

CHAPTER 12 COST ESTIMATE OF THE MASTER PLAN

12.1 Total Cost

The total cost of Master Plan is as follows:

Table 12.1.1 Cost of Master Plan

(R\$×10³)

Safety Level of Flood Control	5 years	10 years	25 years	50 years
Flood Disaster Mitigation Measure	202,000	541,000	1,025,000	1,996,000
Landslide Disaster Mitigation Measure			54,000	
Flood Forecasting and Warning System			4,000	
Early Warning System for Flush Flood and Landslide Disaster			4,000	
Total	264,000	603,000	1,087,000	2,058,000

Source: JICA Survey Team

The cost of the measure was estimated with base of the prices of 10/2010, in accordance with the following exchange rate;

$$R\$1.0 = JPY47.87 = USD0.58.$$

The unit cost of the each work was estimated on the basis of the unit cost applied at the DEINFRA.

12.2 Cost Component

(1) Cost

The cost component is as follow;

- i) Construction cost
- ii) Land acquisition and compensation
- iii) Government administration expenditure
- iv) Engineering service
- v) Physical contingency /Price escalation

(2) Construction cost

The construction cost was calculated based on the following conditions;

- vi) Construction Cost = Work Quantity x Unit Price
- vii) Temporary work = 30% of major works

(3) Compensation

The Compensation cost was calculated on the basis of the land valuation's information of CREA, classifying into urban and rural area. The forest area at river margins was excluded of the extent of the compensation, considering that this land is in the public power. Besides, the compensation was calculated presupposing that each residential land has 100m² of dimension.

Table 12.2.1 Detail of the Cost of Land Compensation

		Unit	Unit Cost (R\$)
Cost of land compensation	Urban Area	m ²	0.5~3.0=1.75
	No Urban	m ²	950,00
Compensation cost for resettlements	Each Case		100m ² ×1,100R\$/m ² =111,000,00 (1,036~1,127,04 1.100R\$/m ²)

Source: JICA Survey Team

(4) Others Costs

The administrative expense was estimated as being 3 % of the total construction costs and of land compensation and the consultants cost as being 10 % of the construction direct cost. The physical Contingency was stipulated as being 10 % of the total of the construction costs, compensation, administrative expenses and consultants. The price escalation was stipulated the readjustment of price of 5 % on the amount of the physical Contingency.

12.3 Flood Disaster Mitigation Measures

12.3.1 Work Quantities

The amounts of the main works items listed in the Master Plan, are as follows;

Table 12.3.1 List of Works Amount for Each Safety Level

Safety level of Flood Control	Construction Type	Unit.	5-years	10-years	25-years	50-years
Measure in river						
Heightening of dam						
Oeste dam	Heightening	Unit.	-	-	1	1
Sul dam	Heightening	Unit.	-	-	1	1
Improvement of river channel						
Taio	Dyke	m	-	-	3,682	3,682
Rio do Sul	Dyke	m	-	-	10,269	9,081
Timbo	Dyke	m	-	-	1,000	1,000
Blumenau	Dyke	m	-	-	-	8,667
Blumenau tributary	Dyke	m	7,300	7,300	7,300	7,300
Itajai	Dyke	m	-	12,828	12,828	-
Itajai Mirim	Dyke	m	950	950	950	950
Flood Gates (Itajai Mirim)	Gate	Unit.	2	2	2	2
	Bridge	Unit.	-	-	-	1
Floodway (Com Comporta)	Excavation	m	-	-	-	10,905
Ring dykes (Ilhota)	Dyke	m	-	-	8,000	8,000
New flood control dam	Dam	Unit.	-	-	1	1
Measure in Basin						
Rain water containment in rice fields		ha	22,000	22,000	22,000	22,000
Small-scale dams		Unit.	2	5	7	7

Source: JICA Survey Team

The compensation area is as follow;

Table 12.3.2 Compensation Area for Each Safety Level for Flood Control

(Unit:m²)

Area	5-years	10-years	25-years	50-years
Urban Area	20,619	194,581	302,647	574,086
Rural Area	3,056,000	7,693,710	10,861,750	13,645,719
Total	3,076,619	7,888,291	11,164,397	14,219,805

Source: JICA Survey Team

12.3.2 Unit Cost

The applied unit cost for the Cost estimate was of base in 10/2010.

12.3.3 Work Cost

The estimate costs of the construction works for each safety level are illustrated in Tables below. The measures of flood disaster mitigation are subdivided into three parts: measures in the river/basin and no-structural measure. And, because of that the no-structural measure is only the

improvement of the operation method of the dams during the flood, therefore, this cost estimation was not considered of this extent.

Table 12.3.3 Construction Cost for Each SafetyLevel (by each type of work)

Safety level of Flood Control	5-years	10-years	25-years	50-years
Measure in river	109,000	357,000	781,000	1,752,000
Heightening of dam				
Oeste dam	-	-	27,000	27,000
Sul dam	-	-	-	6,000
Improvement of river channel				
Taio	-	-	56,000	114,000
Rio do Sul	-	-	190,000	268,000
Timbo	-	-	21,000	21,000
Blumenau	-	-	-	267,000
Blumenau tributary	35,000	98,000	144,000	196,000
Itajai	-	181,000	197,000	-
Itajai Mirim	36,000	38,000	46,000	50,000
Flood Gates (Itajai Mirim)	38,000	40,000	42,000	44,000
Floodway (Com Comporta)	-	-	-	593,000
Ring dykes (Ilhota)	-	-	58,000	70,000
New flood control dam	-	-	-	95,000
Measure in Basin	93,000	184,000	244,000	244,000
Rain water containment in rice fields	33,000	33,000	33,000	33,000
Small-scale dams	60,000	151,000	211,000	211,000
TOTAL	202,000	541,000	1,025,000	1,996,000

Source: JICA Survey Team

12.4 Measures for Landslide Disasters

12.4.1 Unit Cost and Construction Works Cost

In Table 12.4.1, the direct costs of construction works and project cost (include of consultants, administrative, Physical contingency and Price Escalation) are shown;

Table 12.4.1 Cost for Structure Measure for Landslide Disaster

Classification of Risk level	Site Number	Work Item R\$(x10 ³)	Consultants Fee (10% of Work Cost) R\$(x10 ³)	Administration Cost (3% of work cost) R\$(x10 ³)	Physical Contingency (10% of work cost) R\$(x10 ³)	Price Escalation (4% of work cost) R\$(x10 ³)	Project Cost R\$(x10 ³)
High Risk Level Potential Annual Loss (more than R\$ 500 mil)	13	14,514	1,451	435	1,451	73	18,650
Medium Risk Level Potential Annual Loss (R\$50 & 500 mil)	54	27,528	2,753	826	2,753	138	35,374
Total	67	42,042	4,204	1,261	4,204	210	54,024

