 413 | 336 | 375 | 710 |
| Total | 544 | 831 | 1,375 | 4,407 | 4,583 | 8,990 | 2,282 | 2,417 | 4,699 | 3,533 | 3,788 | 7,321 | 1,527 | 1,641 | 3,169 | 2,573 | 2,874 | 5,447 |

| Item | Basin 7 | | | Basin 8 | | | Basin 9 | | | Basin 10 | | | Basin 11 | | | Basin 12 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL |
| I Preparatory Work (15% of II) | 387 | 400 | 787 | 129 | 142 | 271 | 201 | 215 | 415 | 81 | 81 | 162 | 306 | 321 | 627 | 325 | 346 | 670 |
| II Construction Cost | 2,580 | 2,668 | 5,248 | 861 | 945 | 1,806 | 1,338 | 1,430 | 2,768 | 539 | 539 | 1,078 | 2,039 | 2,138 | 4,177 | 2,165 | 2,304 | 4,469 |
| III Compensation Cost | | 9 | 9 | | 4 | 4 | | 1 | 1 | | 0 | 0 | | 13 | 13 | | 15 | 15 |
| IV Administration Cost (5% of I + II) | | 302 | 302 | | 104 | 104 | | 159 | 159 | | 62 | 62 | | 240 | 240 | | 257 | 257 |
| V Engineering Service (10% of I + II) | 483 | 121 | 604 | 166 | 42 | 208 | 255 | 64 | 318 | 99 | 25 | 124 | 384 | 96 | 480 | 411 | 103 | 514 |
| VI Physical Contingency (15% of I+II+III+IV+V) | 517 | 525 | 1,042 | 173 | 185 | 359 | 269 | 280 | 549 | 108 | 106 | 214 | 409 | 421 | 831 | 435 | 454 | 889 |
| Total | 3,967 | 4,025 | 7,992 | 1,330 | 1,422 | 2,751 | 2,062 | 2,149 | 4,211 | 827 | 813 | 1,640 | 3,139 | 3,229 | 6,368 | 3,336 | 3,478 | 6,814 |

## TABLE 14 FINANCIAL COST FOR FLOOD DISASTER PREVENTION WORKS (1/2)

ALTERNATIVE C-2(2)

| Item | Unit | Quantity | Foreign Currency Unit Cost | Foreign Currency Amount (1,000US$) | Local Currency Unit Cost | Local Currency Amount (1,000US$) | Total (1,000US$) |
|---|---|---|---|---|---|---|---|
| I. Preparatory Works (5% of II) | | | | 695 | | 520 | 1,215 |
| II. Construction Cost | | | | | | | |
| II.1 Dike | m3 | 157,000 | 2.1 | 330 | 1.4 | 220 | 550 |
| II.2 Excavation | m3 | 256,000 | 1.8 | 461 | 1.2 | 307 | 768 |
| II.3 Dredging | m3 | 256,000 | 2.7 | 691 | 1.8 | 461 | 1,152 |
| II.4 Revetment | m2 | 6,700 | 15.0 | 101 | 35.0 | 235 | 335 |
| II.5 Culvert (11 Nos.) | L.S. | 1 | | 384 | | 256 | 640 |
| II.6 Diversion Weir | L.S. | 1 | | 240 | | 160 | 400 |
| II.7 Overflow Weir | L.S. | 1 | | 130 | | 90 | 220 |
| II.8 Diversion Channel (Cubatao) | L.S. | 1 | | 530 | | 850 | 1,380 |
| II.9 Tunnel (2 Nos.) | m | 1,200 | 7,800 | 9,360 | 5,200 | 6,240 | 15,600 |
| II.10 Diversion Channel (Sao Vicente) | L.S. | 1 | | 340 | | 640 | 980 |
| II.11 Road Bridge (2 Nos.) | L.S. | 1 | | 192 | | 120 | 312 |
| II.12 Railway Bridge (1 Nos.) | L.S. | 1 | | 300 | | 210 | 510 |
| II.13 Protection Dike | L.S. | 1 | | 143 | | 87 | 230 |
| II.14 Riverbed Protection | L.S. | 1 | | 36 | | 24 | 60 |
| II.15 Miscellaneous (5% of Total II.1 - II.14) | | | | 662 | | 495 | 1,157 |
| Total of II | | | | 13,899 | | 10,394 | 24,293 |
| III. Compensation Cost | | | | | | | |
| III.1 Residence | Nos. | 10 | | | 400 | 4 | 4 |
| III.2 Factory | L.S. | 1 | | | | 0 | 0 |
| III.3 Residential Area | m2 | 800 | | | 2.5 | 2 | 2 |
| III.4 Non-Residential Area | m2 | 248,000 | | | 0.7 | 174 | 174 |
| Total of III | | | | | | 180 | 180 |
| IV. Administration Cost (5% of I + II) | | | | | | 1,275 | 1,275 |
| V. Engineering Service (10% of I + II) | | | | 2,041 | | 510 | 2,551 |
| VI. Physical Contingency (15% of I + II + III + IV + V) | | | | 2,495 | | 1,932 | 4,427 |
| VII. Price Contingency (F/C 3%, L/C 3%) | | | | 5,242 | | 4,058 | 9,300 |
| Total | | | | 24,372 | | 18,869 | 43,241 |

## TABLE 14 FINANCIAL COST FOR FLOOD DISASTER PREVENTION WORKS (2/2)

ALTERNATIVE H-2

| Item | Unit | Quantity | Foreign Currency Unit Cost | Foreign Currency Amount (1,000US$) | Local Currency Unit Cost | Local Currency Amount (1,000US$) | Total (1,000US$) |
|---|---|---|---|---|---|---|---|
| I. Preparatory Works (5% of II) | | | | 378 | | 283 | 661 |
| II. Construction Cost | | | | | | | |
| II.1 Dike | m3 | 250,000 | 2.1 | 525 | 1.4 | 350 | 875 |
| II.2 Excavation | m3 | 846,000 | 1.8 | 1,523 | 1.2 | 1,015 | 2,538 |
| II.3 Dredging | m3 | 584,000 | 2.7 | 1,577 | 1.8 | 1,051 | 2,628 |
| II.4 Revetment | m2 | 24,800 | 15.0 | 372 | 35.0 | 868 | 1,240 |
| II.5 Culvert (7 Nos.) | L.S. | 1 | | 240 | | 160 | 400 |
| II.6 Intake Weir (1 No.) | L.S. | 1 | | 72 | | 48 | 120 |
| II.7 Groundsill (4 Nos.) | L.S. | 1 | | 120 | | 80 | 200 |
| II.8 Road Bridge | L.S. | 1 | | 1,000 | | 700 | 1,700 |
| II.9 Railway Bridge | L.S. | 1 | | 1,600 | | 1,000 | 2,600 |
| II.10 Repair of Riprap Dike (4 Nos.) | L.S. | 1 | | 174 | | 116 | 290 |
| II.11 Miscellaneous (5% of Total II.1 - II.10) | | | | 360 | | 269 | 630 |
| Total of II | | | | 7,563 | | 5,658 | 13,221 |
| III. Compensation Cost | | | | | | | |
| III.1 Residence | Nos. | 0 | | | 400 | 0 | 0 |
| III.2 Factory | L.S. | 1 | | | | 0 | 0 |
| III.3 Residential Area | m2 | 0 | | | 2.5 | 0 | 0 |
| III.4 Non-Residential Area | m2 | 354,000 | | | 0.7 | 248 | 248 |
| Total of III | | | | | | 248 | 248 |
| IV. Administration Cost (5% of I + II) | | | | | | 694 | 694 |
| V. Engineering Service (10% of I + II) | | | | 1,111 | | 278 | 1,388 |
| VI. Physical Contingency (15% of I + II + III + IV + V) | | | | 1,358 | | 1,074 | 2,432 |
| VII. Price Contingency (F/C 3%, L/C 3%) | | | | 2,299 | | 1,801 | 4,100 |
| Total | | | | 12,708 | | 10,035 | 22,743 |

## TABLE 15 SUMMARY OF FINANCIAL COST (EXCLUDING PRICE CONTINGENCY) FOR FLOOD DISASTER PREVENTION WORKS

Unit : 1,000 US$

| Item | Alternative C - 1 | | | Alternative C - 2 (1) | | | Alternative C - 2 (2) | | | Alternative K - 1 | | | Alternative M - 2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL |
| I Preparatory Work (5% of II) | 543 | 399 | 942 | 951 | 699 | 1,650 | 695 | 520 | 1,215 | 450 | 337 | 788 | 378 | 283 | 661 |
| II Construction Cost | 10,865 | 7,975 | 18,840 | 19,015 | 13,988 | 33,003 | 13,899 | 10,394 | 24,293 | 9,009 | 6,748 | 15,757 | 7,563 | 5,658 | 13,221 |
| III Compensation Cost | | 19,343 | 19,343 | | 180 | 180 | | 180 | 180 | | 698 | 698 | | 248 | 248 |
| IV Administration Cost (5% of I + II) | | 989 | 989 | | 1,733 | 1,733 | | 1,275 | 1,275 | | 827 | 827 | | 694 | 694 |
| V Engineering Service (10% of I + II) | 1,583 | 396 | 1,978 | 2,772 | 693 | 3,465 | 2,041 | 510 | 2,551 | 1,324 | 331 | 1,654 | 1,111 | 278 | 1,388 |
| VI Physical Contingency (15% of I+II+III+IV+V) | 1,949 | 4,365 | 6,314 | 3,411 | 2,594 | 6,005 | 2,495 | 1,932 | 4,427 | 1,617 | 1,341 | 2,959 | 1,358 | 1,074 | 2,432 |
| Total | 14,939 | 33,467 | 48,406 | 26,149 | 19,887 | 46,036 | 19,130 | 14,811 | 33,941 | 12,400 | 10,283 | 22,683 | 10,409 | 8,235 | 18,644 |

## TABLE 16 FINANCIAL COST FOR MASTER PLAN

Unit : 1,000 US$

| Item | Sediment Disaster Prevention Works | | | Flood Disaster Prevention Works | | | | | | | | | (Sediment+Flood) Disaster Prevention Works | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Cubatao | | | Moji | | | (Cubatao + Moji) | | | | | |
| | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL |
| I Preparatory Work (5-15% of II) | 2,879 | 3,102 | 5,980 | 695 | 520 | 1,215 | 378 | 283 | 661 | 1,073 | 803 | 1,876 | 3,952 | 3,904 | 7,856 |
| II Construction Cost | 19,191 | 20,678 | 39,869 | 13,899 | 10,394 | 24,293 | 7,563 | 5,658 | 13,221 | 21,462 | 16,052 | 37,514 | 40,653 | 36,730 | 77,383 |
| III Compensation Cost | | 188 | 188 | | 180 | 180 | | 248 | 248 | | 428 | 428 | | 616 | 616 |
| IV Administration Cost (5% of I + II) | | 2,292 | 2,292 | | 1,275 | 1,275 | | 694 | 694 | | 1,969 | 1,969 | | 4,262 | 4,262 |
| V Engineering Service (10% of I + II) | 3,668 | 917 | 4,585 | 2,041 | 510 | 2,551 | 1,111 | 278 | 1,388 | 3,151 | 788 | 3,939 | 6,819 | 1,705 | 8,524 |
| VI Physical Contingency (15% of I+II+III+IV+V) | 3,861 | 4,077 | 7,937 | 2,495 | 1,932 | 4,427 | 1,358 | 1,074 | 2,432 | 3,853 | 3,006 | 6,859 | 7,714 | 7,083 | 14,796 |
| VII Price Contigentcy (F/C 3%, L/C 3%) | 6,901 | 7,289 | 14,190 | 5,242 | 4,058 | 9,300 | 2,299 | 1,801 | 4,100 | 7,541 | 5,859 | 13,400 | 14,442 | 13,148 | 27,590 |
| Total | 36,499 | 38,543 | 75,042 | 24,372 | 18,869 | 43,241 | 12,708 | 10,036 | 22,744 | 37,080 | 28,905 | 65,985 | 73,579 | 67,448 | 141,027 |

## TABLE 17 LATE SECONDARY AND CLIMAX SPECIES FOR THE REPLANTATION

| SPECIE | FAMILY |
|---|---|
| Alchornea triplinervia | EUPHORBIACEAE |
| Aspidosperma olivaceum | APOCYNACEAE |
| Cabralea canjerana | MELIACEAE |
| Cariniana estrellensis | LECYTHIDACEAE |
| Chrysophyllum flexuosum | SAPOTACEAE |
| Chrysophyllum viride | SAPOTACEAE |
| Cordia ecalyculata | BORAGINACEAE |
| Coussarea nodosa | RUBIACEAE |
| Cryptocarya moschata | LAURACEAE |
| Cupania oblongifolia | SAPINDACEAE |
| Didymopanax calvum | ARALIACEAE |
| Drymis brasiliensis | WINTERACEAE |
| Eriotheca pentaphylla | BOMBACACEAE |
| Eugenia brasiliensis | MYRTACEAE |
| Eugenia cerasifolia | MYRTACEAE |
| Eugenia involucrata | MYRTACEAE |
| Eugenia myrtifolia | MYRTACEAE |
| Eugenia pyriformis | MYRTACEAE |
| Euplassa cantareirae | PROTEACEAE |
| Euterpe edulis | PALMAE |
| Guatteria australis | ANNONACEAE |
| Guatteria dusenii | ANNONACEAE |
| Guatteria polycarpa | ANNONACEAE |
| Hieronyma alchorneoides | EUPHORBIACEAE |
| Hyrtella hebeclada | CHRYSOBALANACEAE |
| Ilex paraguariensis | AQUIFOLIACEAE |
| Ilex theezans | AQUIFOLIACEAE |
| Inga sessilis | LEG.-MIMOSOIDEAE |
| Licania kunthiana | CHRYSOBALANACEAE |
| Lonchocarpus denudatus | LEG.-FABOIDEAE |
| Manilkara subsericea | SAPOTACEAE |
| Matayba guianensis | SAPINDACEAE |
| Matayba junglandifolia | SAPINDACEAE |
| Maytenus evonymoides | CELASTRACEAE |
| Micropholis cuneata | SAPOTACEAE |
| Nectandra puberula | LAURACEAE |
| Nectandra rigida | LAURACEAE |
| Ocotea aciphylla | LAURACEAE |
| Ocotea catharinensis | LAURACEAE |
| Ocotea elegans | LAURACEAE |
| Ocotea odorifera | LAURACEAE |
| Ocotea paranapiacabensis | LAURACEAE |
| Ocotea paulensis | LAURACEAE |
| Ocotea porosa | LAURACEAE |
| Ocotea pulchella | LAURACEAE |
| Ocotea teleiandra | LAURACEAE |
| Paivaea langsdorfii | MYRTACEAE |
| Pera glabrata | EUPHORBIACEAE |
| Persea alba | LAURACEAE |
| Podocarpus sellowii | PODOCARPACEAE |
| Posoqueria acutifolia | RUBIACEAE |
| Pouteria torta | SAPOTACEAE |
| Prunus sellowii | ROSACEAE |
| Pseudobombax grandiflorum | BOMBACACEAE |
| Roupala brasiliensis | PROTEACEAE |
| Schizolobium parahyba | LEG.-CAESALPINOIDEAE |
| Sclerolobium denudatum | LEG.-CAESALPINOIDEAE |
| Siparuna brasiliensis | MONIMIACEAE |
| Sloanea guianense | ELAEOCARPACEAE |
| Sloanea monosperma | ELAEOCARPACEAE |
| Swartzia langsdorfii | LEG.-FABOIDEAE |
| Syagrus pseudococus | PALMAE |
| Tabebuia alba | BIGNONIACEAE |
| Tabebuia heptaphylla | BIGNONIACEAE |
| Tapirira guianensis | ANACARDIACEAE |
| Virola gardneri | MYRISTICACEAE |
| Virola oleifera | MYRISTICACEAE |
| Vochysia magnifica | VOCHYSIACEAE |
| Vochysia selloii | VOCHYSIACEAE |
| Xylopia brasiliensis | ANNONACEAE |

TABLE 18 WORK QUANTITIES FOR SEDIMENT RUN-OFF DISASTER PREVENTION WORKS

Unit : m3

| Dam No. | Item | Dam | Channel | Groundsill | Total |
|---|---|---|---|---|---|
| 2-1 | V | 22,000 | ( 530 m ) | 1,200 | 23,200 |
| | Ve | 35,200 | 70,800 | 15,700 | 121,700 |
| 3-1 | V | 9,800 | ( 490 m ) | 200 | 10,200 |
| | Ve | 8,500 | 31,200 | 100 | 39,800 |
| 7-1 | V | 3,600 | ( 250 m ) | 1,000 | 4,600 |
| | Ve | 10,300 | 39,400 | 10,500 | 60,200 |
| 7-3 | V | 3,800 | ( 0 m ) | - | 3,800 |
| | Ve | 2,400 | - | - | 2,400 |
| 7-4 | V | 2,000 | ( 0 m ) | - | 2,000 |
| | Ve | 1,200 | - | - | 1,200 |
| Sub-total | V | 9,400 | ( 250 m ) | 1,000 | 10,400 |
| | Ve | 13,900 | 39,400 | 10,500 | 63,800 |
| 8-1 | V | 3,700 | ( 440 m ) | 400 | 4,100 |
| | Ve | 6,400 | 23,200 | 4,000 | 33,600 |
| 10-1 | V | 1,100 | ( 0 m ) | - | 1,100 |
| | Ve | 600 | - | - | 600 |
| 11-1 | V | 7,300 | ( 410 m ) | 1,100 | 8,400 |
| | Ve | 4,400 | 12,300 | 15,700 | 32,400 |
| 12-1 | V | 4,900 | ( 750 m ) | 900 | 5,800 |
| | Ve | 3,900 | 64,000 | 19,000 | 86,900 |
| Total | V | 58,200 | ( 2,870 m ) | 4,800 | 63,000 |
| | Ve | 72,900 | 240,900 | 65,000 | 378,800 |

Note : V ; volume of structure
Ve ; excavation volume

TABLE 19 WORK QUANTITIES FOR FLOOD DISASTER PREVENTION WORKS

| Item | | Unit | Quantity |
|---|---|---|---|
| (1) | Dike (L=9.3km) | | |
| | 1) Gravel metalling | m3 | 6,600 |
| | 2) Excavation | m3 | 329,000 |
| | 3) Dredging | m3 | 141,000 |
| | 4) Embankment | m3 | 255,000 |
| | 5) Sod Facing | m2 | 111,600 |
| (2) | Revetment (L=1.45km) | | |
| | 1) Wet stone masonry | m2 | 9,800 |
| | 2) Concrete block | m3 | 170 |
| | 3) Berm concrete | m3 | 120 |
| | 4) Gabion | m3 | 2,900 |
| (3) | Culvert (6 Sites) | | |
| | 1) Excavation | m3 | 2,300 |
| | 2) Concrete | m3 | 550 |
| | 3) Reinforcement bar | ton | 30 |
| | 4) Form | m2 | 960 |
| | 5) RC pile | m | 136 |
| | 6) Gate | ton | 8 |
| (4) | Intake Weir (1 Site) | | |
| | 1) Excavation | m3 | 2,000 |
| | 2) Concrete | m3 | 270 |
| | 3) Wet stone masonry | m2 | 460 |
| | 4) Concrete block | m3 | 840 |
| (5) | Parapet wall (1 Site) | | |
| | 1) Excavation | m3 | 680 |
| | 2) Concrete | m3 | 310 |
| | 3) Reinforcement bar | ton | 25 |
| | 4) Form | m2 | 870 |
| (6) | Road Bridge (1 Site) | | |
| | 1) Embankment | m3 | 5,100 |
| | 2) Super structure (Steel) | ton | 74 |
| | 3) Sub structure (Concrete) | m3 | 350 |
| | 4) Steel pile | m | 450 |
| (7) | Railway Bridge (1 Site) | | |
| | 1) Embankment | m3 | 5,240 |
| | 2) Ballast | m3 | 550 |
| | 3) Super structure (Steel) | ton | 270 |
| | 4) Sub structure (Concrete) | m3 | 440 |
| | 5) Steel pile | m | 620 |