Source: JICA Survey Team

12.5 Flood Forecasting and Warning System

12.5.1 Equipments

The monitoring and necessary communication equipments for the FFWS are composed of the following;

- Automatic rain gage
- Automatic water level gage (radar system)
- Date logger (Registrations of data).
- Solar panel and battery (for the Guarantee of energy).
- Converter to send the observed data (system GPRS of cellular telephone)
- Receiving system and Base the Central Station (CEOPES)
- Communication (Internet) net communicated between the monitoring (Rio do Sul and Itajai) stations.
- Communication (Internet) net communicated between the Headquarters of Monitoring (Florianópolis).
- Real Time Flood Situation monitoring System

12.5.2 Cost

The Cost for the installation of the flood alert and alarm system is as follow;

Table 12.5.1 Project Cost for the Installation of FFWS

Items	Despesas (R\$)
1 Observation equipments of alert and alarm system (FFWS)	2,350,000.00
2 River Inventory	938,000.00
3 Training	296,000.00
4 Consultants	416,000.00
Total	4,000,000.00

Source: JICA Survey Team

12.6 Early Warning System for Flush Flood and Landslide Disaster

In Table 12.6.1, estimated costs of the rain gage, transmission equipments GPRS and of installation are shown;

Table 12.6.1 Project Cost for Installation of Early Warning System for Flush Flood and Landslide Disaster

Discrimination	Qty	Unit.	Unit Price (R\$)	Cost (R\$)
Rain gage Station	53	Unit.		
Equipment	53	Unit.	19,800	1,049,400
Data server and Data Bank Licenses	10	Unit.	100,600	100,600
Subtotal				1,150,000
Radio Base/ VHF Data Emission				
Equipments	10	Unit.	110,000	1,100,000
Internet Link server and Satellite Internet System	3	Unit.	16,667	50,000
Subtotal				1,150,000
Alarm and Alert System for lands slide ad Flashflood. Transmission and Data Banking	1	Unit.	1,700,000	1,700
TOTAL				4,000,000

Source: JICA Survey Team

Annual expense of maintenance of the data processing system estimated to be 5% of the expense of development of the system.

CHAPTER 13 ECONOMIC EVALUATION OF MASTER PLAN

13.1 Methodology

In economical and financial evaluations, followings criteria were applied;

- Applied price for the estimation of cost and benefit is of a base of year 2010.
- The evaluation will be made for whole program for each safety level of 5, 10, 25 and 50 years.
- The evaluation period is of 50 years.
- The evaluations will be carried out as a total program of the disaster mitigation measures, including FFWS and early warning system for flashflood and landslide disasters.
- The evaluation will be carried out the financial and economical point of view. In the financial evaluation, the market price will be applied and for the economical evaluation, the economic price discounted taxes and the compensations portion from project cost.
- In an evaluation, the concept of the Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit/Cost Ratio (B/C) will be used.
- As a discount rate for the estimation of NPV and B/C, the commonly used rate of 12%, rate calculated from the Certificate of Interbanking Deposit's Rate and the rate of the long term Interest (TJLP) in last 9 years will be utilized.
- The estimated benefit values for each flood safety level will be calculated by statistic method, on the basis of the registered disaster's damages value published by the State Government. The expected annual damage reduction benefit will be considered multiplying the probabilities of each inundation and the damages caused by each safety level. Besides this benefit, also, the benefit from land valorizations through improvement of safety level will be possible. However, this kind of benefit, in this evaluation, will not be considered.
- The values used as bases of damages estimation for each safety level were of flood damages registered at October, 2001 and November, 2008.
- The flood at October, 2001 was considered equivalent to the one of 7 years Safety level, and the flood of November, 2008 was considered as of 50 years of Safety level.

13.1.1 Cost for Master Plan

The measures required for the mitigations of the disasters are the following ones:

Table 13.1.1 Cost for Master Plan

	5 year	10 year	25 year	50 year
Flood Mitigation Measure	202.000	541.000	1.025.000	1.996.000
Land Slide Mitigations Measures	54.000	54.000	54.000	54.000
Flood Prevention and Alert	4.000	4.000	4.000	4.000
Land Slide Prevention and Alert	4.000	4.000	4.000	4.000
Total	264.000	603.000	1.087.000	2.058.000

Source: JICA Survey Team

13.1.2 Conversion Rate (Economic Evaluation)

The applied price for the economical evaluation is considered the economic price using a conversion rate. In this study, the conversion rate for the estimation of economic price, the conversion value of 0.5 is used.

13.1.3 Discount Rate

The discount rate applied for the financial evaluation is considered the rate of Certificate of Inerbanking Deposit (CDI) and for the economical evaluation, the Tax of Interest the Long term was considered.

Table 13.1.2 Discount Rate

	Financial Evaluation	Economical Evaluation
Discount rate (1)	10.0 %	6.0 %
Discount rate (2)	23.0 %	10.0 %
Referred Discount Rate	12.0 %	12.0 %

Source: JICA Survey Team

The discount rate (1) is the value when the economy of Brazil is stable. The discount rate (2) is the value for the economy of Brazil is in situation of high interest rate.

13.2 Cost

13.2.1 Cost in a Market Price

The annual Cost and maintenance cost for each Safety level is considered the following ones;

Table 13.2.1 Annual Cost for Safety Level and Maintenance Cost

TR (year)	Total cost	1st year	2nd year	3rd year	4th year	5th year	Maintenance Cost
5	264,000	88,000	88,000	88,000			13,200
10	603,000	201,000	201,000	201,000			30,200
25	1,087,000	271,750	271,750	271,750	271,750		54,400
50	2,058,000	411,600	411,600	411,600	411,600	411,600	102,900

Source: JICA Survey Team

13.2.2 Measure Cost – Economic Values

(1) Measure cost for each safety level

The cost of the measures to be used for the economic evaluation is considered, discounting the taxes and the lands compensations from market prices. The schedule of cost application is considered the following;

Table 13.2.2 Application of Annual Cost in Economic Price

TR (year)	Total cost	1st year	2nd year	3rd year	4th year	5th year	Maintenance Cost
5	91,000	30,333	30,333	30,333			4,600
10	141,000	47,000	47,000	47,000			7,100
25	303,000	75,750	75,750	75,750	75,750		15,200
50	594,000	118,800	118,800	118,800	118,800	118,800	29,700

Source: JICA Survey Team

13.3 Benefit

13.3.1 Accounting Method of Benefit

In this Study, it was taken the assumption that the damages will be caused by disasters for each Safety level, will be converted as a benefit, through the effect of improvement. The mentioned losses will be minimized by the implementation of the measures for inundations. With this concept, the benefits of the measures were considered, classified as

- Economy of Emergency Expenses
- Economy of Reconstructions expense
- Losses in the Economical Activities (Agricultural section, Trade, Industry and Transport)

The emergencies expenses are those applied in the public calamities, rescue, expenses with shelters, health, feeding, etc.