TABLE 20 UNIT COST REVISED

| Item | Unit | Unit Cost (US$) F/C | Unit Cost (US$) L/C | Total |
|---|---|---|---|---|
| (For Sediment Control) | | | | |
| (1) Excavation | m3 | 1.7 | 1.8 | 3.5 |
| (2) Outer Concrete | m3 | 76.7 | 83.3 | 160.1 |
| (3) Inner Concrete | m3 | 71.3 | 80.4 | 151.6 |
| (4) Form | m2 | 7.7 | 15.4 | 23.1 |
| (5) Wetstone Masonry | m2 | 13.6 | 23.4 | 36.9 |
| (6) Concrete Block | m3 | 60.9 | 94.6 | 155.5 |
| (7) Berm Concrete | m3 | 60.9 | 94.6 | 155.5 |
| (8) Gabion | m3 | 18.4 | 30.3 | 48.7 |
| (For Flood Control) | | | | |
| (9) Gravel Metalling | m3 | 12.1 | 18.4 | 30.4 |
| (10) Excavation | m3 | 2.1 | 1.3 | 3.4 |
| (11) Dredging | m3 | 2.4 | 1.6 | 4.0 |
| (12) Embankment | m3 | 2.2 | 1.4 | 3.6 |
| (13) Sod Facing | m2 | 0.2 | 0.6 | 0.7 |
| (14) Concrete | m3 | 74.0 | 81.8 | 155.8 |
| (15) Reinforcement Bar | ton | 642.2 | 488.2 | 1130.4 |
| (16) RC Pile | m | 12.0 | 8.0 | 20.0 |
| (17) Gate | ton | 3000.0 | 2000.0 | 5000.0 |
| (18) Steel Pile | m | 162.0 | 108.0 | 270.0 |
| (19) Ballast | m3 | 16.2 | 35.7 | 51.8 |
| (For Compensation) | | | | |
| (20) Residence | m2 | | 400 | 400 |
| (21) Residential Area | m2 | | 2.5 | 2.5 |
| (22) Non-Residential Area | m2 | | 0.7 | 0.7 |
| (23) Factory Area | m2 | | 1.3 | 1.3 |

TABLE 21 SUMMARY OF FINANCIAL COST FOR SEDIMENT DISASTER PREVENTION WORKS IN EACH BASIN (FOR PRIORITY PROJECT)

Unit : 1,000 US$

| Item | Basin 2 | | | Basin 3 | | | Basin 7 | | | Basin 8 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL |
| I Preparatory Work (15% of II) | 368 | 413 | 781 | 160 | 183 | 343 | 168 | 188 | 356 | 74 | 86 | 160 |
| II Construction Cost | 2,453 | 2,751 | 5,204 | 1,068 | 1,218 | 2,286 | 1,120 | 1,253 | 2,373 | 495 | 573 | 1,068 |
| III Compensation Cost | | 11 | 11 | | 10 | 10 | | 9 | 9 | | 4 | 4 |
| IV Administration Cost (5% of I + II) | | 299 | 299 | | 131 | 131 | | 136 | 136 | | 61 | 61 |
| V Engineering Service (10% of I + II) | 479 | 120 | 598 | 210 | 53 | 263 | 218 | 55 | 273 | 98 | 25 | 123 |
| VI Physical Contingency (15% of I+II+III+IV+V) | 495 | 539 | 1,034 | 216 | 239 | 455 | 226 | 246 | 472 | 100 | 112 | 212 |
| VII Price Contingency (F/C 3%,L/C 3%) | 527 | 574 | 1102 | 230 | 255 | 485 | 241 | 262 | 503 | 107 | 120 | 226 |
| Total | 4,322 | 4,707 | 9,029 | 1,884 | 2,089 | 3,973 | 1,973 | 2,149 | 4,122 | 874 | 981 | 1,855 |

| Item | Basin 10 | | | Basin 11 | | | Basin 12 | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | Total |
| I Preparatory Work (15% of II) | 15 | 17 | 32 | 132 | 150 | 281 | 122 | 141 | 263 | 1,039 | 1,177 | 2,216 |
| II Construction Cost | 102 | 114 | 216 | 878 | 997 | 1,875 | 810 | 940 | 1,750 | 6,926 | 7,846 | 14,772 |
| III Compensation Cost | | 0 | 0 | | 13 | 13 | | 15 | 15 | | 62 | ERR |
| IV Administration Cost (5% of I + II) | | 12 | 12 | | 108 | 108 | | 101 | 101 | | 849 | ERR |
| V Engineering Service (10% of I + II) | 20 | 5 | 25 | 173 | 43 | 216 | 161 | 40 | 201 | 1,359 | 340 | 1,699 |
| VI Physical Contingency (15% of I+II+III+IV+V) | 21 | 22 | 43 | 177 | 197 | 374 | 164 | 186 | 349 | 1,399 | 1,541 | 2,940 |
| VII Price Contingency (F/C 3%,L/C 3%) | 22 | 24 | 46 | 189 | 209 | 398 | 175 | 198 | 372 | 1,490 | 1,642 | 3,133 |
| Total | 180 | 194 | 374 | 1,549 | 1,717 | 3,265 | 1,431 | 1,620 | 3,051 | 12,213 | 13,457 | 25,670 |

TABLE 22 FINANCIAL COST FOR PRIORITY PROJECT

Unit : 1,000 US$

| Item | Sediment Disaster Prevention Works | | | Flood Disaster Prevention Works Moji River | | | (Sediment+Flood) Disaster Prevention Works | | |
|---|---|---|---|---|---|---|---|---|---|
| | F/C | L/C | TOTAL | F/C | L/C | TOTAL | F/C | L/C | TOTAL |
| I Preparatory Work (5-15% of II) | 1,039 | 1,177 | 2,216 | 198 | 156 | 354 | 1,237 | 1,333 | 2,570 |
| II Construction Cost | 6,926 | 7,846 | 14,772 | 3,959 | 3,125 | 7,084 | 10,885 | 10,971 | 21,856 |
| III Compensation Cost | | 62 | 62 | | 180 | 180 | | 242 | 242 |
| IV Administration Cost (5% of I + II) | | 849 | 849 | | 372 | 372 | | 1,221 | 1,221 |
| V Engineering Service (10% of I + II) | 1,359 | 340 | 1,699 | 595 | 149 | 744 | 1,954 | 489 | 2,443 |
| VI Physical Contingency (15% of I+II+III+IV+V) | 1,399 | 1,541 | 2,940 | 713 | 597 | 1,310 | 2,111 | 2,138 | 4,250 |
| VII Price Contigentcy (F/C 3%, L/C 3%) | 1,490 | 1,642 | 3,133 | 760 | 637 | 1,396 | 2,250 | 2,279 | 4,529 |
| Total | 12,213 | 13,457 | 25,670 | 6,224 | 5,216 | 11,440 | 18,437 | 18,673 | 37,111 |

# FIGURES

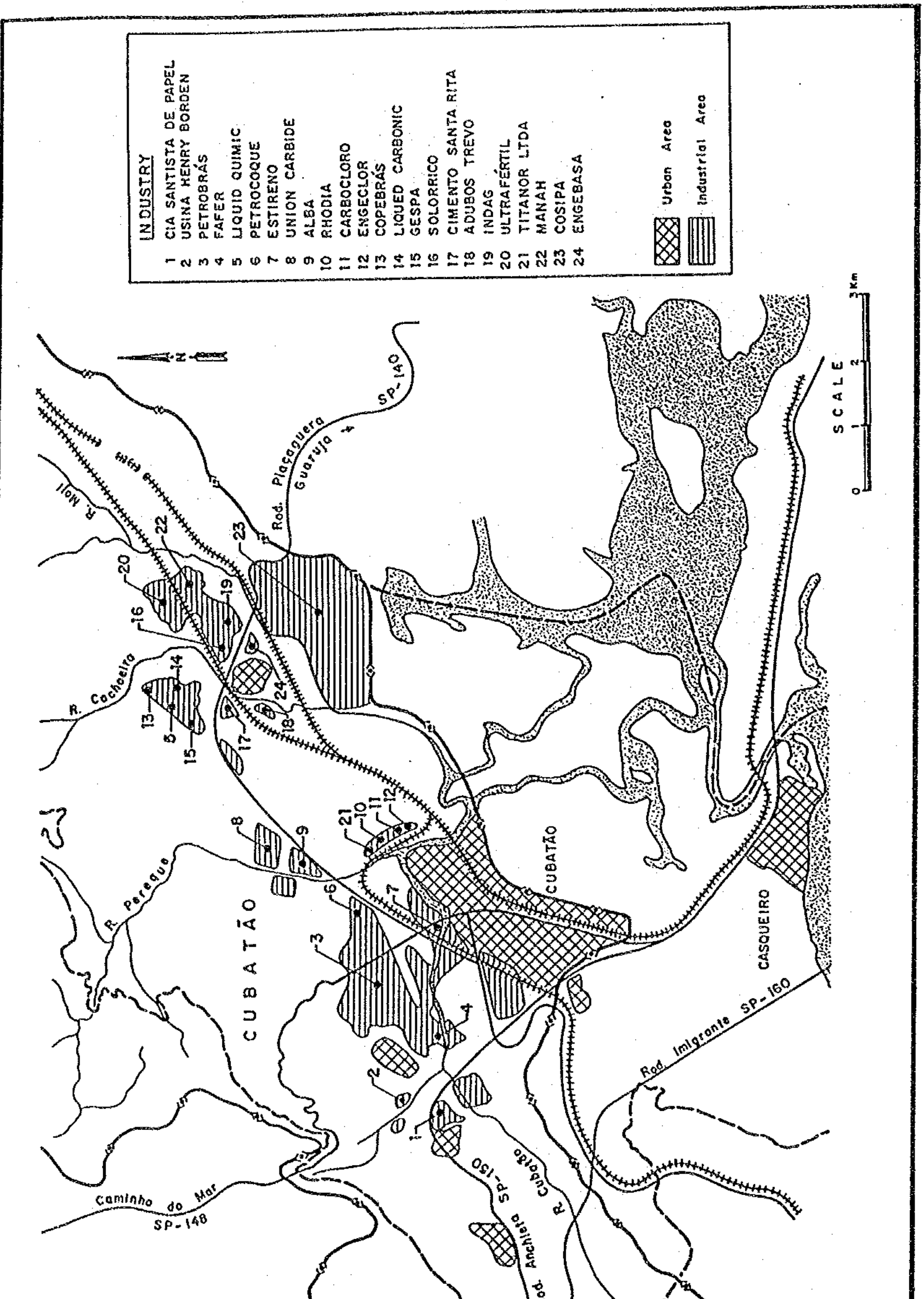



FIG. 1
LOCATION MAP OF MAJOR INDUSTRIAL ESTABLISHMENTS IN CUBATÃO

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

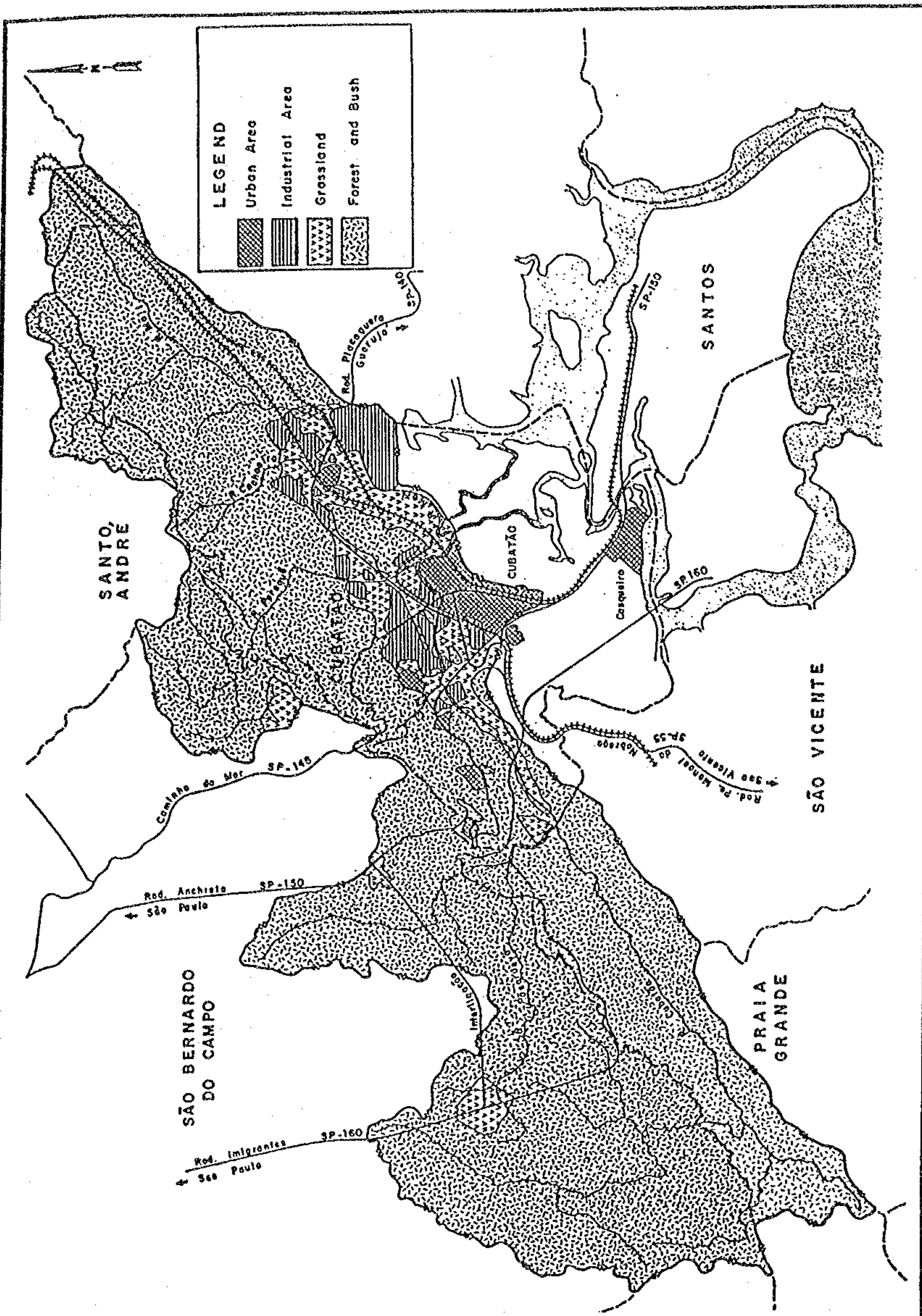



FIG. 2
PRESENT LAND USE MAP
IN STUDY AREA : 1990

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

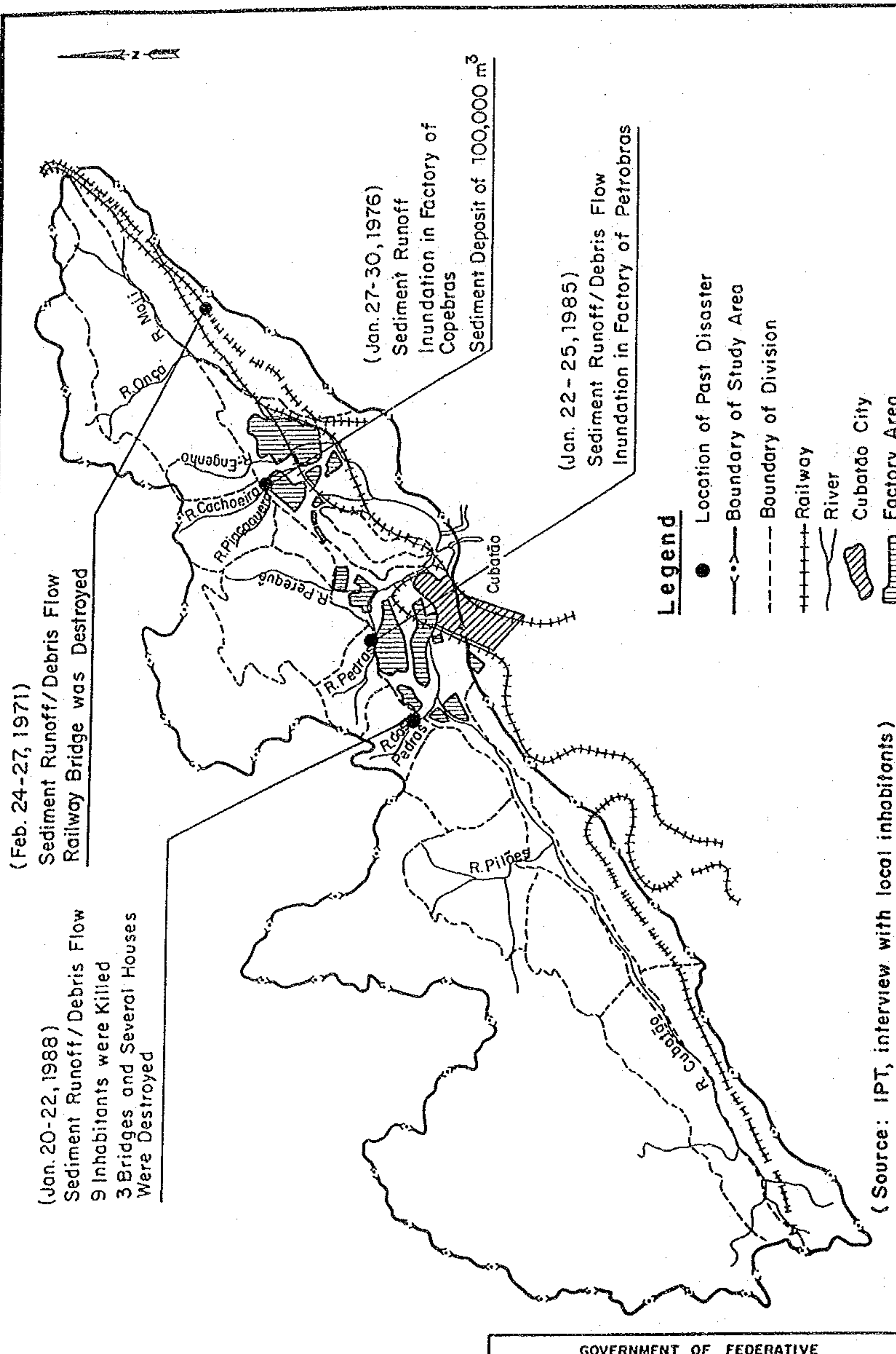



FIG. 3
LOCATION MAP OF PAST
MAJOR DISASTERS

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

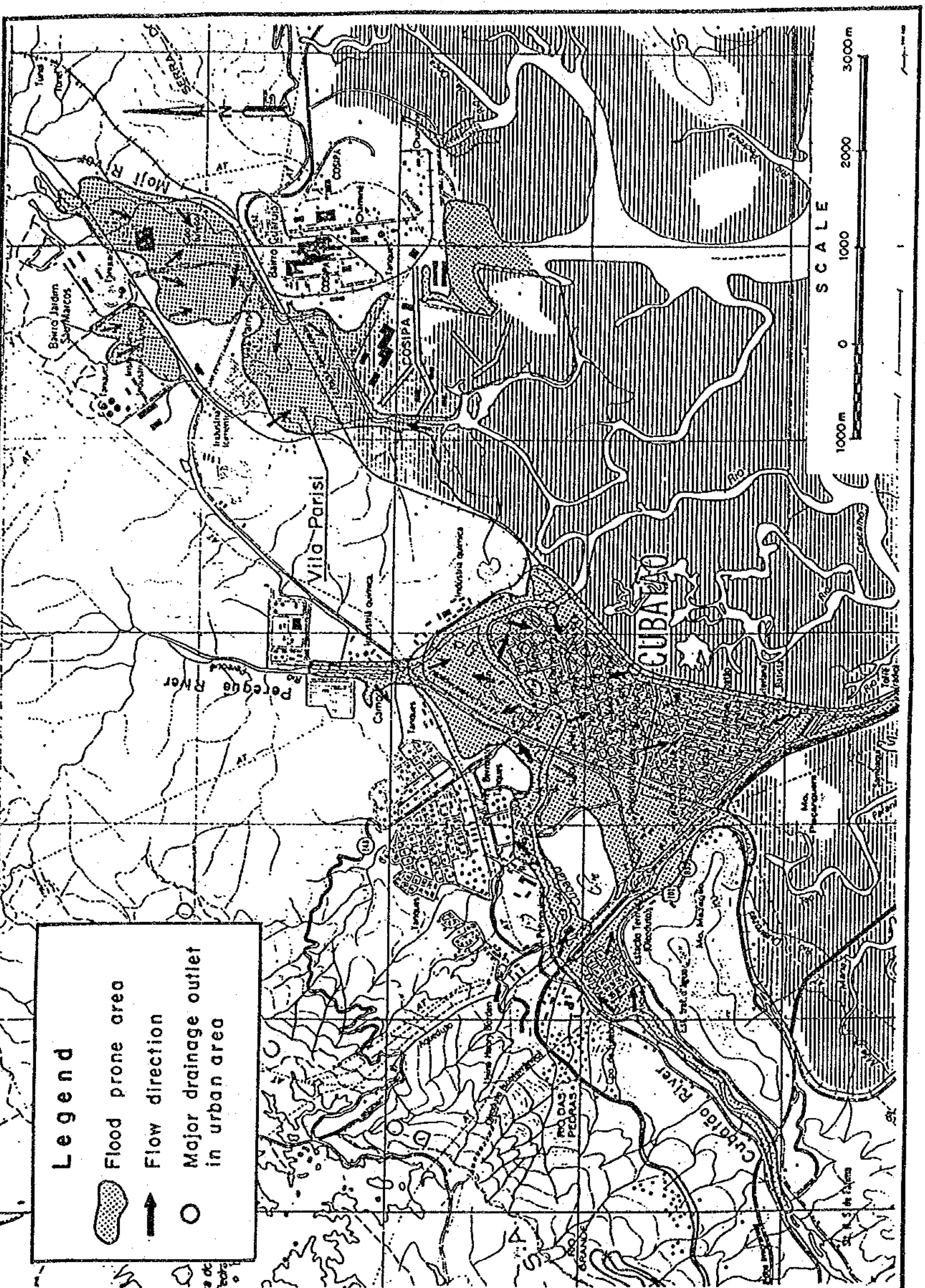
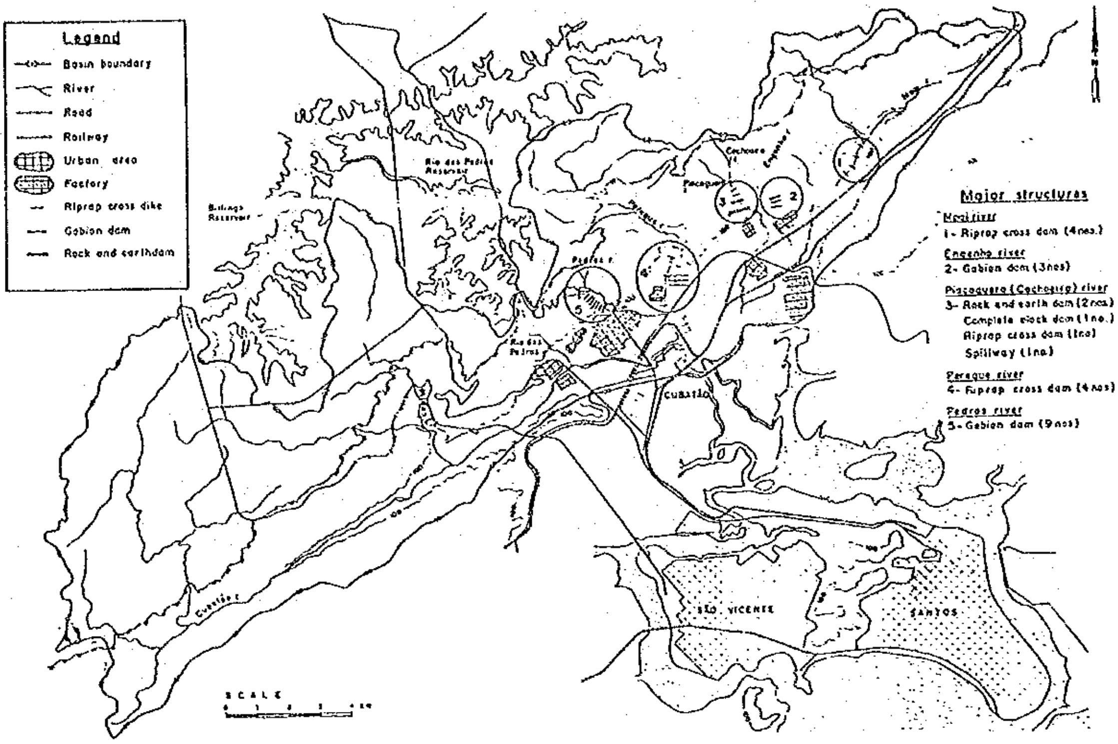



FIG. 4
LOCATION MAP OF FLOOD PROTECTION AREA

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

## Sediment Runoff Control




## Flood Control

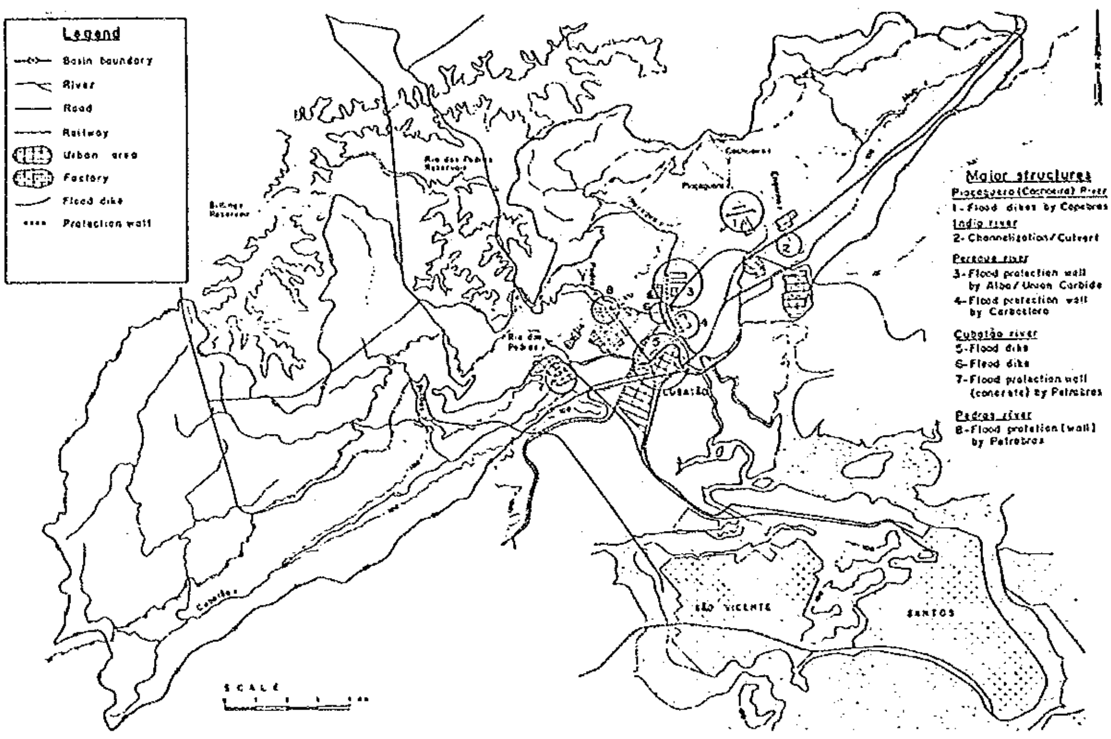



**FIG. 5**

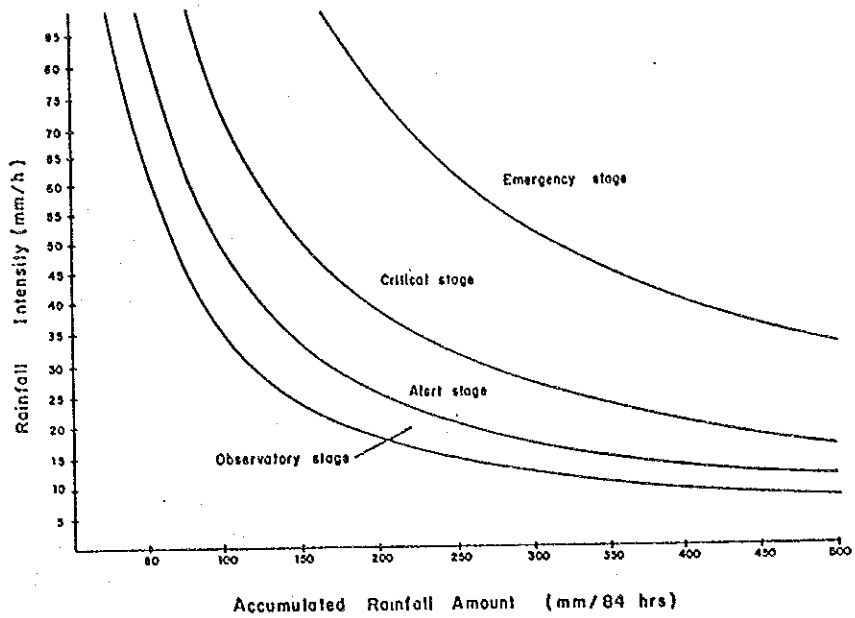
**LOCATIONS OF EXISTING DISASTER PREVENTION WORKS FOR SEDIMENT RUNOFF AND FLOOD CONTROL**