The expenses of the reconstructions are those expenses with the reconstructions in the affected areas for the disaster, as ports, highways, electrification, sanitation, school, hospital, etc.

The economical losses were estimated for the differences among the normality time and with disaster. The items considered to estimate the economical loss were of agricultural production, service and transport. The economical losses in the agricultural production were estimated for lost cereals by the disaster. The economical losses in the industry, transport and services were estimated with base in the data of ICMS.

For the benefits, for each Safety level, the flood of the October of 2001 was used as equivalent to 7 years of Safety level and the flood of November of 2008, equivalent to 50 years of Safety level.

13.3.2 Benefit at Market Price

The expected annual Value of the economical losses for the measure for each Safety level was estimated, considering the probabilities of occurrences for each Safety level. The expected annual value of the economical losses is the following ones:

Table 13.3.1 Benefit at Market Price

(unit; R\$ millions)

Safety Level	Economic Loss by Flood	Expected Annual values by Mitigation of Economic Loss	Emergencies Expenses and Reconstruction Cost in a Implementation of measure for possible flood
5	502,1	143.2	37.7
10	1,006.4	206.3	36.4
25	2,779.3	281.5	33.2
50	6,921.7	378.1	23.3
100	20,686.4	525.5	

Source: JICA Survey Team

13.3.3 Economic Benefit

The Estimated value of the losses in economical value for each Safety level was converted using the conversion factor above described (13.1). The economical losses for each Safety level are considered the following ones:

Table 13.3.2 Benefit at Economic Price (unit; R\$ millions)

Safety Level	Economic Loss by Flood	Expected Annual values by Mitigation of Economic Loss	Emergencies Expenses and Reconstruction Cost in a Implementation of measure for possible flood
5	252.1	71.9	18.8
10	504.9	103.6	18.2
25	1,383.1	141.3	16.6
50	3,466.7	189.7	11.6
100	16,675.0	309.3	-

Source: JICA Survey Team

13.4 Financial and Economical Evaluation

13.4.1 Financial Evaluation

The results of the financial evaluations are the following ones:

Table 13.4.1 Results of Financial Evaluation

Evaluation Index		5 year	10 year	25 year	50 year
FIRR		20.1 %	22.2 %	18.1 %	12.4 %
Discount Rate 10 %	B/C	1.43	1.43	1.35	1.08
	ENPV(R\$10 ⁶)	282.4	465.7	570.6	218.4
Discount Rate 23 %	B/C	0.91	0.82	0.72	0.55
	ENPV(R\$10 ⁶)	-31.2	-125.4	-291.7	-780.9
Discount Rate 1 2%	B/C	1.33	1.29	1.20	0.95
	ENPV(R\$10 ⁶)	187.0	286.5	302.7	-112.8

Source: JICA Survey Team

The result of the evaluation for the index FIRR (Financial Internal Rate of Return), is indicated 20.1 % in the measure in Safety level 10 years, and 12.4 % in the intervention of Safety level 50 years.

In the cost-benefit (B/C) ratio with the discount rate of 10 %/year, the index shows positive results. But, with the discount rate of 23 %/year, the index shows low profitability. However, the discount rate of 23 %/year is considered very high in a current economical scenery of Brazil.

In the relationship of Net Present Value (NPV), with the discount rate of 23 %/year, the result is shown negative. However, if taking in consideration the last tendencies of CDI, having varied among 10 %/year to 12 %/year, the possibility of the high rate to return is low. Considering these circumstances, it is considered viable the implementation of the measure presented in this report with the Safety level 50 years. Besides, to be considered the valorizations of the lands with less disaster risk, the economical viability would be getting better abruptly.

13.4.2 Economic Evaluation

The Economical Evaluation takes place converting to the economical price that discounts the taxes. The results of the economic evaluations are the following ones:

Table 13.4.2 Results of the Economic Evaluation

Evaluation Index		5 year	10 year	25 year	50 year
Economic IRR		29.2 %	52.1 %	41.6 %	21.2 %
Discount Rate 6%	B/C	1.95	3.02	3.08	2.24
	ENPV(R\$10 ⁶)	390.4	1,135.2	1,437.9	1,427.9
Discount Rate 10%	B/C	1.72	2.71	2.59	1.65
	ENPV(R\$10 ⁶)	197.5	642.2	758.6	582.2
Discount Rate 12%	B/C	1.62	2.56	2.37	1.43
	ENPV R\$10 ⁶)	145.6	507.9	575.6	362.4

Source: JICA Survey Team

The results of the evaluation without tax and of compensation show the positive indicators in all of the aspects. These results indicate high economical viability of the implementations of the interventions presented in this report.

13.4.3 Total Evaluation

The Itajaí basin shows a positive tendency of development, especially in the areas of mouth of the river Itajaí, with great attractiveness to new investments. Every year, the need to structure this area of strategic importance for the State is big, mainly in what refers to the prevention of disasters.

In the results of the evaluations high economical viability is shown, even with the implementations aiming at the Safety level 50 year.

CHAPTER 14 IMPLEMENTATION PLAN OF MASTER PLAN

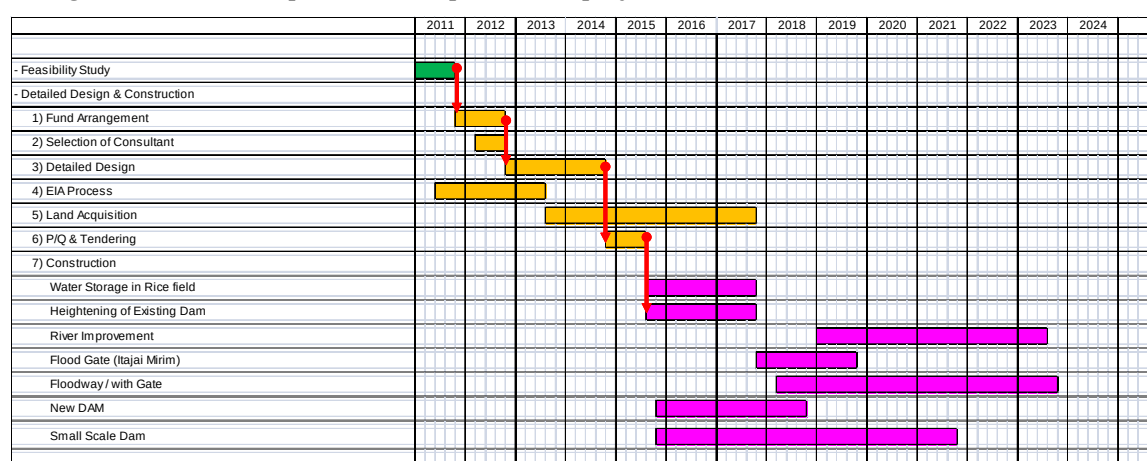
14.1 Implementation Plan

14.1.1 Flood Disaster Mitigation Measures

The conditions for formulation of the implementation plans of the projects were established, as below.