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

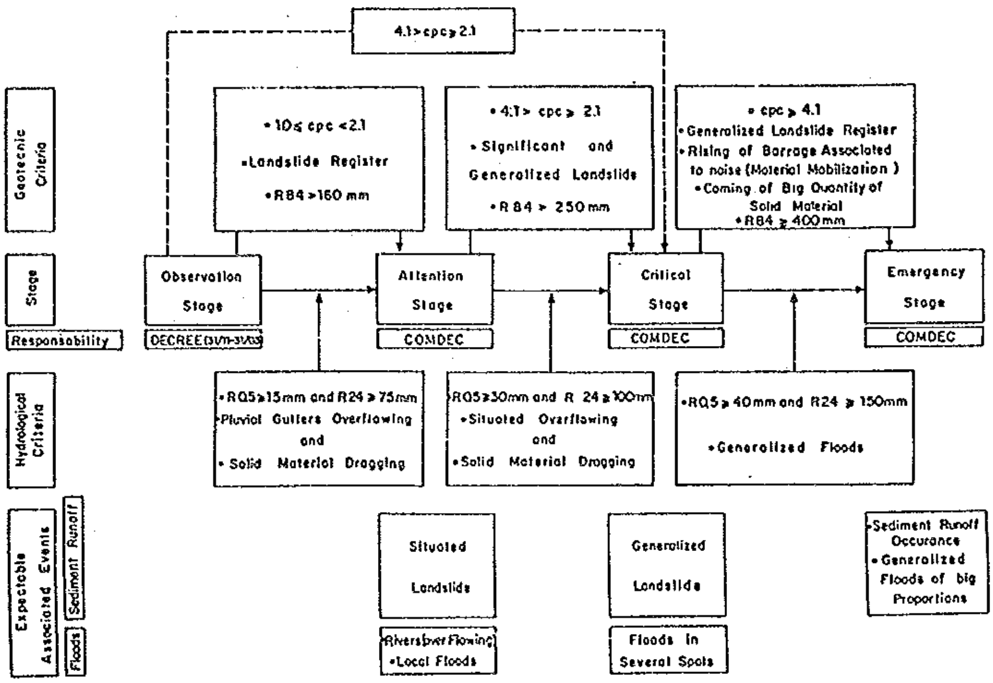
## Guide Line Curves of Warning System




Source : Divisão de Operações de Risco ( EO) in Cetesb

## Action Flow Chart of Civil Defence Plan

**Criteria on Changing Stages**




Source: Secretariat of Environment (SMA) and CETESB

**FIG. 6**
**GUIDE LINES OF WARNING SYSTEMS OF CUBATÃO RIVER BASIN**

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

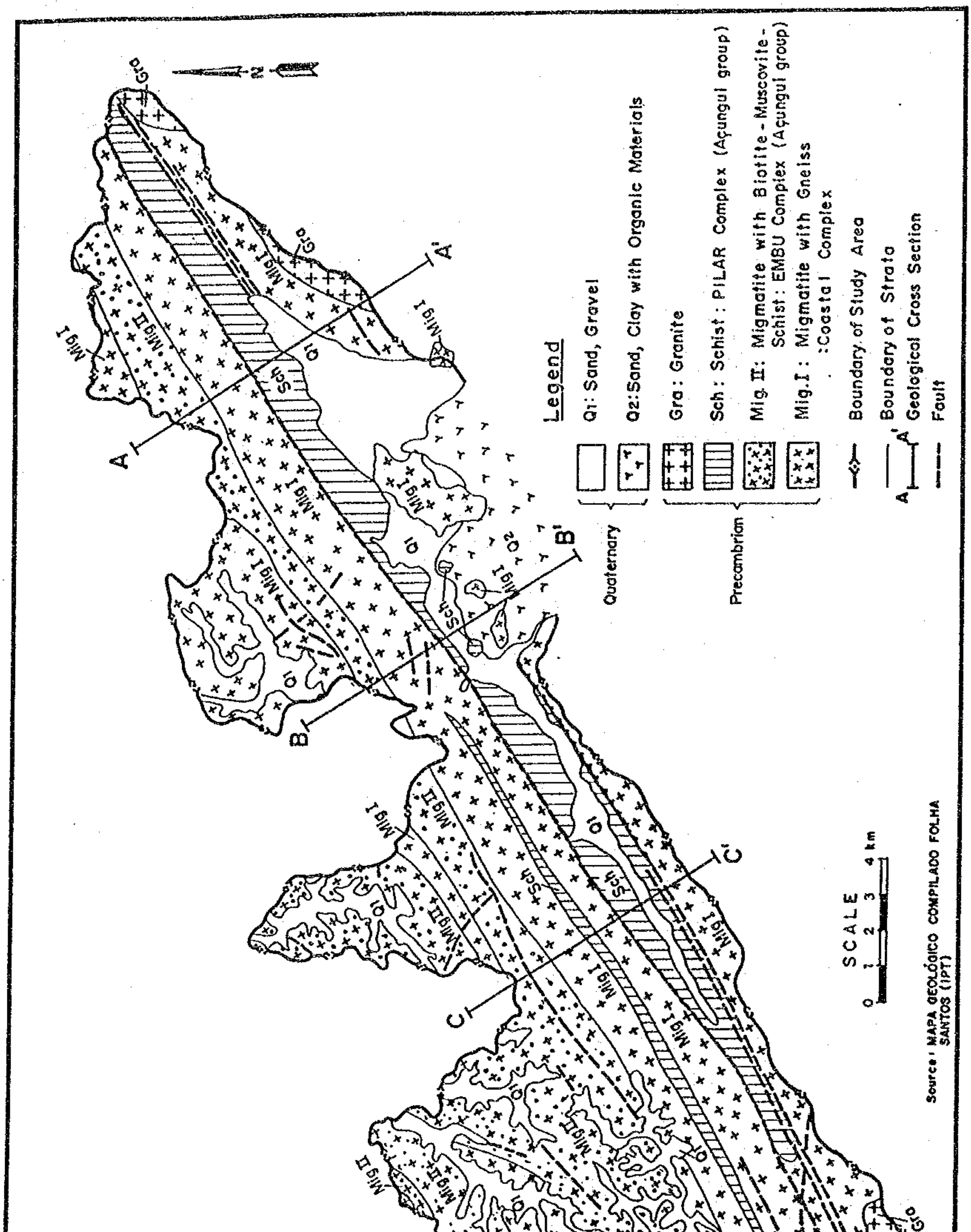



FIG. 7
GEOLOGICAL MAP OF THE STUDY AREA

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

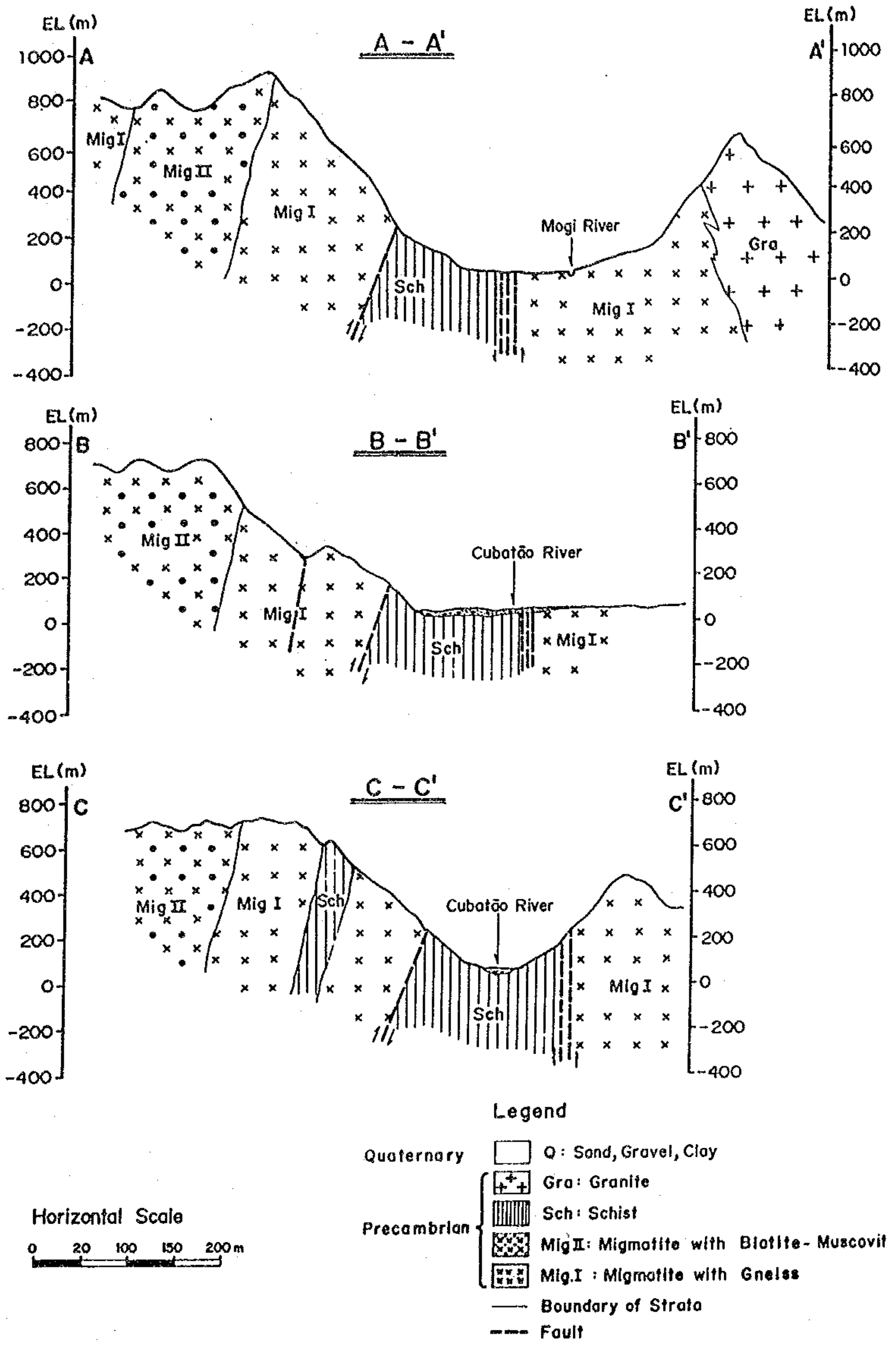



FIG. 8
GEOLOGICAL PROFILES OF THE STUDY AREA

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

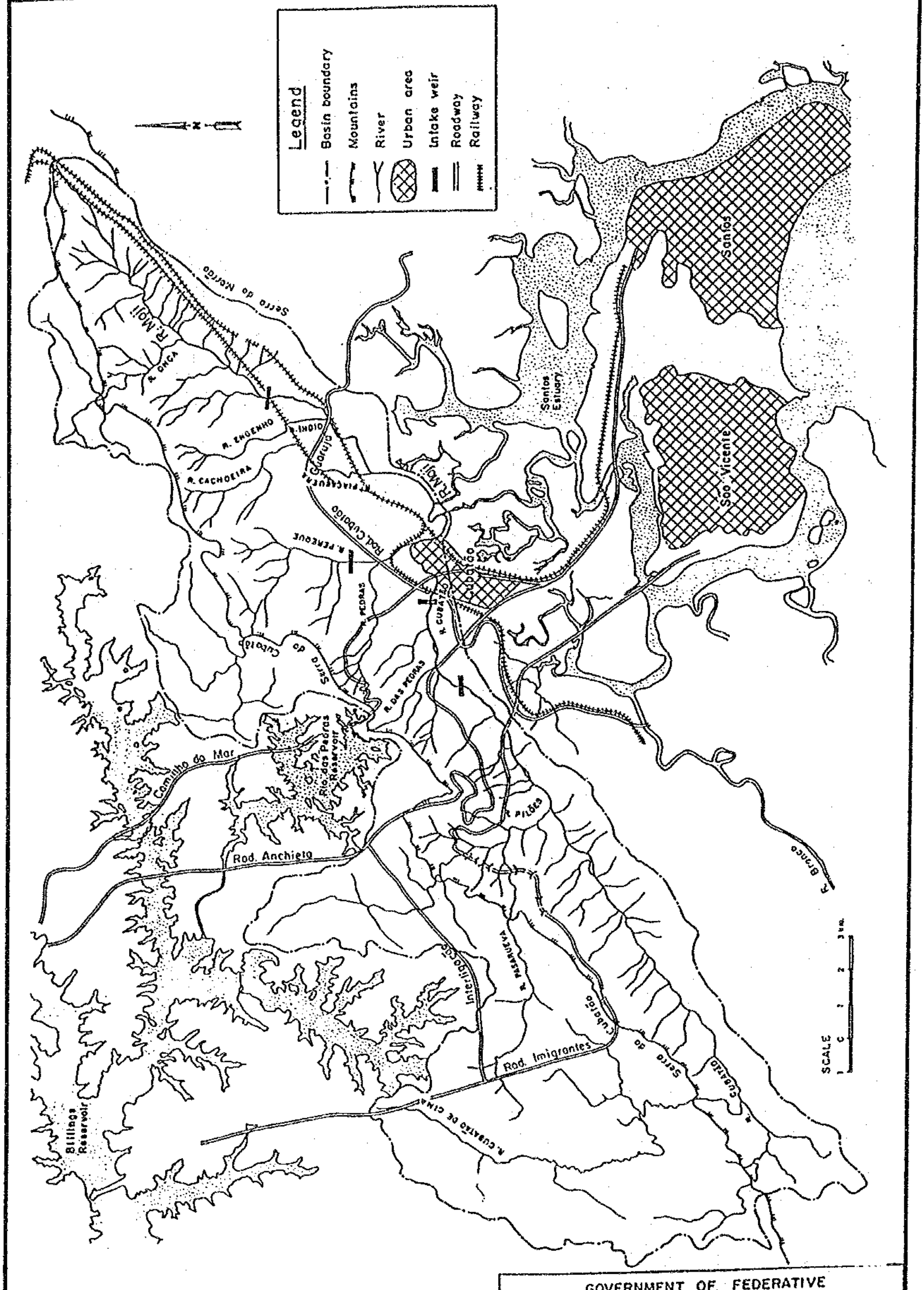
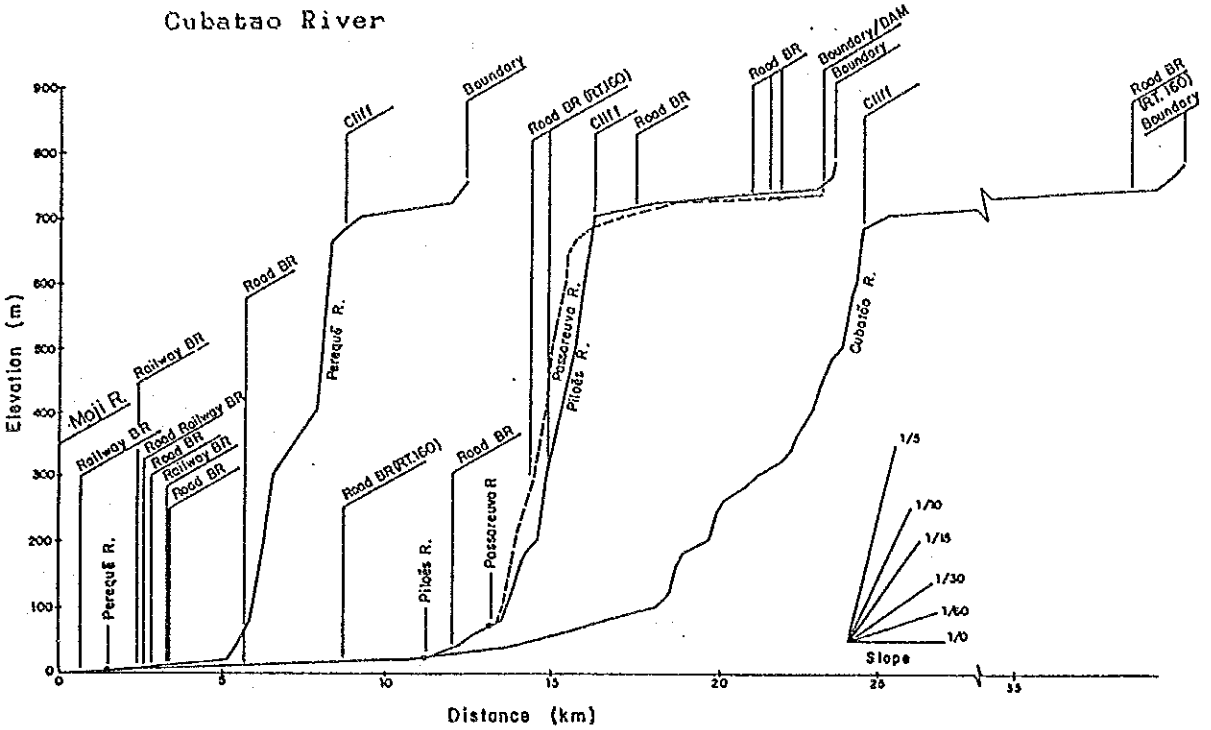



FIG. 9
RIVER BASIN AND SYSTEM

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



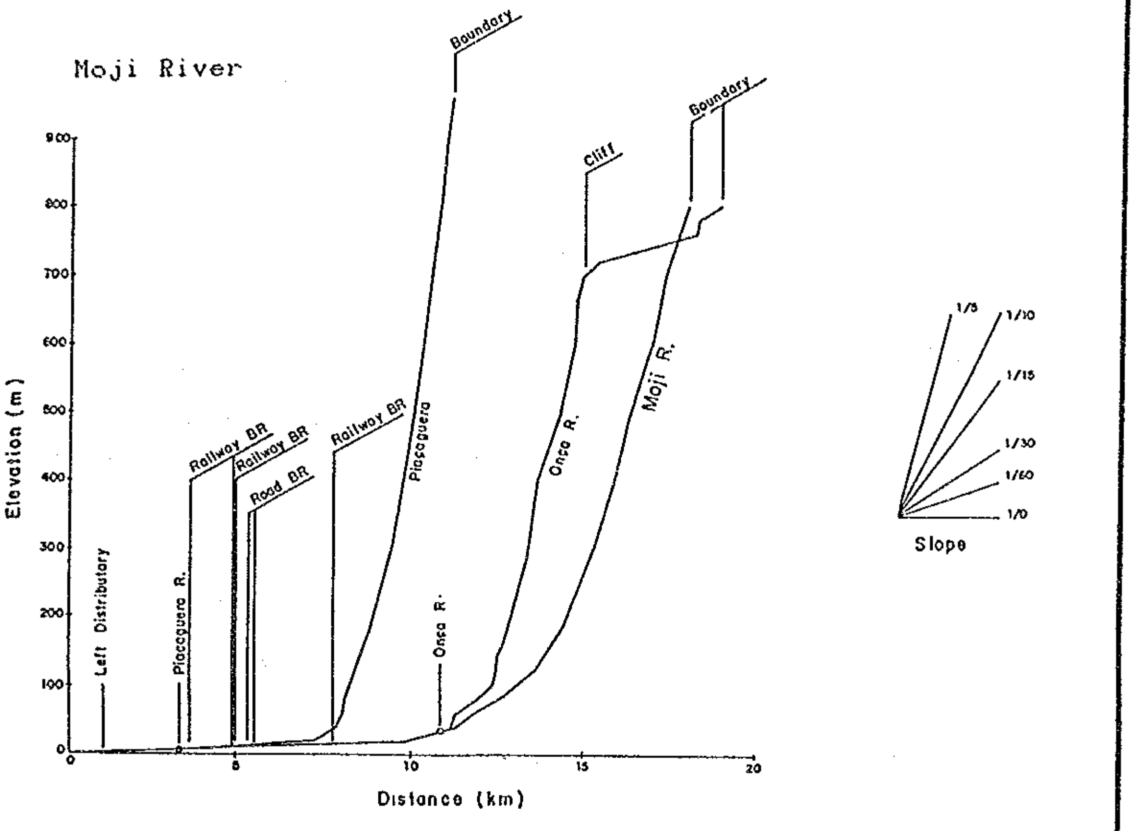
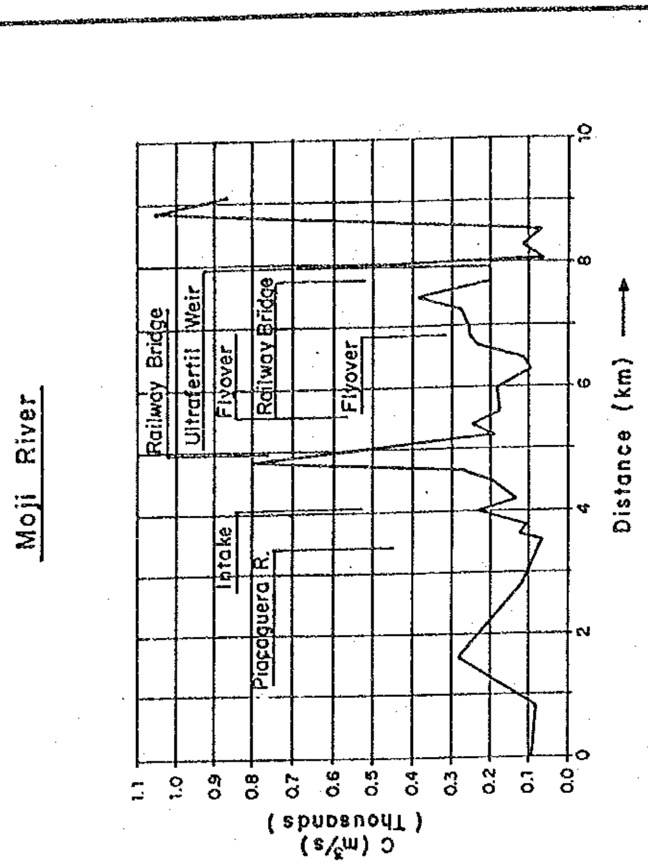




**FIG.10**
**LONGITUDINAL PROFILES OF CUBATÃO AND MOJI RIVERS**

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY




Note:

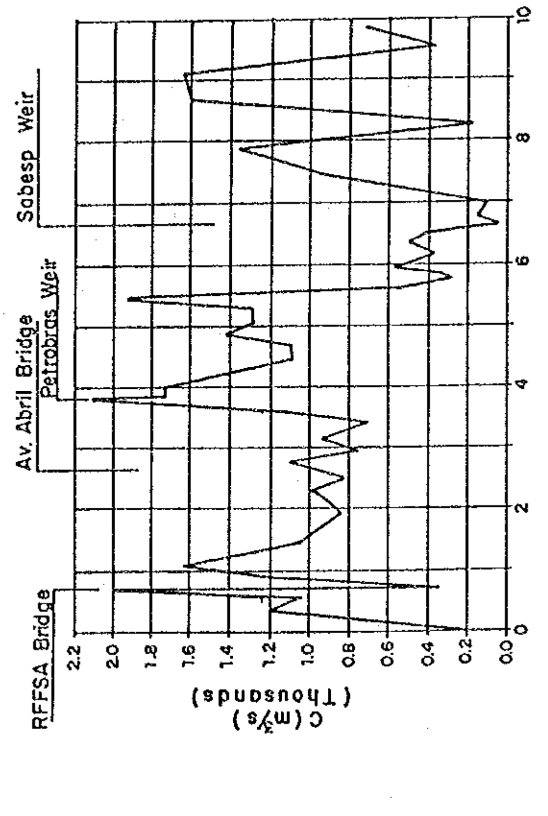
1- Water level is Calculated by Nonuniform Flow Method.

2- Discharge Rating Curve Shown in Fig. I.16 is Adopted.

3- Bankful Capacity is Estimated as Capacity of Channel Below the Lower Bank Elevation of Both Banks

4- Distance and its Sections are Presented in Figs F18 and F19

The Details are Presented in Data Book



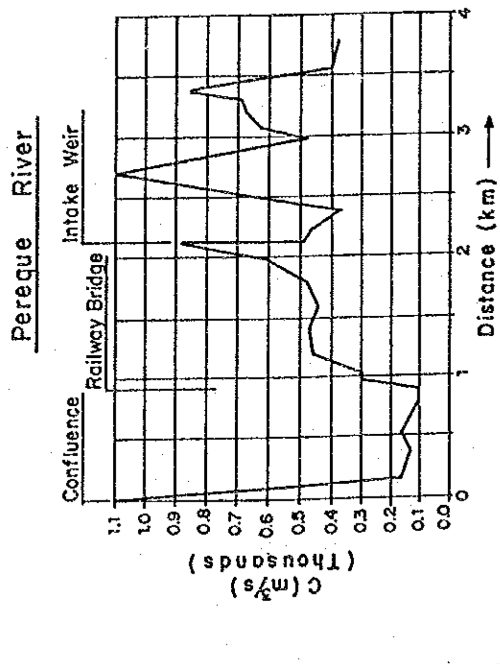
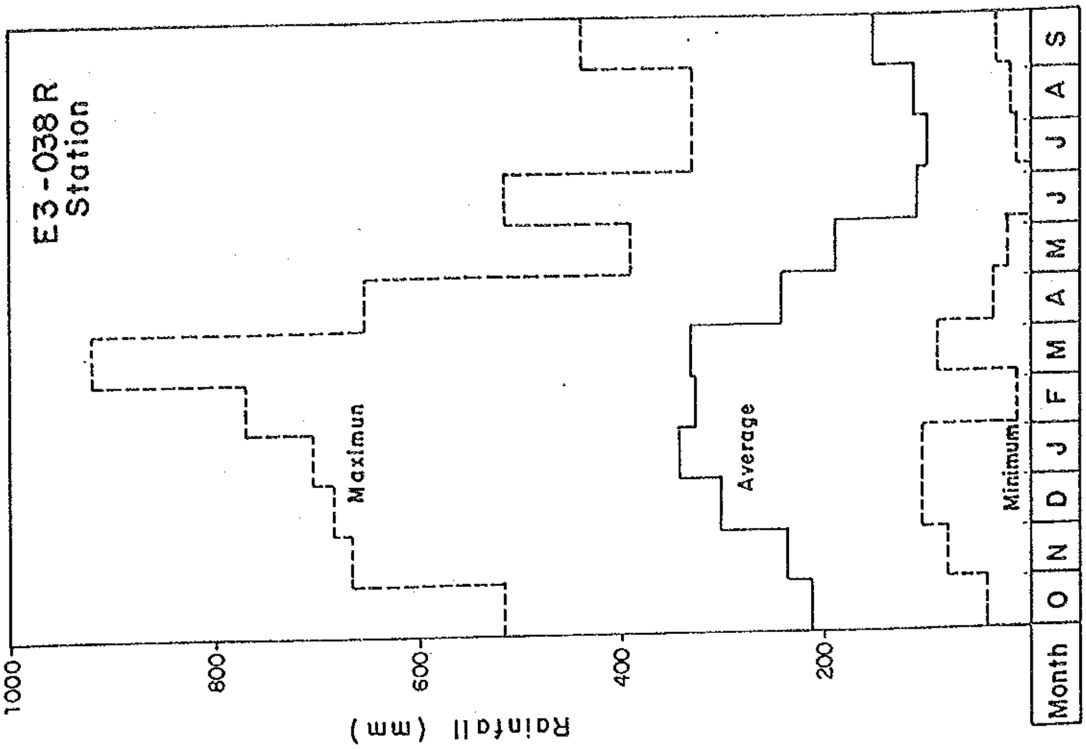




FIG.11
ESTIMATED CARRYING CAPACITY
OF CHANNEL

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



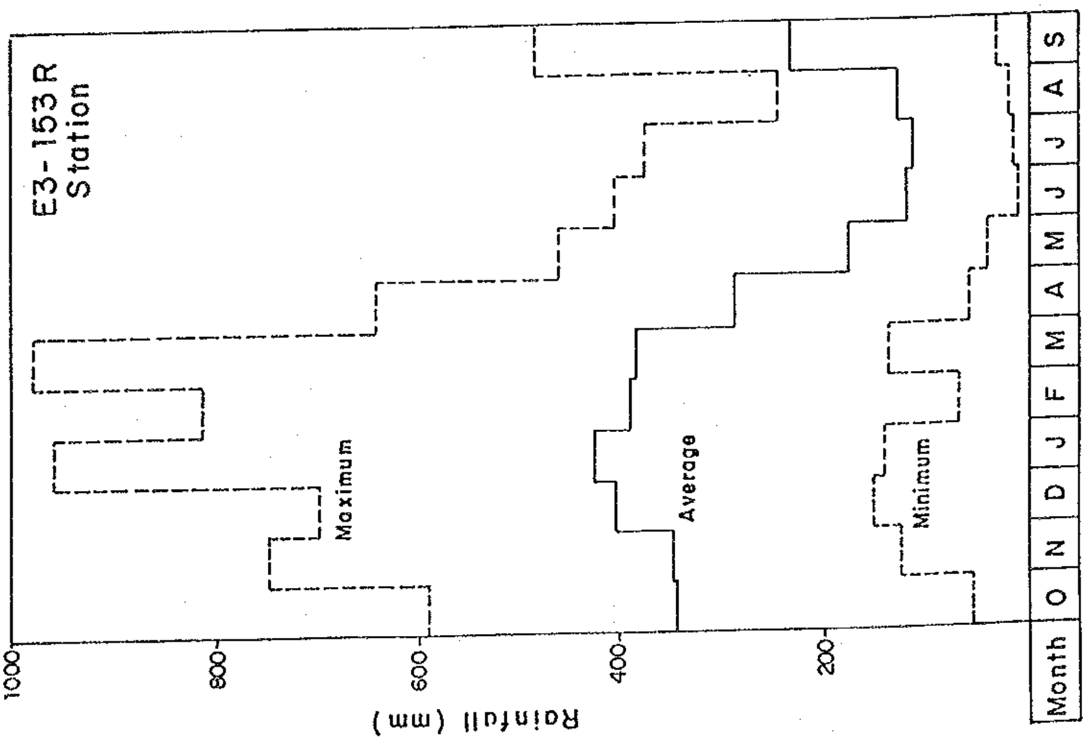
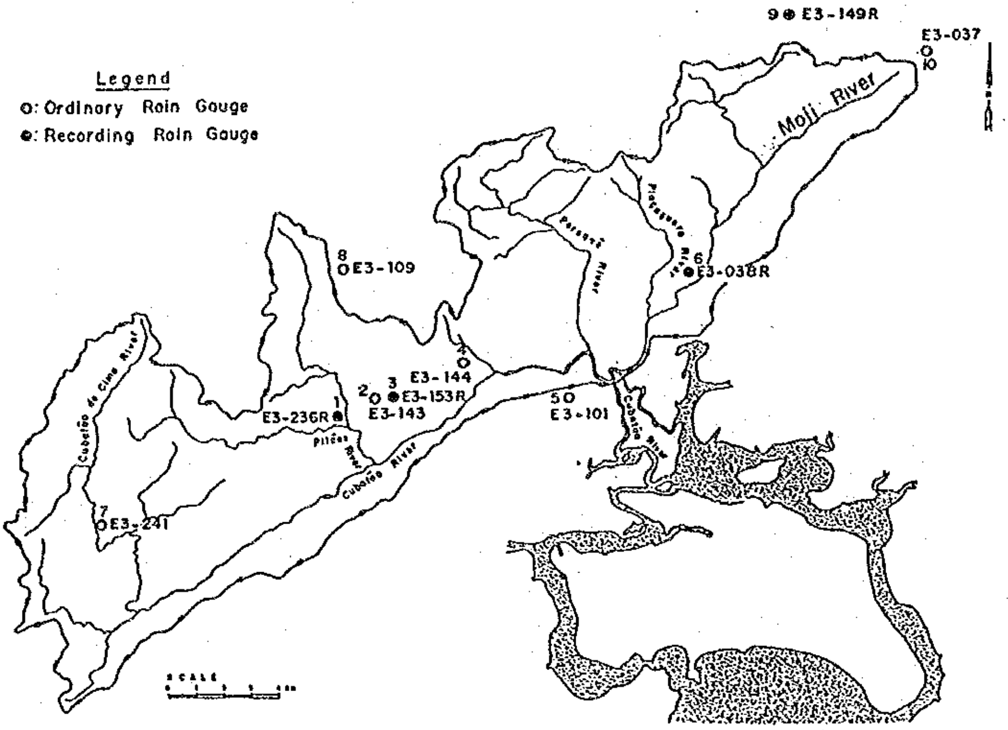




**FIG.12**
**MONTHLY DISTRIBUTION OF RAINFALL**

| |
|---|
| GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL<br>THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO |
| JAPAN INTERNATIONAL COOPERATION AGENCY |




AVAILABILITY OF RAINFALL RECORDS

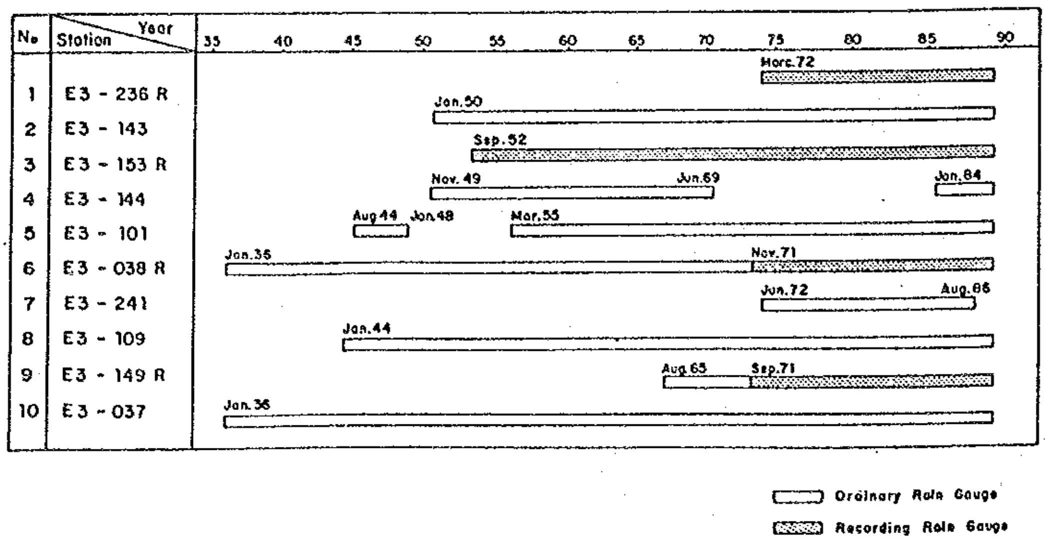
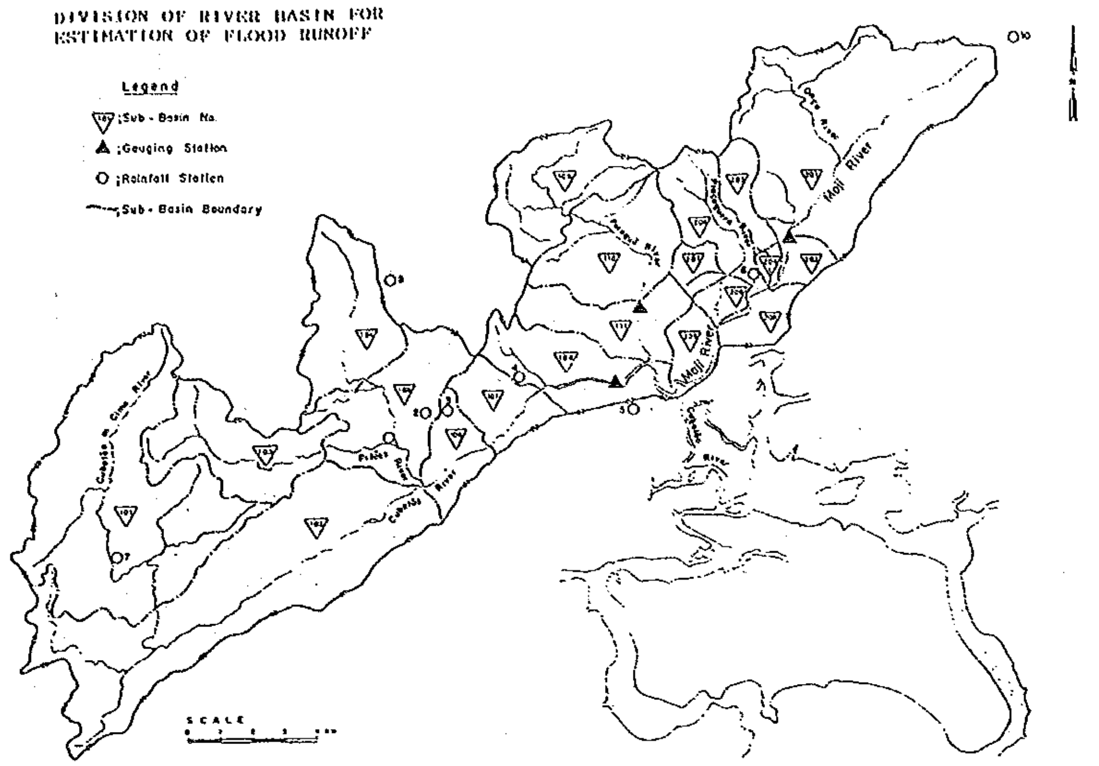



**FIG.13**
**LOCATION MAP OF RAINFALL STATIONS AND THEIR RECORD AVAILABILITY**

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



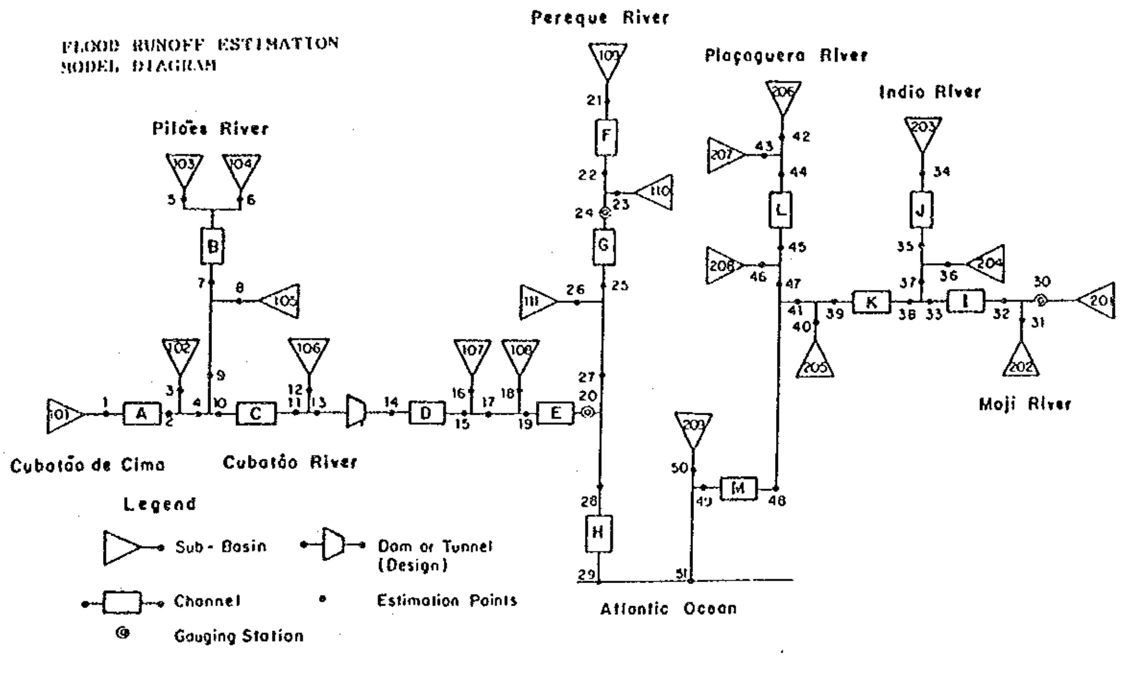
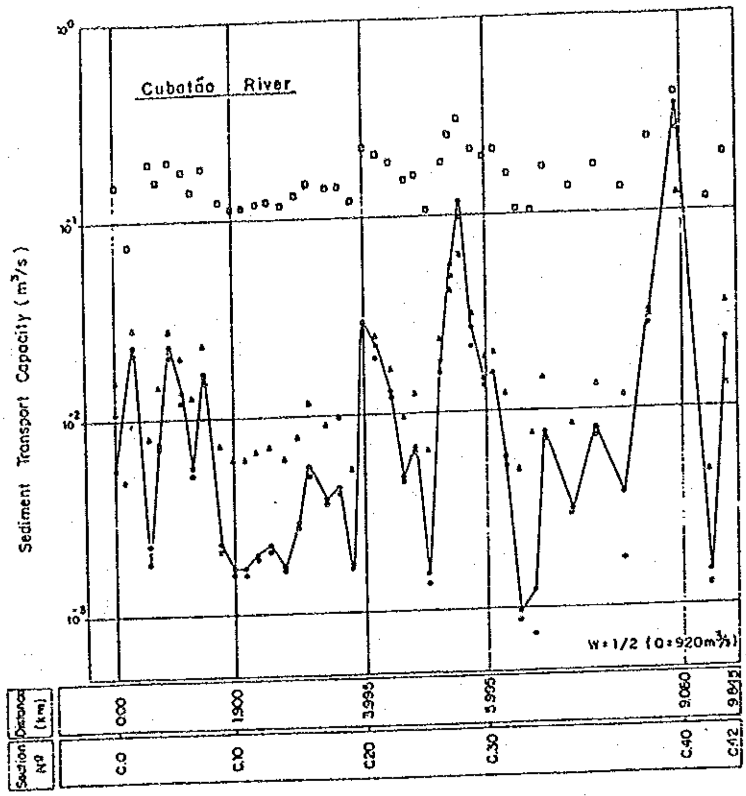



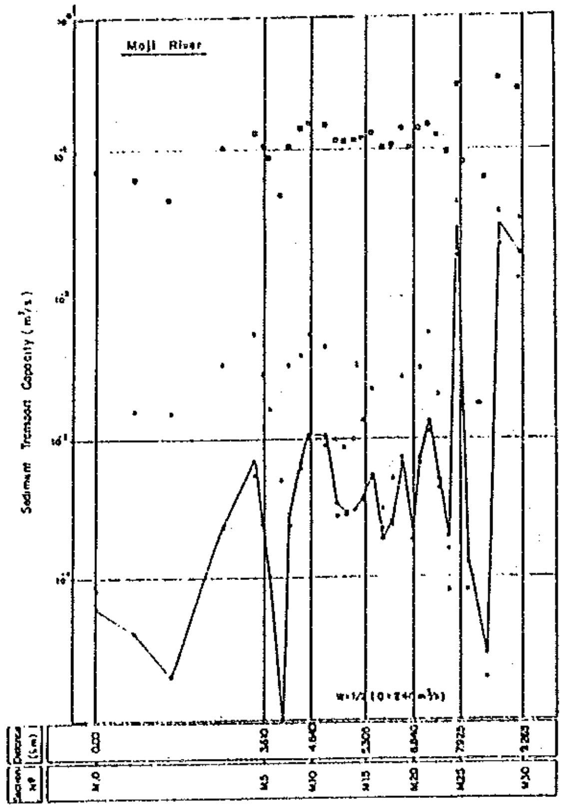

**FIG.14**
**DIVISION OF RIVER BASIN FOR ESTIMATION OF FLOOD RUNOFF**

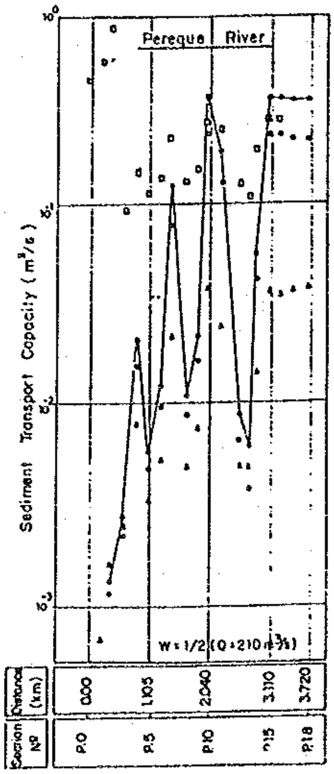
GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY




Legend

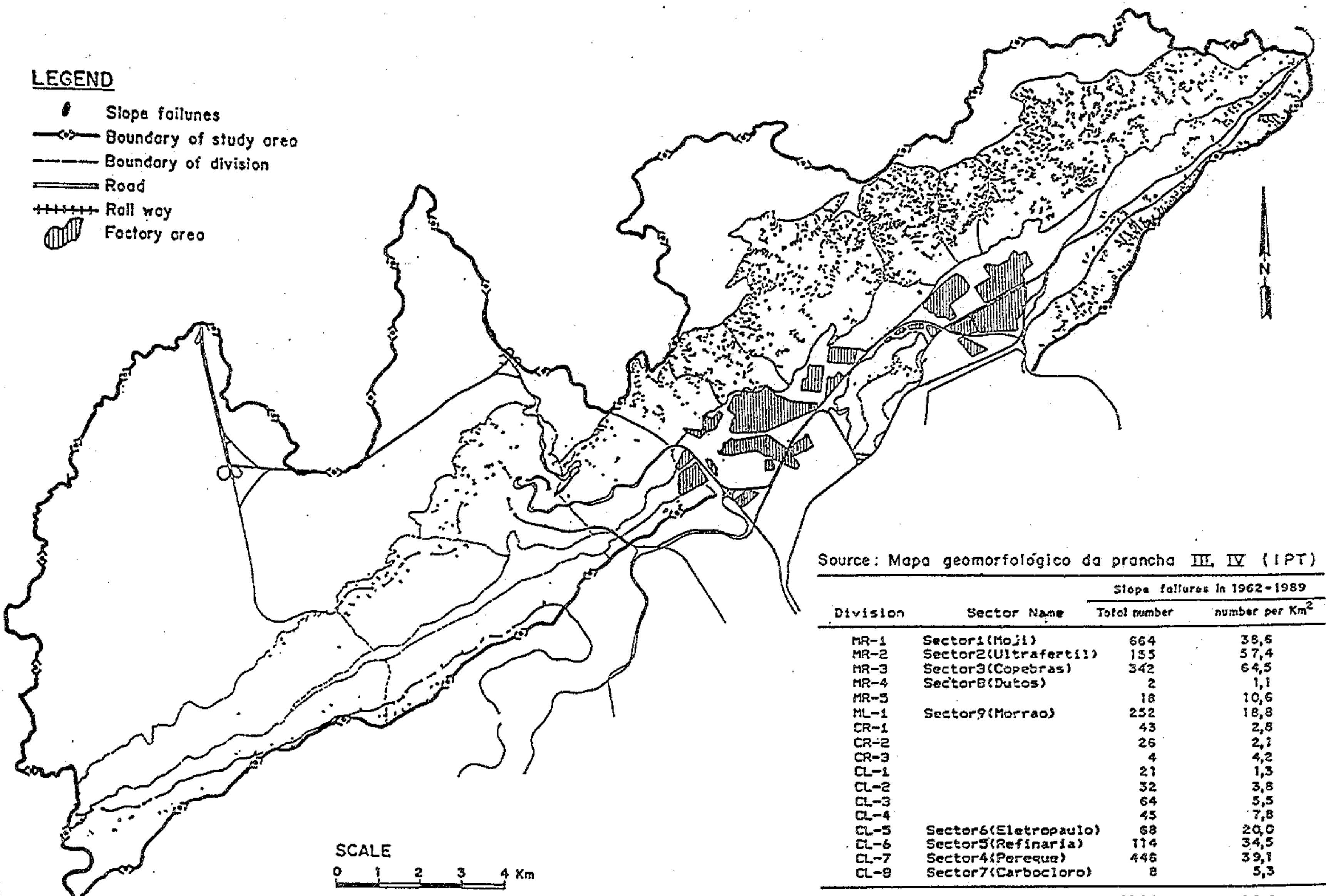
- Sato - Kikkawa - Ashida Formula
- Brown Formula
- Engelund - Hansen Formula

FIG.15
SEDIMENT TRANSPORT CAPACITY
IN EXISTING CHANNEL

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY




| Division | Sector Name | Slope failures in 1962-1989: Total number | Slope failures in 1962-1989: number per $Km^2$ |
|---|---|---|---|
| MR-1 | Sector1(Moji) | 664 | 38,6 |
| MR-2 | Sector2(Ultrafertil) | 155 | 57,4 |
| MR-3 | Sector3(Copebras) | 342 | 64,5 |
| MR-4 | Sector8(Dutos) | 2 | 1,1 |
| MR-5 | | 18 | 10,6 |
| ML-1 | Sector9(Morrao) | 252 | 18,8 |
| CR-1 | | 43 | 2,8 |
| CR-2 | | 26 | 2,1 |
| CR-3 | | 4 | 4,2 |
| CL-1 | | 21 | 1,3 |
| CL-2 | | 32 | 3,8 |
| CL-3 | | 64 | 5,5 |
| CL-4 | | 45 | 7,8 |
| CL-5 | Sector6(Eletropaulo) | 68 | 20,0 |
| CL-6 | Sector5(Refinaria) | 114 | 34,5 |
| CL-7 | Sector4(Pereque) | 446 | 39,1 |
| CL-8 | Sector7(Carbocloro) | 8 | 5,3 |
| Total | | 2304 | 20,4 |

FIG.16
DISTRIBUTION MAP OF TOTAL
SLOPE FAILURES OF 1962-1989

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR,
CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