- In relation to the implementation of the Master plan, it was considered that the State government will include the required projects budget in the annual state budget planning and to provide the loan, after the completion of the feasibility studies.
- If the option takes safety level of 25 or 50 years, the total project costs will be very high. In concrete terms, the implementation plan of the projects will be required to carry out in several stages, in each implementation stage requiring the financial resources arrangement for each year. Therefore, for effect of that master plan's implementation, the period required for provision of the financial resources considered being 1 year.
- In parallel with the budget planning, the process of EIA – Environmental Impact Study will be carried out. After 2 years of the process of EIA, land compensation and resettlement will be considered, if it is necessary.
- Except for the measure for water storage in rice field, other construction works of each component of the master plan will be implemented by bidding contract base. The required period for the Pre-qualification and bidding is assumed to be 1 year.
- In the elaboration of the detailed design and supervision will be employed consultancy company.
- The implementation period of the construction works was considered as being 1.5 to 6 years, depending on the dimension of the construction work.

In Figure 14.1.1, the implementation plan of the projects is shown;



Source: JICA Survey Team

Figure 14.1.1 Implementation Plan of Flood Mitigation Project for 50-year Flood Safety Level

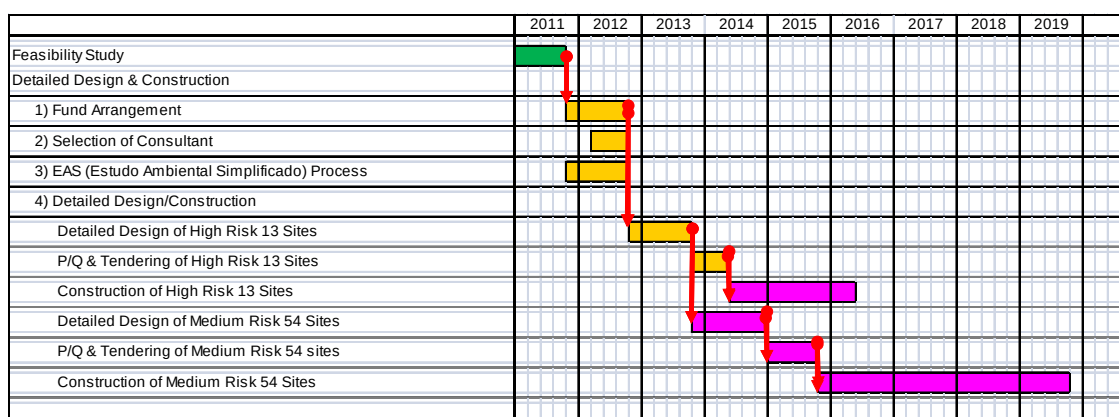
14.1.2 Structural Measures for Landslide Disaster Mitigation

Among the 67 places selected as being priority projects, it was classified into 13 places as being of great risk (annual value of larger potential damage than R\$ 500,000) and 54 places as being of medium risk (annual value of potential damage between R\$ 50,000 and R\$ 500,000). The implementation will be carried out from the place of larger risk.

The conditions for formulation of the implementation plan of the projects were established, as below.

- 1) After the completion of the feasibility study stage, it was assumed that the State government will enter the necessary procedure and necessary budget planning for the implementation of the Project.
- 2) In parallel with the budget planning, the process of EAS – Simplified Environmental Study will be realized, considering 1 year period.
- 3) The construction works will be implemented by bidding contract base. The time for preparatory and bidding stage was considered as being 1 year.
- 4) In the elaboration of the detailed design and supervision will be employed consultancy company.
- 5) In case of the landslide prevention measure, the construction site is in a road area, the compensation of land will not be considered.
- 6) The implementation period was estimated in 2 years for 13 places of larger risk and 4 years for 54 places of medium risk.

In Figure.14.1.2, the implementation plan of the projects is shown;

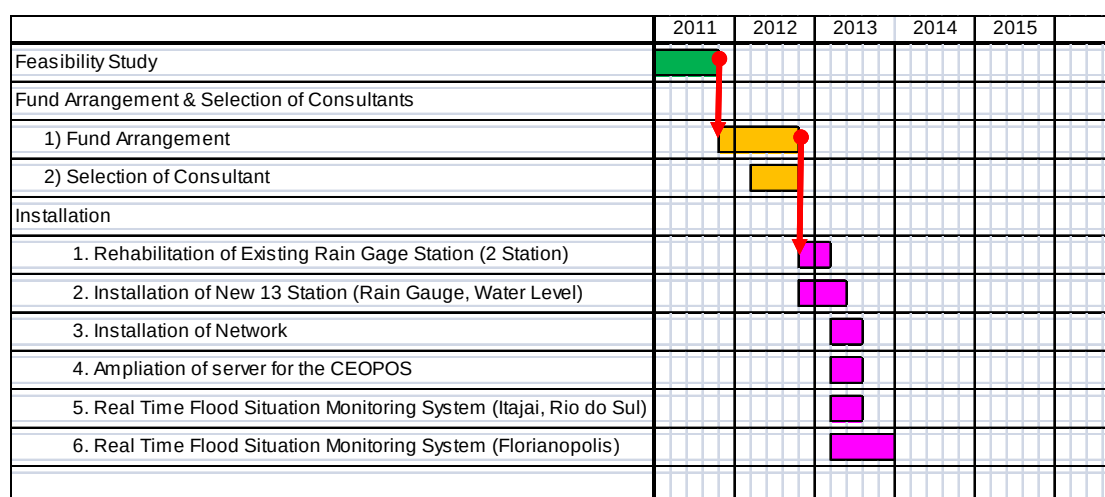


Source: JICA Survey Team

Figure 14.1.2 Implementation Plan of Structural Measures for the Landslide Mitigation

14.1.3 FFWS

With the intention to strength the monitoring network of the existing FFWS, it will be provisioned and installed equipments for rain gage observation, data transmission equipments and information systems. In Figure 14.1.6, shows the implementation plan;



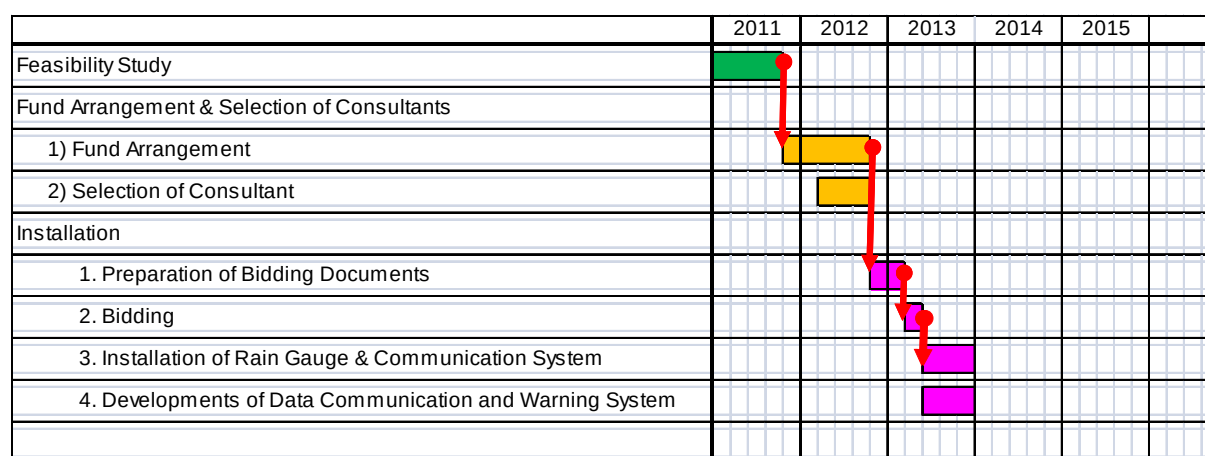
Source: JICA Survey Team

Figure 14.1.3 Implementation Plan for FFWS

As explained in Section 12.5 of Chapter 12, the field (station and monitoring center) technicians' training will be realized, after the strengthening of the existing FFWS, besides the implementation of the river inventory.

14.1.4 Early Warning System for Flush Flood and Landslide Disaster

With the intention to collect the new rainfall index (soil moisture), the provision/installation of rain gage, data transmission equipments and information systems will be carried out. In Figure. 14.2.1, shows the implementation schedule.



Source: JICA Survey Team

Figure 14.1.4 Implementation Plan of Early Warning System for Flush Flood and Landslide Disaster

14.2 Procedures for Provision of the International Financing for Brazil

The State government of the Santa Catarina will elaborate and to make request of foreign loan to SEAIN, based on the procedure of SEAIN's regulation. In Figure, 14.2.1, shows the procedure of loan contract that from the request to the SEAIN, until loan signing.

Table 14.2.1 Schedule for the Approval Procedure of the Japanese Government's Loan

	1												2											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1 【Brazil】Carta Consulta																								
2 【Brazil】GTEC/COFIEIX																								
3 【Brazil】Solicitação (MRE)																								
4 【Foreign】Avaliação (Evaluation)																								
5 【Foreign】Pré-comunicado																								
6 【Brazil/Foreign】E/N																								
7 【Brazil】Aprovação federal de confirmação financeira (STN)																								
8 【Brazil/Foreign】Negociação do Acordo de Empréstimo																								
9 【Brazil】Aprovação do Congresso Brasileiro																								
10 【Brazil/Foreign】Assinatura do Acordo de Empréstimo																								

Source: JICA Survey Team

CHAPTER 15 RECOMMENDATIONS FOR THE MASTER PLAN

15.1 Recommendations on Master Plan for Flood Mitigation

The level of safety for floods (level of flood protection) which serves as a goal for the formulation of flood mitigation master plan are usually represented by the probability of occurrence of flood or its recurrence interval. The flood safety level is determined politically, taking into consideration the size of river basin, importance and development potential in view of the national and regional economic activities, basin population, land use, and distribution of assets, etc. From the long-term perspective of civilian stability, highest level of flood protection as much as possible is desirable, although it takes huge investment and long time for realization.

In Brazil, a flood safety level has not been established based on the importance of the river. However, it is a basic policy to put water resources management including flood control into practice in the Federal Law No. 9433/08/01/1997. In this Preparatory Survey, respective flood mitigation master plans were formulated for the 5-year, 10-year, 25-year and 50-year floods. For the future, the most desirable flood safety level for flood mitigation in the Itajai River basin would be determined by the State Government through discussions with the Itajai River Basin Committee. Below are overall recommendations for the master plan.

- i) In the water resources management master plan in the Itajai River basin that was formulated by the Itajai River Basin Committee in March of 2010, development of basin storage (small dams) in micro river basin and rain water storage in paddy fields were proposed as an integration of measures for flood mitigation and drought. The development small dams focuses on small water storage (pond) to correspond to shortage of irrigation water during the dry season. If many water storages were built in micro basins, they are considered promising from the aspect to hinder the concentration of flood runoff from micro basins like rain water storage in paddy field. The development of small dams were proposed in the master plan for respective flood safety levels as one of flood control components, it is recommendable to implement small dams with priority.
- ii) The Itajaí River Basin Committee intends to build many very small ponds throughout the basin. Under the current study, due to limited time for study, small dams were selected directly on small streams based on the available topographical maps in scale of 1:50,000 with contour interval of 20. These very small ponds to be built in cultivated lands and pastures could be proposed as an alternative to the small dam proposed in the master plan. However, in case of the safety level for the 5-year flood, the total reservoir capacity required for small dams is around 8 million m³. If a very small pond is assumed to be of 100 m square in 1 m depth (10,000 m³ in capacity), totally 800 ponds would become necessary. In case of the 10-year and 25-year flood protection, it would be necessary to build 2,800 and 4,100 ponds, respectively. Considering that construction of small pond requires huge volume of excavation, construction of small dams on small tributary river is more realistic.
- iii) Heightening of the Oeste and Sulo dams becomes necessary at the safety levels for the 25- and 50-year floods, respectively. For smaller probable floods, both dams are able to control the floods safely with full closure of gates. However, this gate operation increases the risk of overflowing of the spillway. So, heightening of the dams becomes necessary to reduce risk of overflowing.