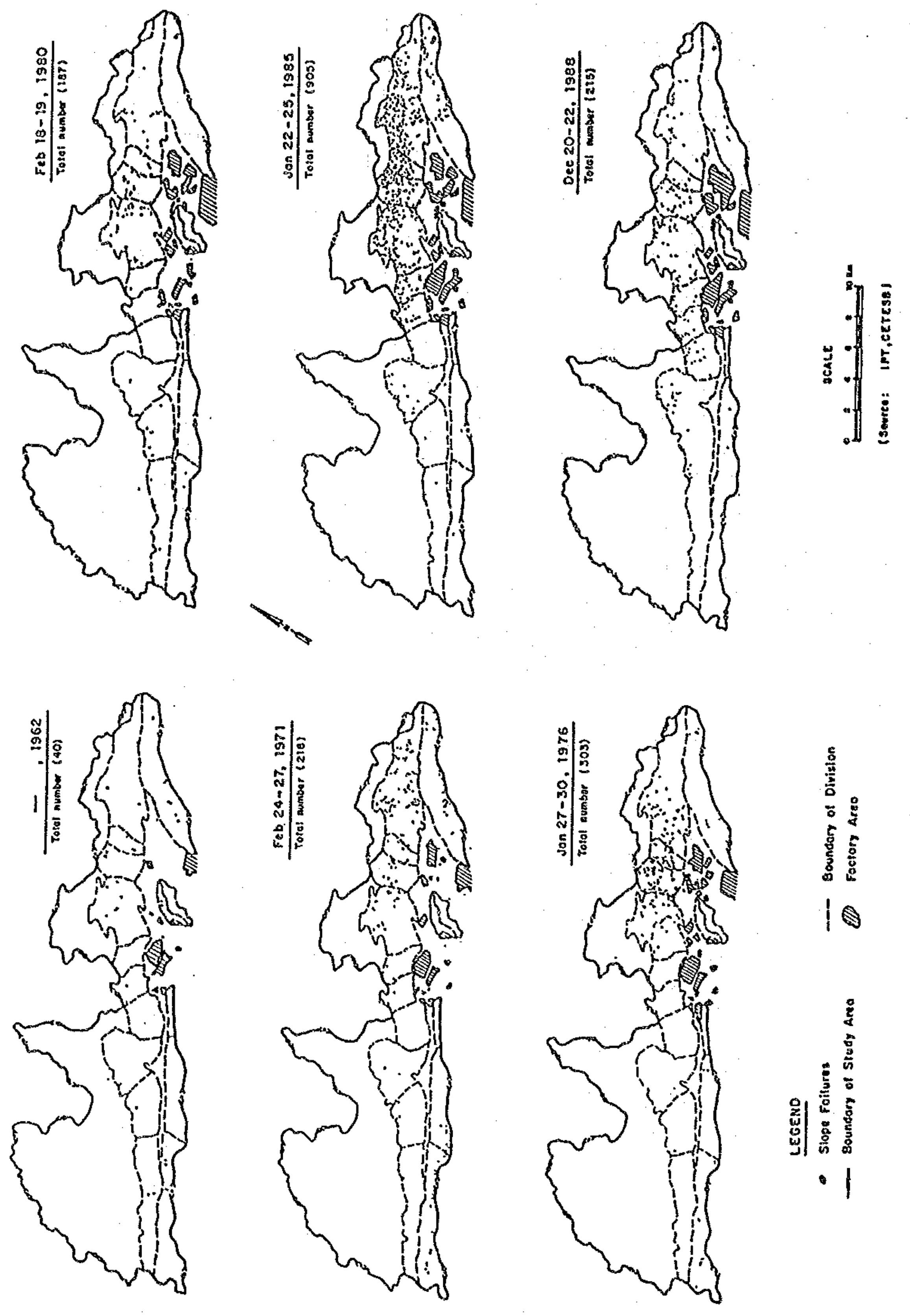



FIG.17
DISTRIBUTION MAP OF INDIVIDUAL PAST MAJOR SLOPE FAILURES

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

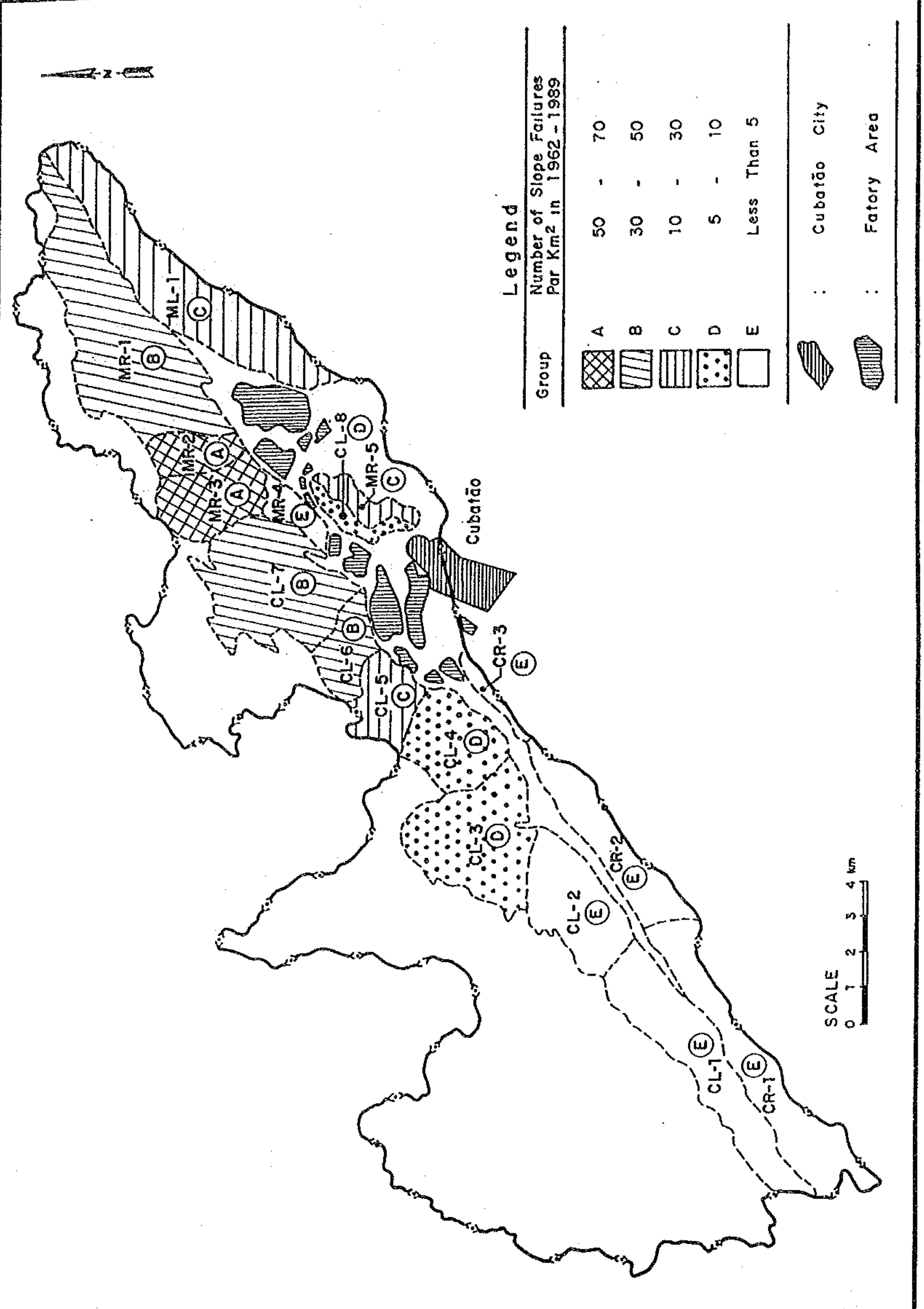



FIG.18
CLASSIFICATION MAP OF
SLOPE FAILURES

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR ,
CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

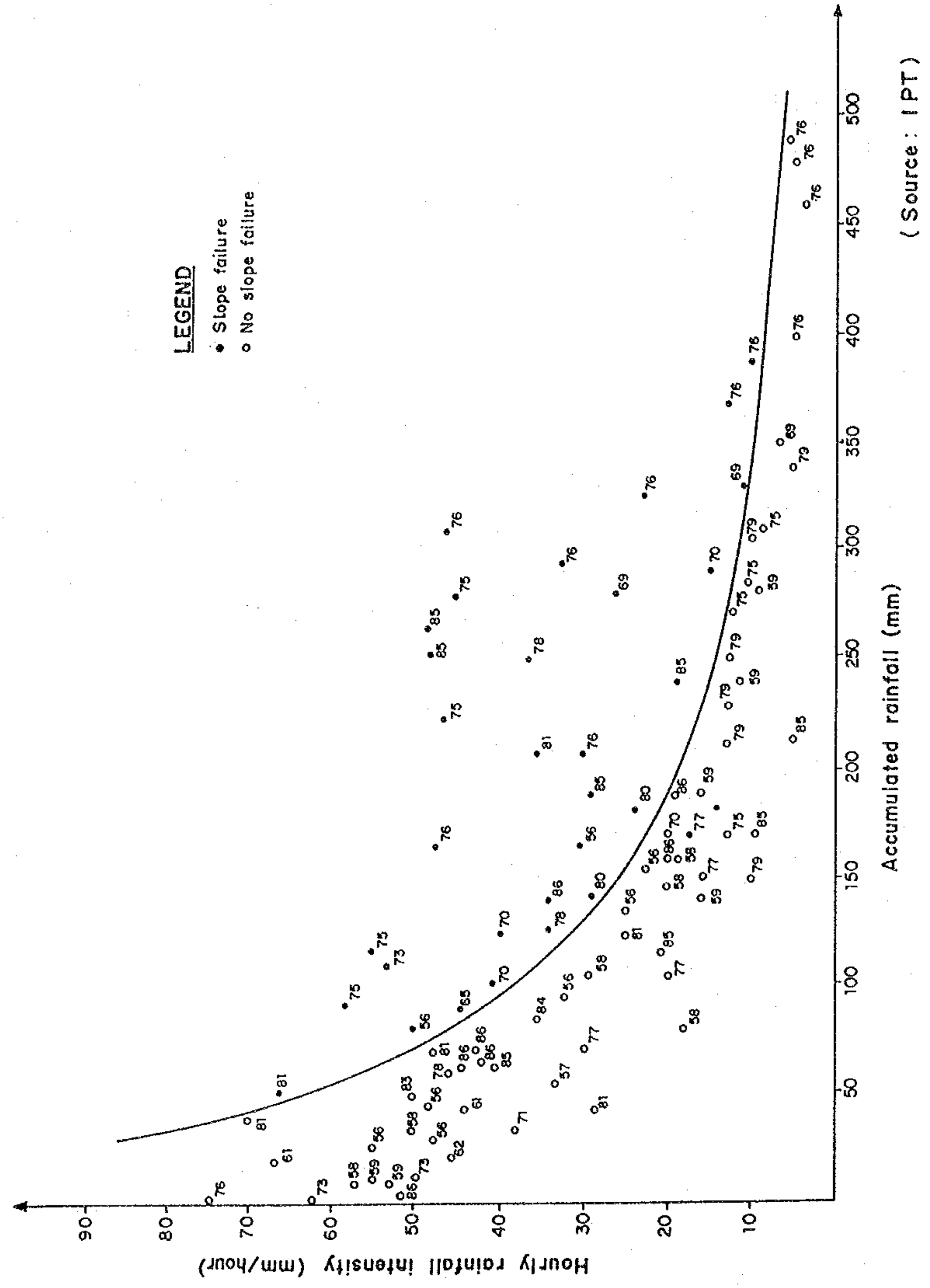
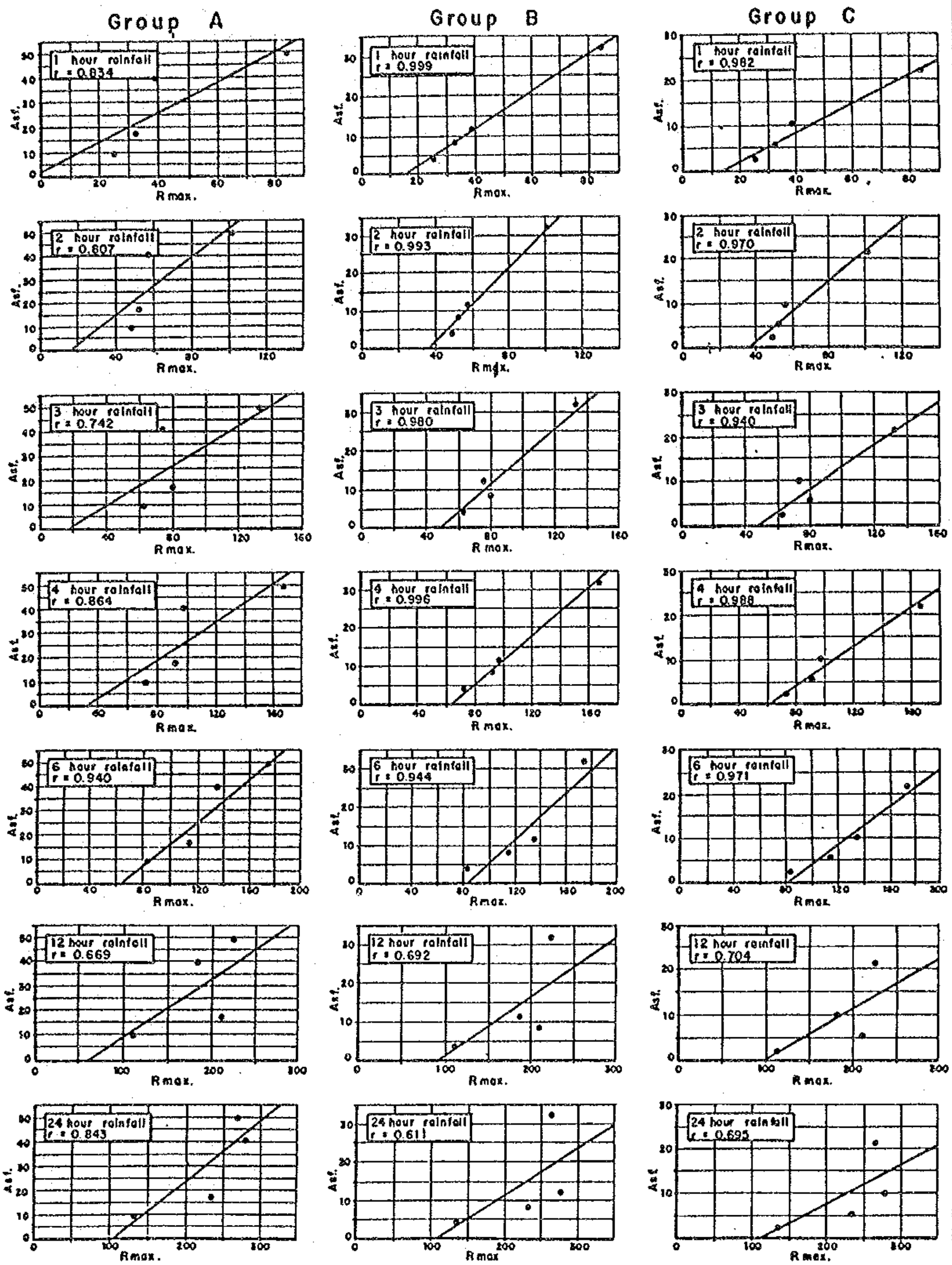



FIG.19
RELATIONSHIP BETWEEN RAINFALL AND OCCURANCE OF SLOPE FAILURES

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY




Note : Asf. : Total Slope Failure Area (Unit : $10^3 \times m^2$)
Rmax. : Maximun Rainfall (Unit : mm.)
r : Correnlation Coefficient

FIG. 20
CORRELATION OF TOTAL AREA OF SLOPE FAILURES AND N-HOUR RAINFALL

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

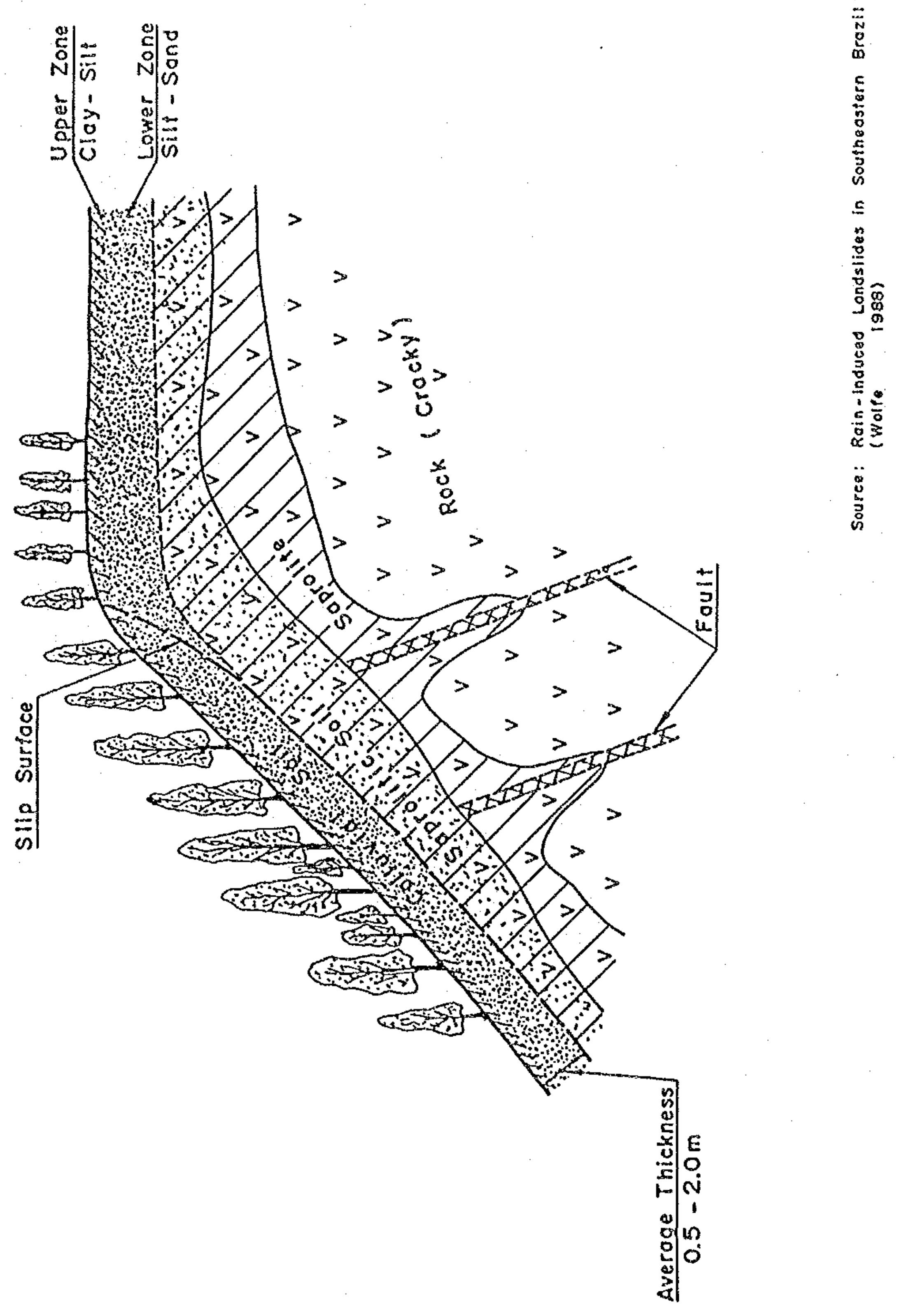



FIG.21
SCHEMATIC PROFILE OF
TYPICAL SLOPE FAILURE

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR ,
CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