- iv) It is necessary to obtain flood inflow into reservoir every hour for proper dam operation. In general, dam inflow is calculated based on the change of reservoir capacity (changes of reservoir water level) and released volume from the dam. Therefore, the administrator of dam should prepare H-V curve (relation between the reservoir water level and reservoir capacity) and H-Q curve (relation between the releasing discharge and gate opening in conjunction with reservoir water level). According to DEINFRA and SELESC as the dam administrator, no H-V and H-Q curves are available. Besides, no as built-drawings (completion drawings) and completion documents of the existing dams have been left so far. A precise H-V curve can be created after completion of the ongoing topographic mapping with a scale of 1:10,000. As for the H-Q curve, it can be created based on the hydraulic calculation. In view of adequate management and operation of dams, it is necessary to develop updated basic information in the above.
- v) In formulating the master plan, the “flood control measures to scatter floods” was established by means of active use of allowable lands for flooding, since the lands subject to frequent flooding such as pasture, paddy and dry fields are expected to hinder the concentration of flood runoff due to natural retarding effects thereof. Therefore, it is to be noted that design flood discharges applied in the master plan did not include an increase of flood discharge to the downstream reaches due to future developments likely to reduce retarding effects (land development, residential development, etc.).
- vi) Particularly, the design flood discharge of Itajai mainstream in Itajai city was estimated assuming natural retarding effect of the existing flood plain spreading from Gaspar city to Itajai city where the Itajai valley drains to the alluvial plain is preserved without land developments. Future land developments in the flood plain should be regulated as much as possible so as not to reduce natural retarding effect. However, when developed, runoff control measures such as retention pond shall be obliged to land development, or additional water storages in the upstream basin shall be provided to compensate an increase of flood discharge in the downstream reaches. The State Government shall be responsible for coordination and arrangement of such measures over the administrative areas of municipal governments.
- vii) Absence of river administrator was pointed out as a problem of the existing FFWS. Although the Itajai River Basin Committee is responsible for formulating a master plan for water resources management, it might be impossible that the Committee becomes an entity for river management. The government institution shall be in charge of river administration considering that political decision is required for planning and implementation of flood control works. The Water Resources Department of SDS shall be recommendable for river management, because this Department is in charge of water resources management (at present mainly for water utilization) and hydro-meteorological information system.
- viii) In relation to the above, it is very important for proper river planning and river management to obtain river channel conditions together with the information on rainfall, river runoff and river water level. As the river runoff is determined from river water level, the H-Q curve (relation between river water level and river runoff) shall be developed. The H-Q curve is developed based on the river section and the measurement of river runoff during normal and flood conditions at the water level gauging station. It is recommendable to annually update the H-Q curve to improve its accuracy by discharge measurement once a year for respective conditions. As sediment deposition in river channel might influence flow capacity, it is also recommendable to carry out river cross section survey periodically. In the survey, reference point shall be established to

monitor change in river channel. A survey interval of 3 to 5 years is desirable at each reference point and carried out every year in order. These basic data shall be stored in database and available for use at all times. As for rainfall and water level gauging stations, regular maintenance and update of gauging equipment shall be scheduled.

15.2 Recommendations on Master Plan for Sediment Disaster Mitigation

Recommendations are summarized below.

- i) The objective river basin of the master plan is the Itajaí River basin. However, the proposed early warning system for landslide/flush flood shall be introduced in the whole area of the Santa Catarina State from the cost effectiveness viewpoint of system development. Considering that there exist any different risks of occurrence of landslides and flush floods in all cities in the State, rainfall gauge shall be installed in at least one location in each city.
- ii) The reference index for issuance of the early warning shall be based on the observed rainfall amount per unit time duration (for example, 30-minutes rainfall). The reference index expressed by single rainfall value is much preferable to combination of two rainfall index values (for example, combination of 90-hour rainfall and 48-hour rainfall). If a single value is introduced, it makes possible to evaluate accurately risk level of the reference index in terms of the return period (recurrence interval). When the warning is issued, it is very important to announce the message easy to understand impending sediment disaster such as “Highest risk of landslide and/or flush flood in these 10 years is rapidly increasing.”
- iii) This early warning system is newly introduced. When the warning for landslide/flush flood is issued, the same dissemination and evacuation actions as the existing FFWS shall be applied. Human losses would be minimized if municipal government identifies beforehand the risky locations and evacuation locations together with evacuation routes. If detailed hazard maps of sediment disasters are prepared like in Blumenau city, these maps would be very useful as the basic data for efficient operation of the early warning system. Besides, the persons in charge of communication and evacuation actions under the disaster situations have already appointed in Ilhota city. These activities and programs shall be applied to other cities.
- iv) As for the disaster prevention measure for land development projects, enhancement of design review by the execution body (State Government and municipal government) and training of engineers for design and construction management by the State Government shall be required.
- v) Due to land developments, flood runoff is likely to increase because of an increase of surface runoff by rainfall. In this respect, technical standards and government guidance for shall be provided for installation of regulation pond for increased flood runoff.
- vi) Structural measures for sediment disasters would also contribute to reduce sediment production. From the viewpoints of contribution to measures for climate change by means of carbon fixation, degraded bare slopes shall be vegetated and planting of trees without danger to be fallen shall be provided on gentle slopes and valley slopes of road.
- vii) Effective measures against sediment production in river basin are forestation of collapsed bare lands and provision of riparian forest to prevent riverbank erosion. These forestation shall be promoted as a multipurpose project with primary purposes of conservation of water resources, forest and environment. As proposed in the Master Plan of Water Resources Management in the Itajai River Basin, riparian forest recovery program and forestation

program for the areas for watershed conservation shall be promoted.

- viii) The Itajaí Port is the only one location where economic loss has occurred due to remarkable riverbed rising. However, no measurements have been so far carried out on sediment inflow into the port and dredged volume in the port. It is necessary to clarify the mechanism of sediment deposition in the port, reflecting sediment inflows from the sea by tide and Itajai River. One idea is to solicit universities such as UNIVALI for hydraulic research and experiment. A reasonable mitigation measure of sediment deposition in the Itajaí Port shall be formulated based on the clarified mechanism.

CHAPTER 16 SELECTION OF PRIORITY PROJECTS FOR THE FEASIBILITY STUDY

16.1 Selection of Priority Projects for Flood Mitigation Measures

16.1.1 Background for Selection of Flood Safety Level

The first phase of the current Preparatory Survey ended on 18th December 2010, with the creation of the Disaster Mitigation Master Plan and submission of the Interim Report. On the 10th and 13th December 2010, presentations were made to the Santa Catarina State Government and the priority projects were discussed with the financing possibilities by the JICA.

The flood safety level, which is the focus of the Master Plan for prevention and mitigation measures for flood disasters, is generally represented in terms of the occurrence probability and return period by years for floods. The flood safety level in Brazil is not established according to the importance of the river and the management of water resources, including flood control. It would be established by the committees of each basin, in accordance with law No. 9,433 (January 8, 1997). In the objective of the current Survey, it is mentioned that the team will create three protection levels of flood plans. In other words, measures for a flood to be occurred once in 5, 10 and 25 years (hereinafter call the “25-year flood”). However, the 50-year flood study has also been solicited as a part of the flood plan study.