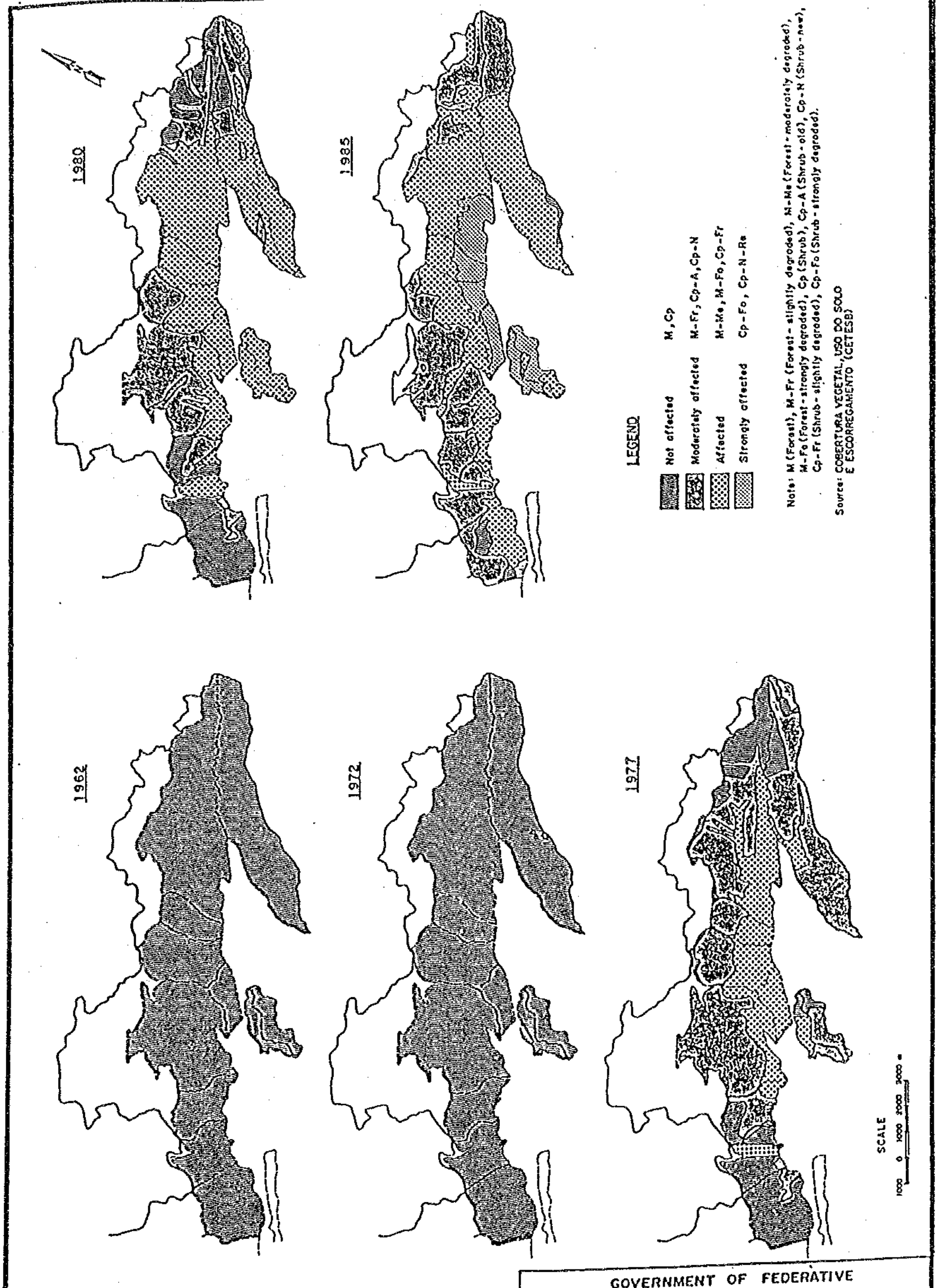



FIG.22
MAP OF VEGETATION CHANGE BY AIR POLLUTION IN 1962-1985

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

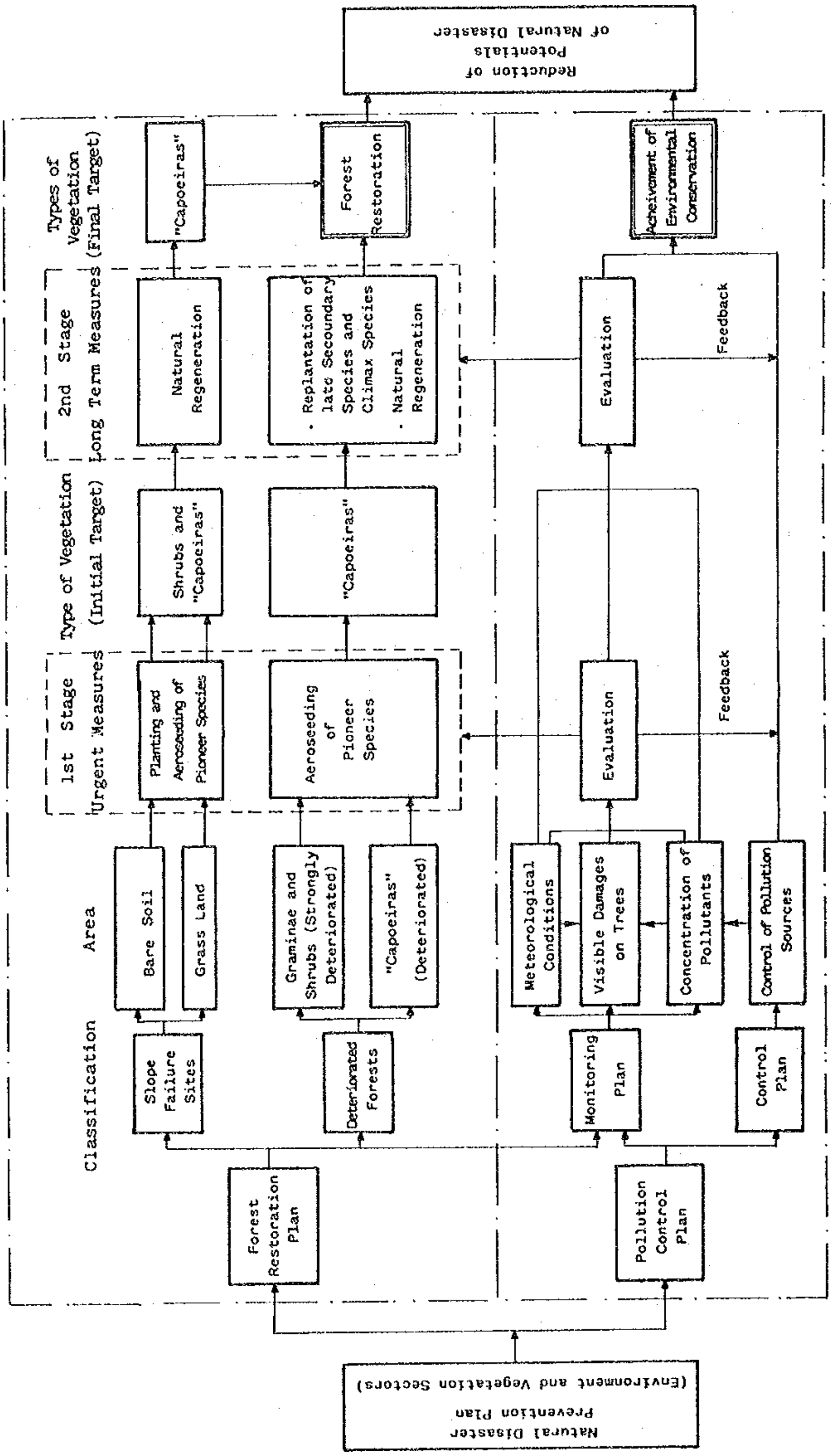



FIG.23

THE OUTLINE OF FOREST RESTORATION PLAN FOR CUBATÃO REGION

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

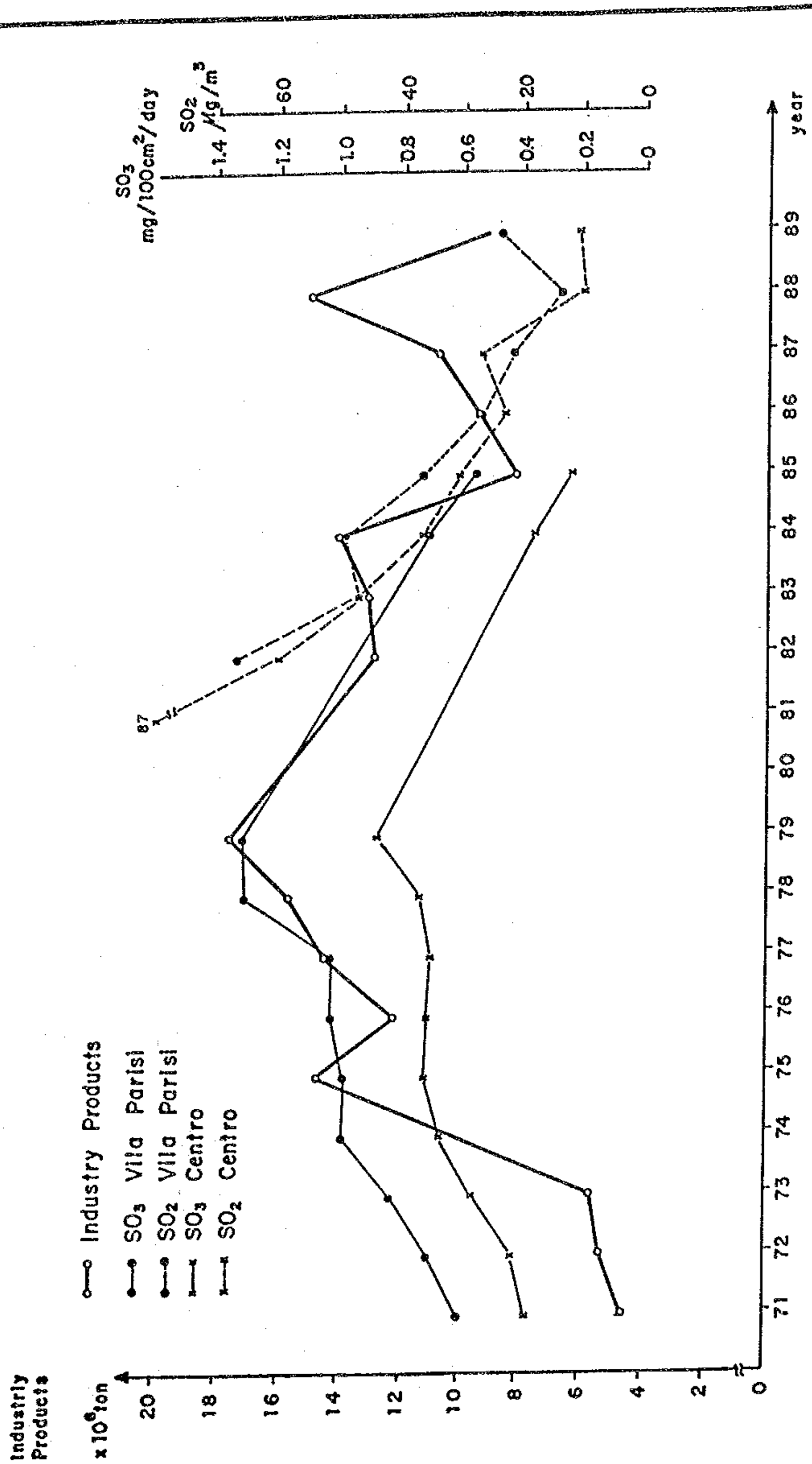



FIG.24
ANNUAL CHANGE OF INDUSTRY PRODUCTS AND SO2/SO3 CONCENTRATION

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

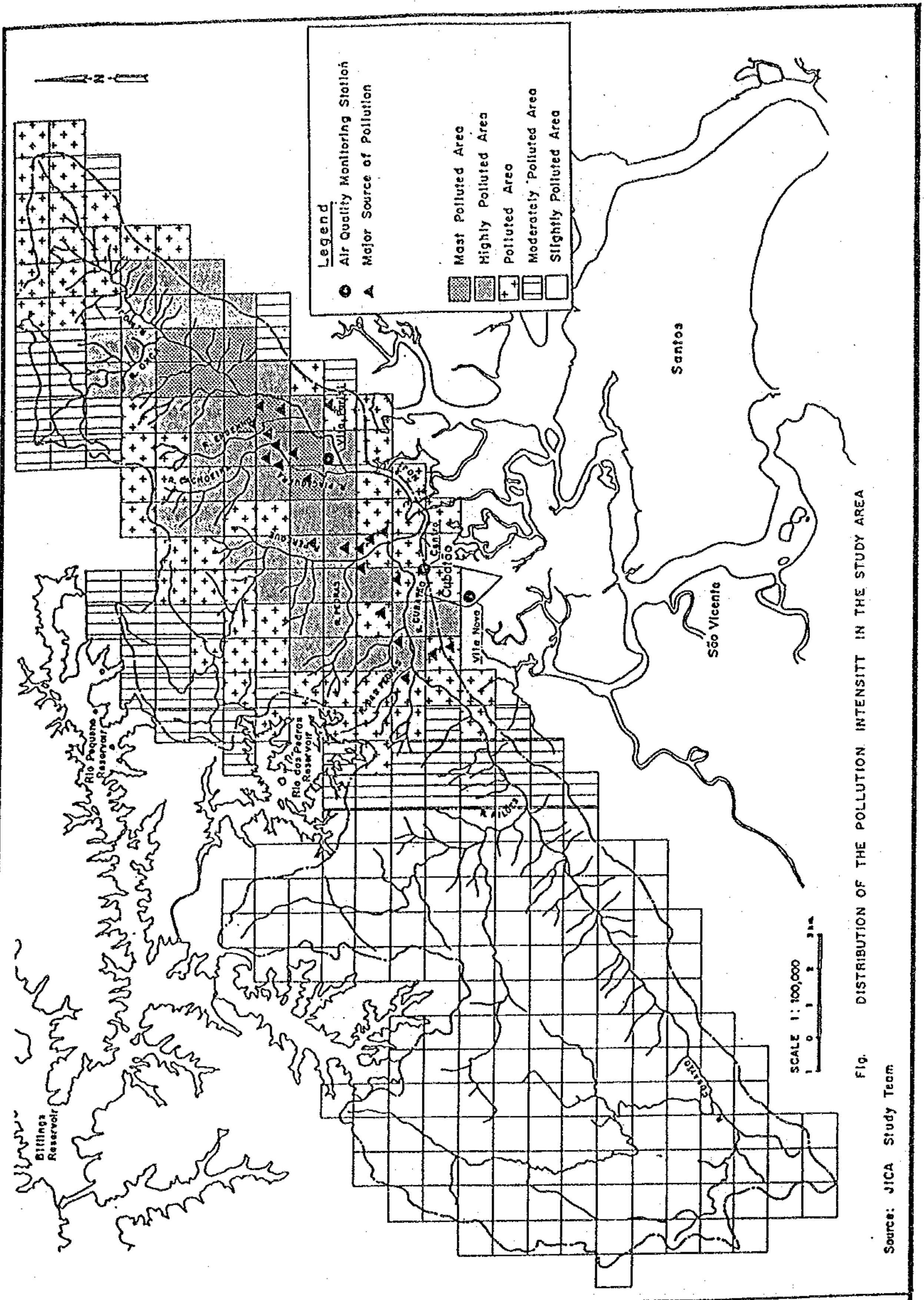



FIG.25
DISTRIBUTION OF AIR
POLLUTION INTENSITY AREA

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL.
THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR,
CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

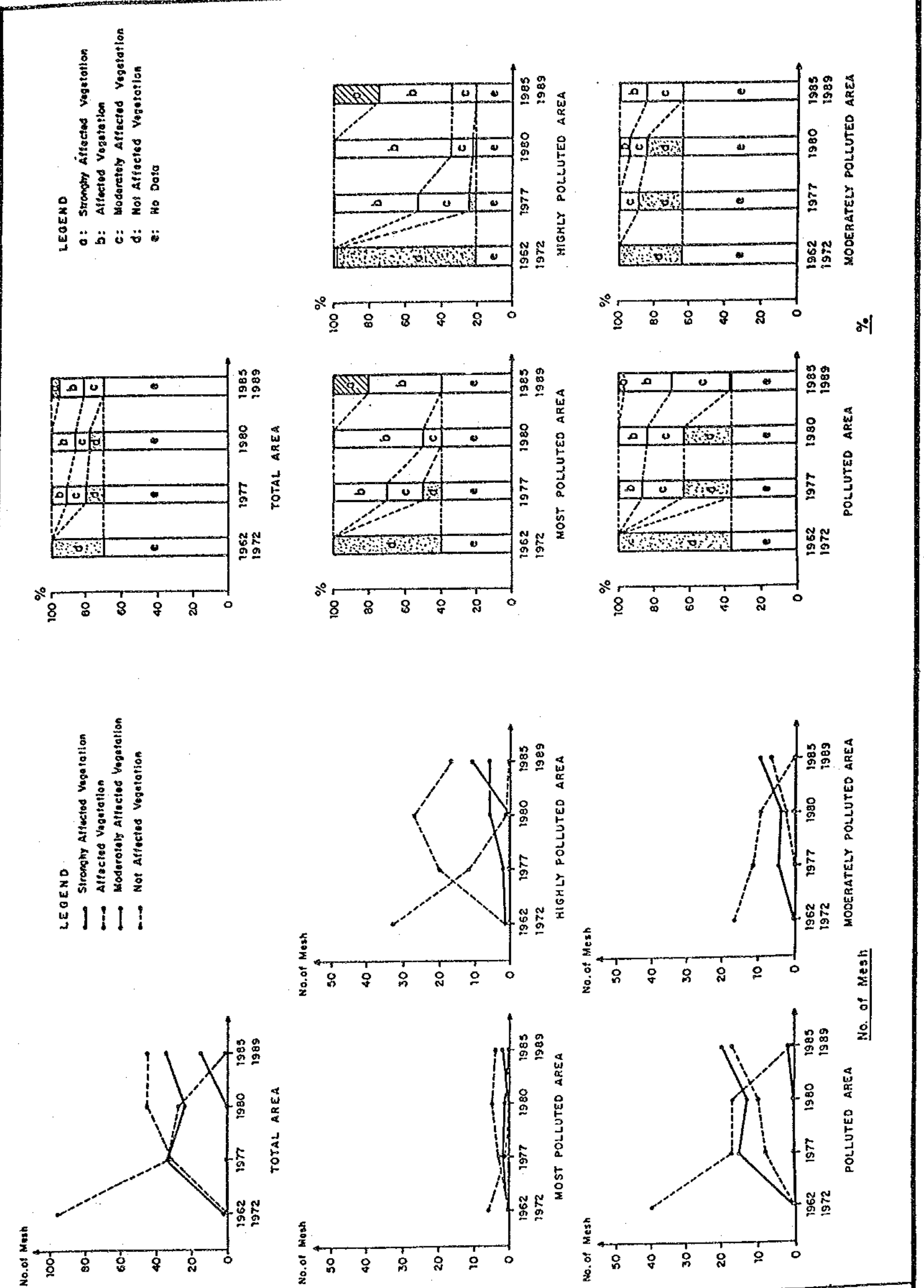



**FIG.26**
**ANNUAL CHANGE OF AFFECTED VEGETATION AREA BY EACH POLLUTION INTENSITY AREA**

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

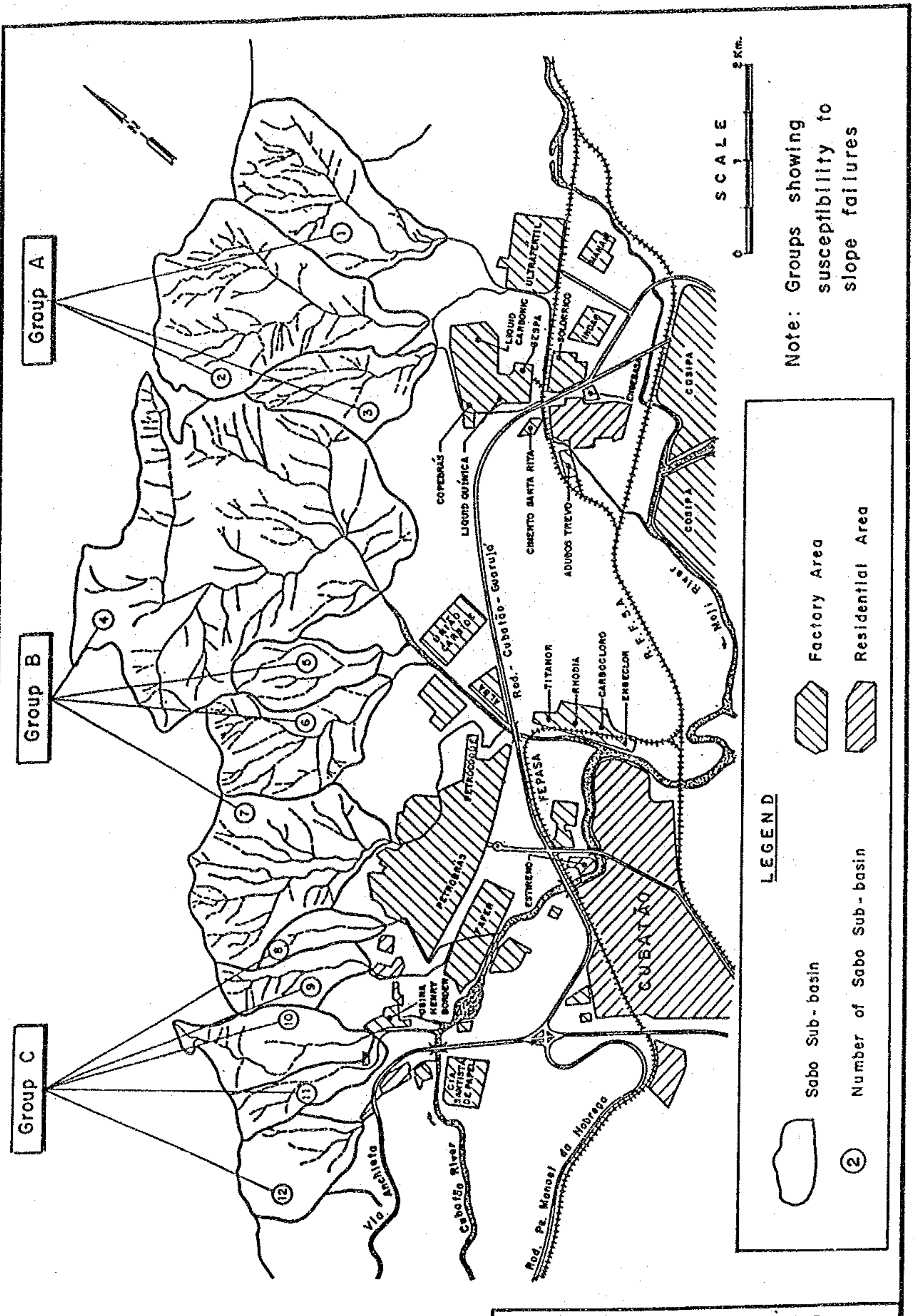



FIG.27
LOCATION MAP OF SABO SUB BASINS
OF PROTECTION AREA

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR,
CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