After an exchange of opinions and interviews with various government institutions, universities and the Itajai River Basin Committee, the regions for flood prevention were selected and the Master Plan was formulated with the goal for each flood plan: 5, 10, 25 and 50-year flood.

Between the 16th and 18th of November 2010, the State Government held a public audience (Itajaí, Blumenau and Rio do Sul). On the 29th November 2010, the counterpart meeting was held for the commission of government representatives to plan the execution of the 50-year flood plan as the final goal in the Itajaí River basin.

16.1.2 Summary of the Flood Mitigation Plan for 50-year Safety Level

(1) Resolution No. 40 of Itajaí River Basin Committee

Basic strategy for formulating a flood mitigation master plan (described in Section 5.2) and the selected regions for protection against flooding (described in Section 8.2) were explained to the Itajaí River Basin Committee on July 28th 2010, as well as to the Technical Chamber for Disaster Prevention on August 11th. And finally, it was the subject of discussion at the Itajaí River Basin Committee general assembly on September 23rd. It was approved in Resolution No. 40 on October 7th 2010.

(2) Flood mitigation plan for the 50-year flood

Under the 50-year flood level, main cities on the margins of the Itajaí River and the Itajaí Mirim River would be inundated. They are Taíó, Rio do Sul, Ituporanga, Timbó Blumenau, Gaspar, Ilhota, Itajaí and Brusque cities. The proposed main measures of 50-year flood mitigation plan are as follows:

- i) As the basin storage measures, water storage in paddy fields (total of 22,000 ha) and basin storage (small dams) in micro-basin along the upper and middle reaches of the Itajai River (total of 41 million m³), heightening the Sul and Oeste dams (2 meters each) and the pre-releasing of water in reservoir at the CELESC hydroelectric dams (4.9 million m³) shall be implemented.

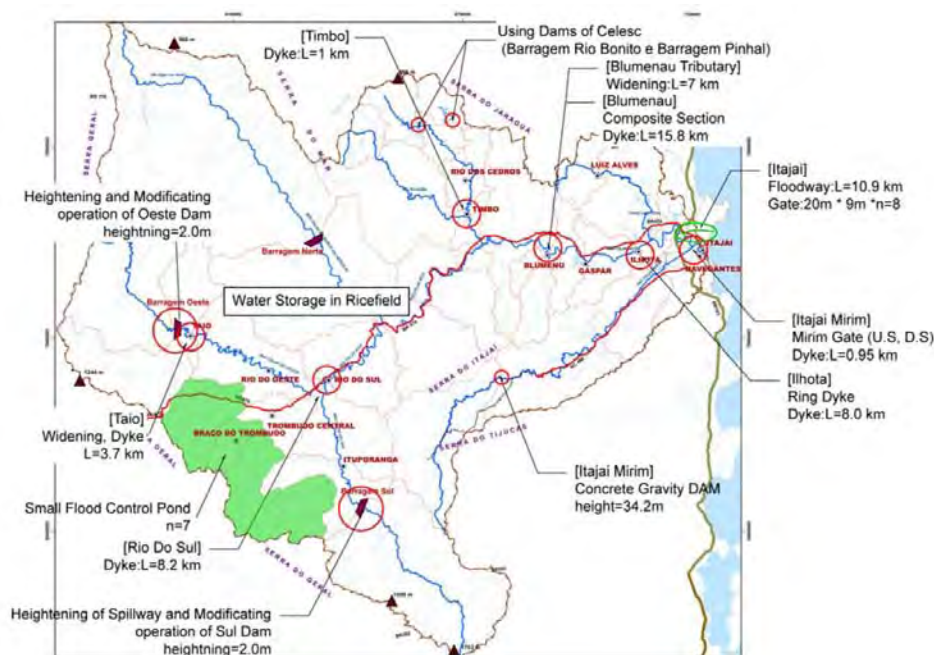
- ii) As there is limitation of the basin storage measures for flood mitigation, it is necessary to provide dykes to increase the current flow capacity in Rio do Sul, Taió and Timbó cities. As well as in Blumenau city, it is necessary to utilize the permanent preservation areas (APP) on the river margins as the flood water channel. This margin can be utilized as park in usual time. The road along the river can work as dyke when flood comes.
- iii) In the city of Itajaí, identical measures will be adopted through installation of flood gates and dykes on the Itajaí Mirim River. However, on the Itajaí River a floodway will be built (from the downstream side of the BR-101 to Navegantes beach) which is economically advantageous compared to the construction of dykes.
- iv) On the Itajaí Mirim River, including Brusque city, the flow capacity is insufficient. It will be necessary to build new flood control dam on the upstream of Brusque city to solve these problems (flood control volume of 15.7 million m³).
- v) In the regions of Garcia and Velha streams which flow into the city of Blumenau, widening of river channel by excavation was proposed in the APP. At the confluence with the Itajaí River, dykes will be provided to avoid back water effect from the Itajaí River.
- vi) However, with a flush flood that includes landslides is difficult to adopt conventional flood control measures. So, an early warning system for landslides and flush flood will be introduced, giving priority to saving human life.

Below, the project costs are demonstrated and a location map of the flood mitigation plan for 50-year flood is outlined.

Table 16.1.1 Project Cost for the 50-year Flood Mitigation Plan

Plan for Measures	Cost (R\$10 ³)	Land Acquisition & Relocation (R\$10 ³)
Rain water containment in rice fields (22,000 ha)	33,000	-
Heightening of dams (Oeste and Sul dam)	33,000	-
Basin Storage (Small dams) (7 places)	211,000	112,100 (53%)
Flood gates in the old Itajaí Mirim canal (2 places) ¹	44,000	-
Floodway in Itajaí and Navegantes cities: 10.9 km	593,000	29,400 (5%)
New flood control dam in Itajaí Mirim river (1 dam)	95,000	15,900 (17%)
Improvement of river channel in Taió: 3.7 km	114,000	54,000 (47%)
Improvement of river channel in Rio do Sul: 8.2 km	268,000	205,200 (77%)
Improvement of river channel in Timbó: 1.0 km	22,000	13,400 (61%)
Improvement of Itajaí River channel in Blumenau: 15.8 km	267,000	231,000 (88%)
Improvement of tributary channels in Blumenau: 7.0 km	196,000	171,500 (88%)
Ring dyke in Ilhota: 8 km	70,000	61,500 (88%)
Improvement of old Itajaí Mirim River channel: 0.95 km	50,000	32,200 (64%)
Total	1,996,000	926,500 (46%)