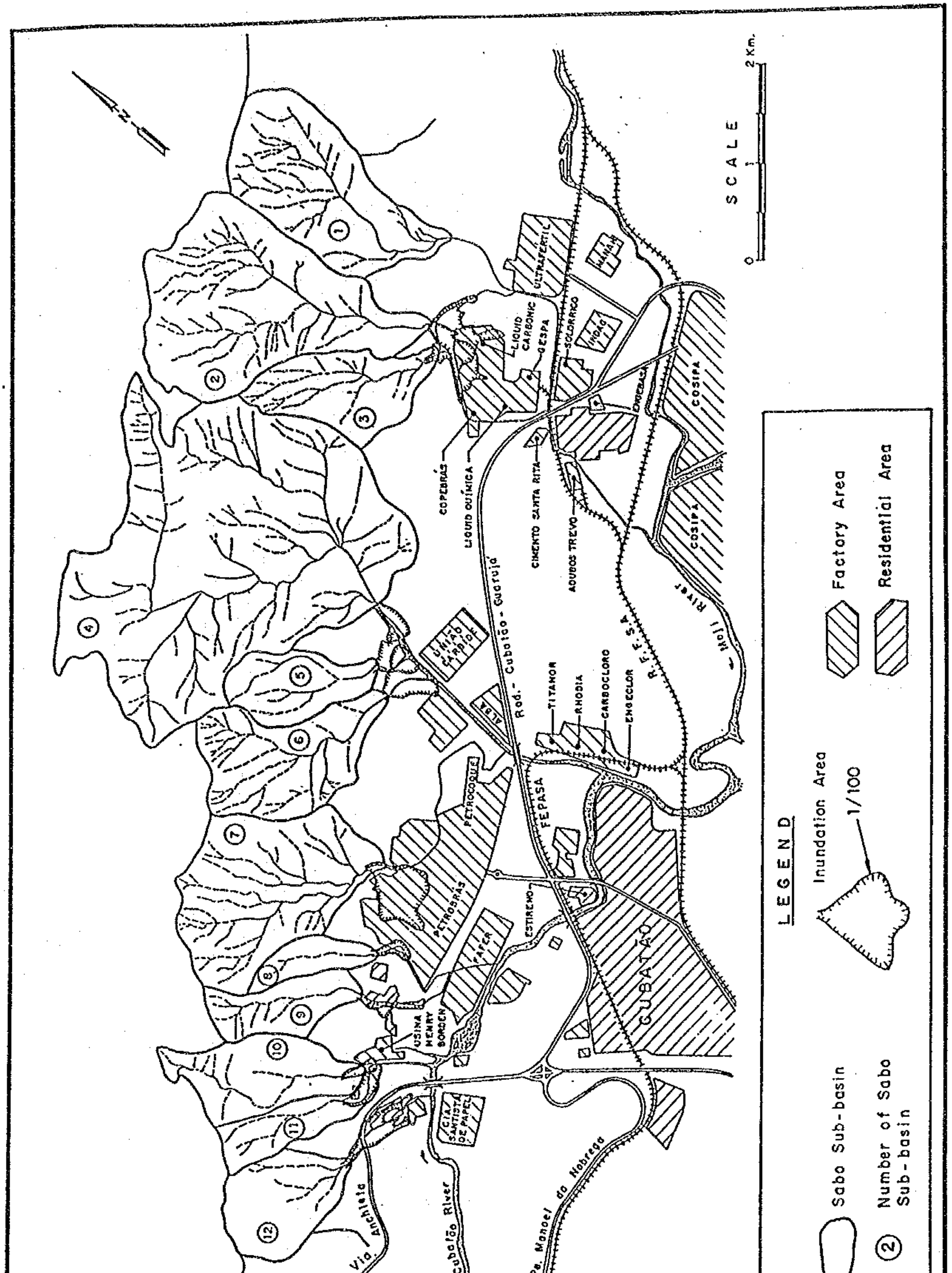



FIG.28
INUNDATION AREA OF DESIGN SEDIMENT RUN-OFF DISCHARGE

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO
JAPAN INTERNATIONAL COOPERATION AGENCY

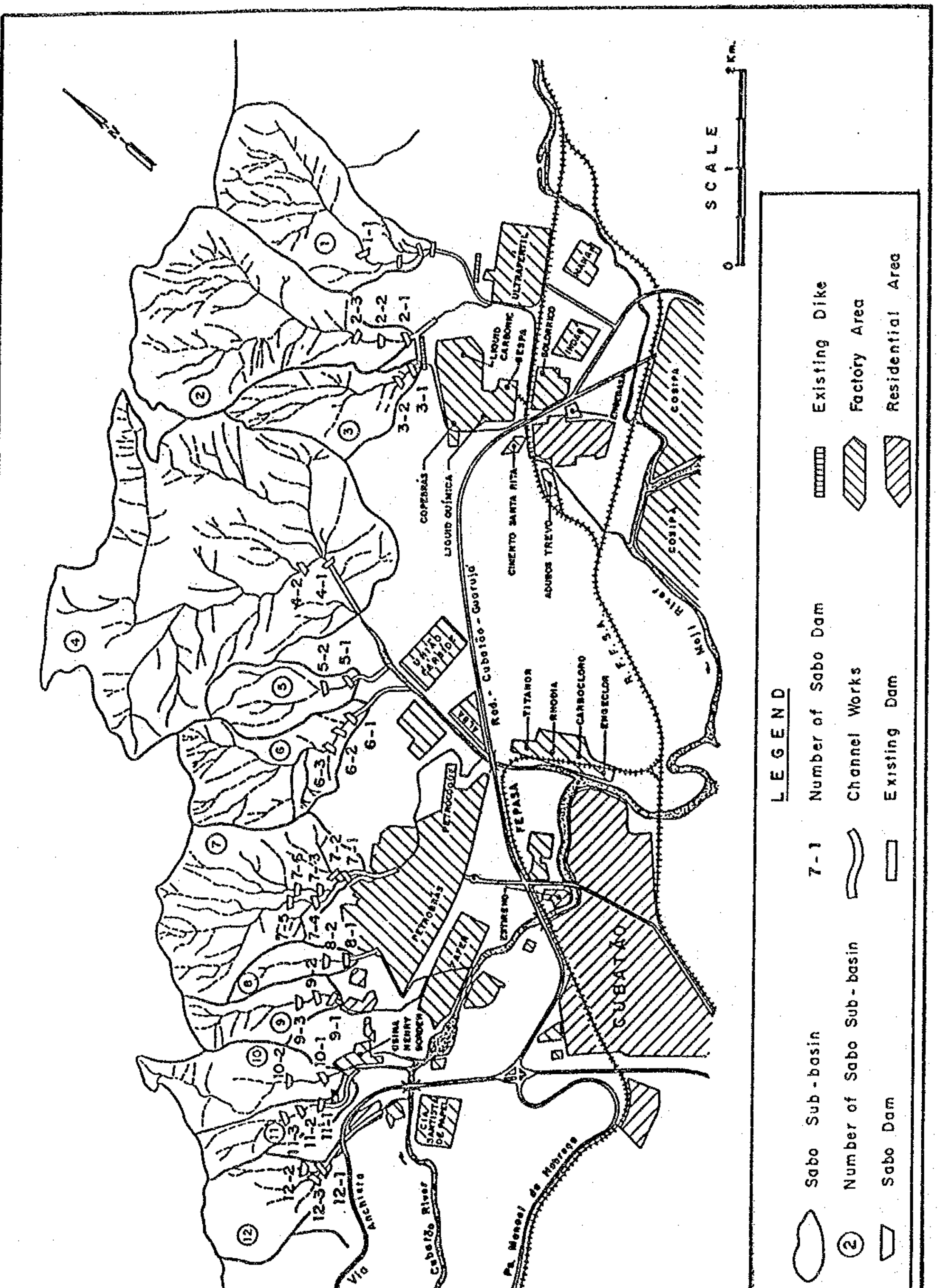



FIG.29

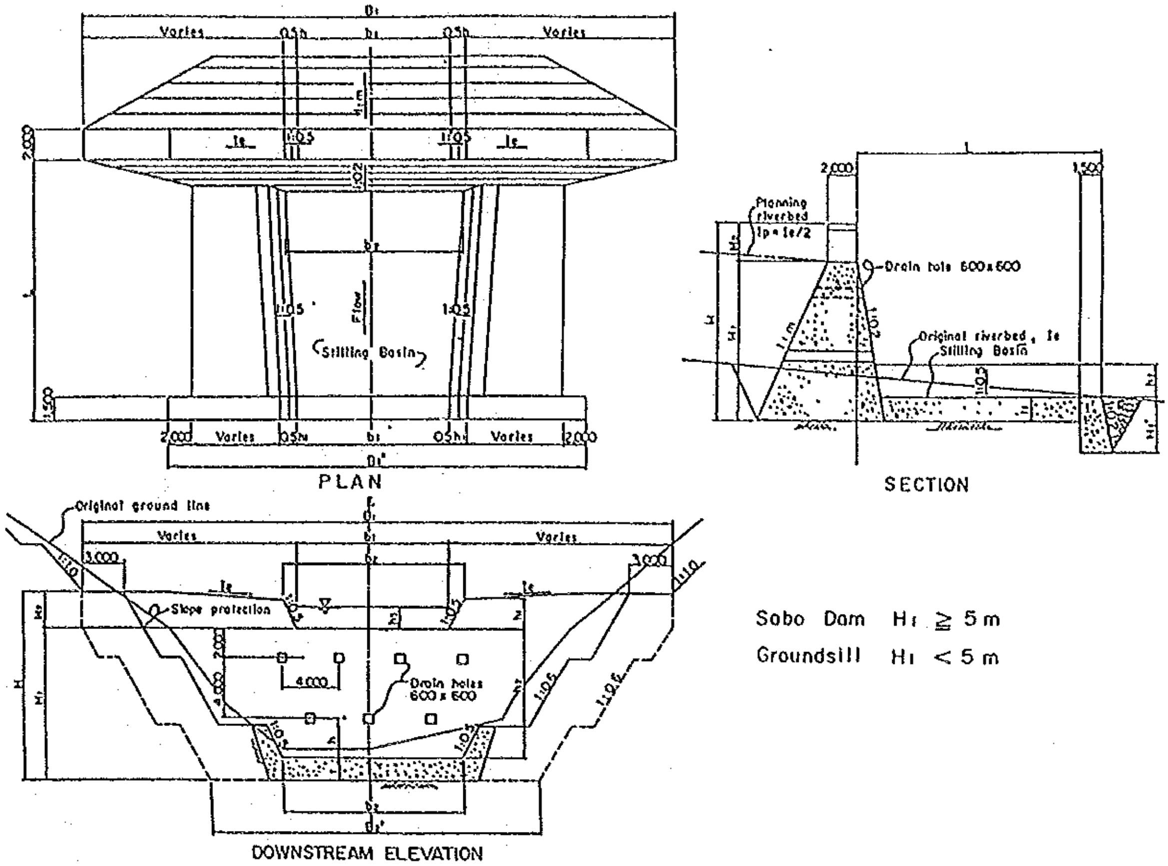
STRUCTURAL LAYOUT OF SEDIMENT RUN-OFF PREVENTION PLAN IN MASTER PLAN

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

(1) Sabo Dam (Groundsill)




(2) Channel Works

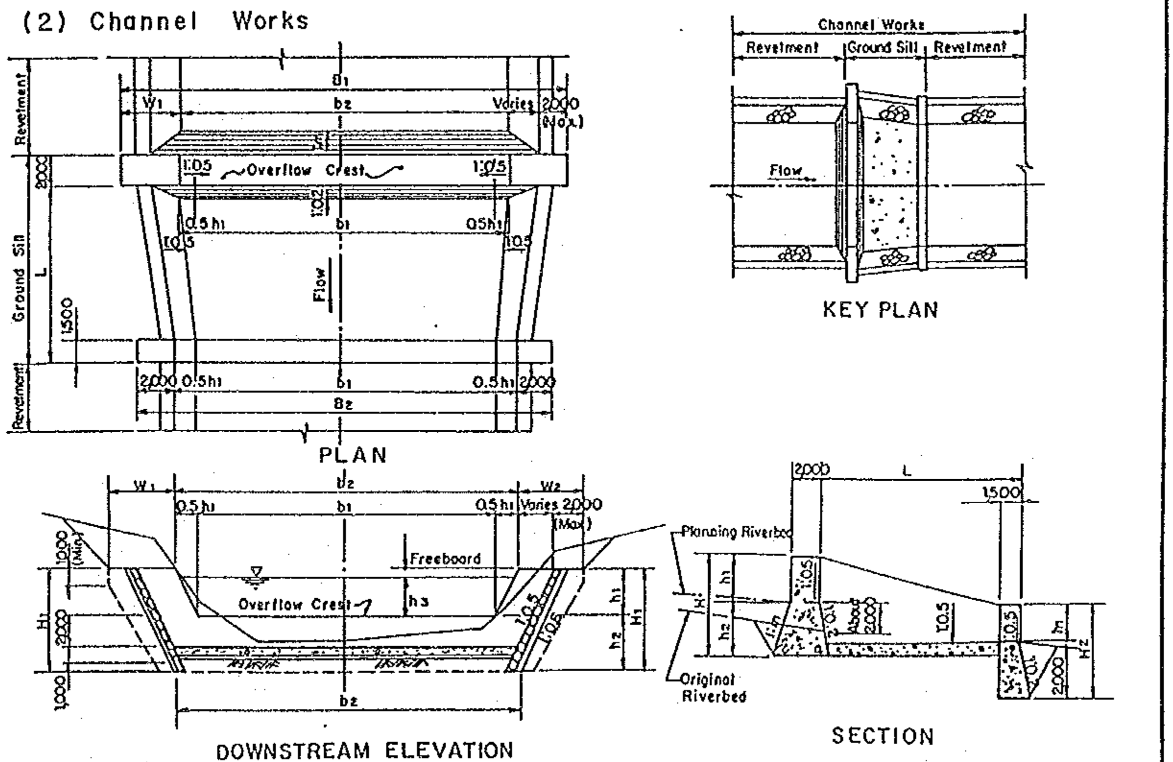



**FIG.30**

**TYPICAL DESIGN OF STRUCTURES FOR SEDIMENT RUN-OFF DISASTER PREVENTION WORKS**

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

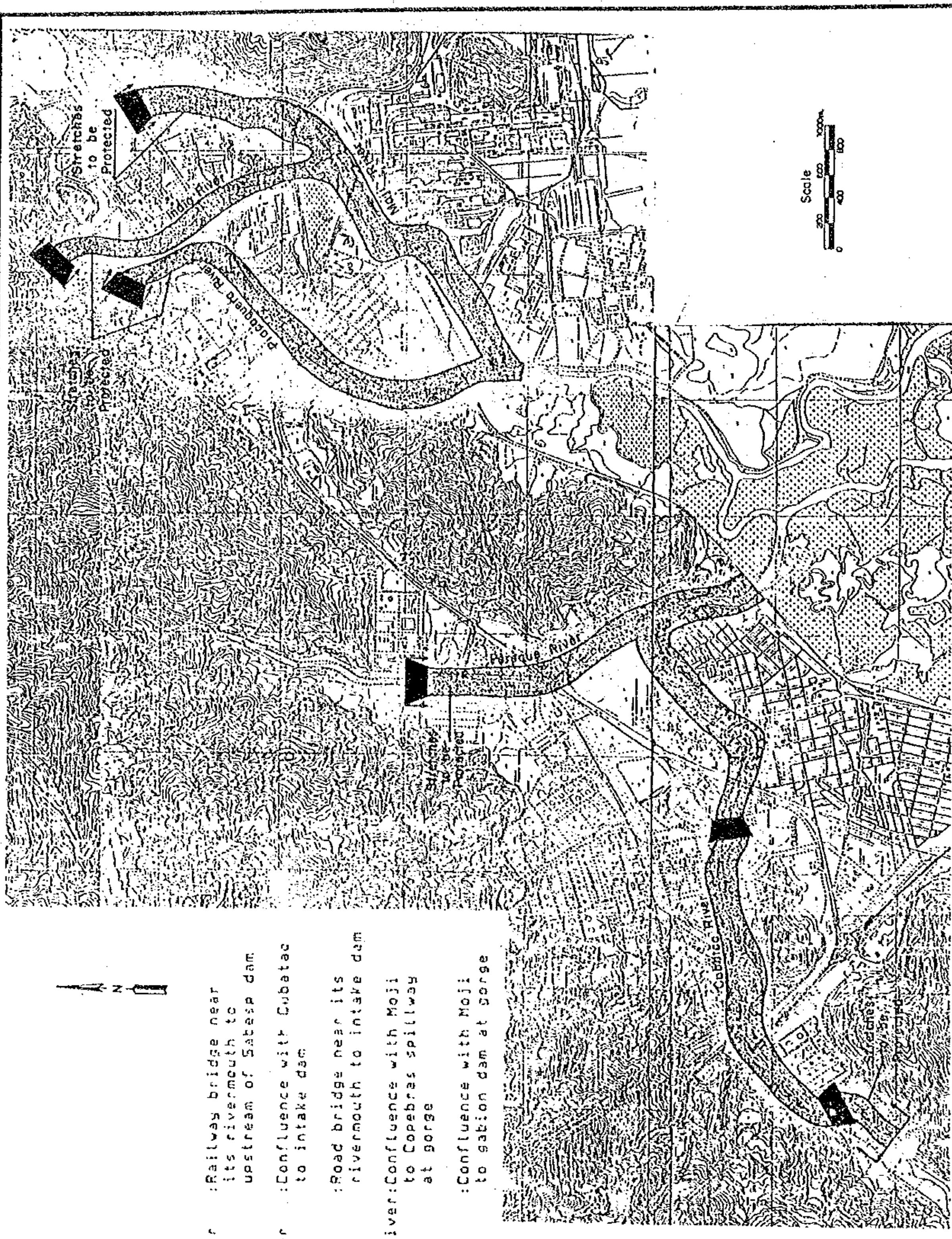



**FIG. 31**

**STRETCHES TO BE PROTECTED BY FLOOD CONTROL MASTER PLAN**

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

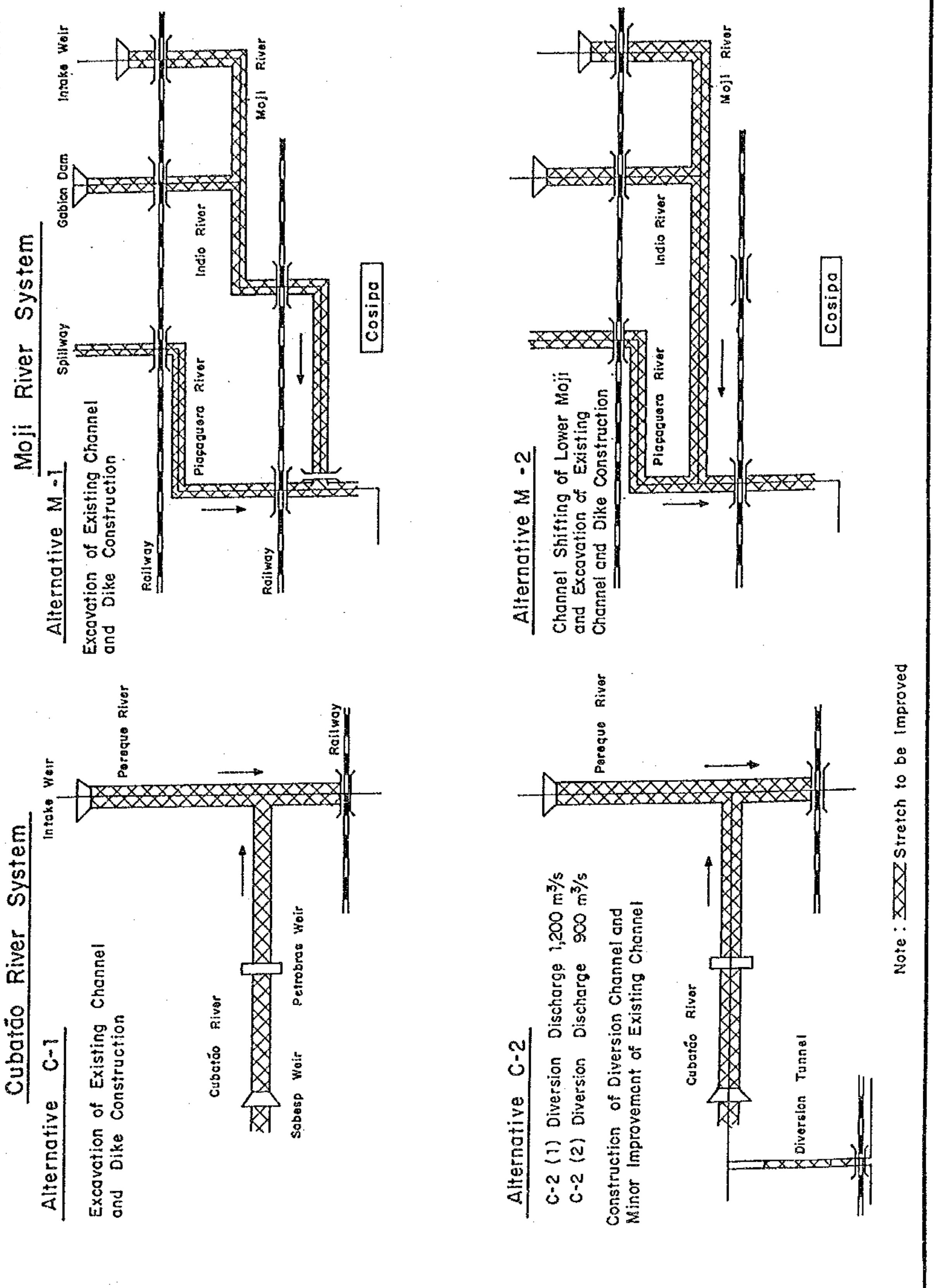



FIG. 32
ALTERNATIVE SCHEMES OF OPTIMUM PLAN

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR., CUBATÃO REGION, STATE OF SÃO PAULO
JAPAN INTERNATIONAL COOPERATION AGENCY