Source: JICA Survey Team



Source: JICA Survey Team

Figure 16.1.1 Location Map of the Mitigation Plan for 50-year Flood

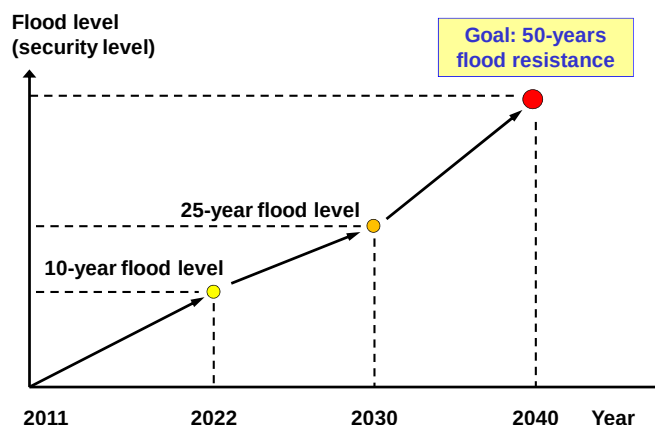
(3) Summary of the plan for flood forecasting warning system (FFWS)

Currently the FFWS is operated by FURB/CEOPS and its observation network is composed of 15 stations with rainfall and water level gauges and 2 more stations with only rainfall gauges. With the intention to improve the accuracy of flood forecast, 13 more stations with rainfall and water level gauges as well as closed circuit cameras (CCTV) in Rio do Sul, Blumenau and Itajaí cities are proposed to strengthen the current FFWS. The implementation cost was estimated at around R\$ 4 million.

16.1.3 Step-wise Implementation of Mitigation Measures for 50-year Flood

(1) Implementation strategy with the establishment of the priority level

To achieve the safety level for 50-year flood in the Itajaí River basin, a lot of resources such as around R\$ 2 billion and long period of implementation will be necessary. However, it is important to implement step-wise gradually increasing safety level according to priority level in combination with the non-structural measures (improvement of the existing FFWS)



Source: JICA Survey Team

Figure 16.1.2 Image of Stage-wise Implementation of Flood Mitigation Plan

(2) Selection of priority projects for the first phase

The target flood safety level for the first phase highly depends on the budget to be allocated by the State Government. However, it is possible to adopt the flood plan with a safety level for around the 10-year flood level as illustrated in Figure 16.1.2.

Tables 16.1.2 and 16.1.3 summarize the components and general features of the plans for respective flood safety levels. It is important to note that respective plans were formulated independently. Especially, for both the 10 and 25-year flood plans, dyke construction on the right margin of the Itajaí River was proposed. However, for the 50-year flood plan a floodway was proposed instead of dykes. The construction of dykes on the right bank will not be implemented to avoid future conflict in the stage-wise implementation of the project. On the other hand, from the viewpoint of flood control, the floodway that is being proposed for the 50-year flood plan also effects the 5, 10 and 25-year plans and the construction of the dyke becomes unnecessary. In conclusion, the floodway is proposed in the 2nd phase of implementation.

As presented in Table 16.1.3, components of each plan are divided into two large categories of measures as basin storage and river improvement to better understanding for the Itajaí River Basin Committee and communities in the basin. The “basin storage” is water storage measures in the micro-basin and the “river improvement” is measures to increase the flow capacity by improvement of river channel.

Table 16.1.2 Flood Mitigation Plans by Safety Level

Measures	Projects	5-years	10-years	25-years	50-years
Basin Storage Measures	Water storage in paddy fields	✓	✓	✓	✓
	Basin Storage (Small dams)	✓	✓	✓	✓
	Heightening of the dam (Oeste dam)			✓	✓
	Heightening of the spillway (Sul dam)				✓
	New flood control dam (Itajaí Mirim River)				✓
	Improve operation of Oeste and Sul dams	✓	✓	✓	✓
	Preventive discharge at the hydro-electric generation dams (2 dams)		✓	✓	✓
River Improvement Measures	Itajaí River, Rio do Sul city stretch			✓	✓
	Itajaí do Oeste River, Taió city stretch			✓	✓
	Benedito River, Timbó city stretch			✓	✓
	Itajaí River, Blumenau city stretch				✓
	Ilhota city, ring dyke			✓	✓
	Garcia and Velha Rivers, in Blumenau city	✓	✓	✓	✓
	Itajaí River improvement, in Itajaí city		✓	✓	
	Floodway in Itajaí and Navegantes cities				✓
	Floodgates and river improvements for the Itajaí Mirim River in Itajaí city	✓	✓	✓	✓

Source: JICA Survey Team

Table 16.1.3 Components of Flood Mitigation Plans by Safety Level

Measures	Projects	5 years	10 years	25 years	50 years
Basin Storage Measures	Containment of water in rice fields	22,000 ha	22,000 ha	22,000 ha	22,000 ha
	Basin Storage (Small dams)	2 units	5 units	7 units	7 units
	Heightening of the dam (Oeste dam)			2 m	2 m
	Heightening of the spillway (Sul dam)				2 m
	New flood control dam (Itajaí Mirim river)				1 unit
	Improve operation and functioning of dams (2 dams)	2 dams	2 dams	2 dams	2 dams
	Preventive discharge at the hydro-electric generation dams (2 dams)		2 dams	2 dams	2 dams
River Improvement Measures	Itajaí river, Rio do Sul city stretch			Excavation 10.3 km	Dykes 8.1 km
	Itajaí de Oeste river, Taió city stretch			Excavation 3.7 km	Dykes 3.7 km
	Benedito river, Timbó city stretch			Excavation 1 km	Dykes 1 km
	Itajaí river, Blumenau city stretch				Dykes 15.8 km
	Ilhota city, ring dykes			8 m	8 km
	Garcia and Velha streams, in Blumenau city	Excavation /Dyke 7.0 km	Excavation /Dyke 7.0 km	Excavation /Dyke 7.0 km	Excavation /Dyke 7.0 km
	Itajaí river in the Itajaí city		Dykes 12.8 km	Dykes 12.8 km	
	Floodway in Itajaí/Navegantes cities				10.9km
	Floodgates and flow improvements for the Itajaí Mirim river in Itajaí city	2 floodgates and 0.95 km dykes	2 floodgates and 0.95 km dykes	2 floodgates and 0.95 km dykes	2 floodgates and 0.95 km dykes

Source: JICA Survey Team

For choosing the priority projects for the first phase, the following should be considered:

- i) It is important for making consensus for implementation to incorporate mind of Itajai River Basin Committee, which is responsible to suggest for water resources development plans and the water resources management in the Itajai River. As the development of water storage in paddy fields and basin storage (small dams) in micro-basin is proposed in the Water Resource Management Master Plan, this agrees with the intention of Itajai River Basin Committee. Therefore, basin storage measures have high priority.
- ii) The goal of flood safety level is for the 50-year flood and thus the first phase of implementation is of provisional to the goal. It takes long time to realize the target safety level, and therefore the flood protection level is forced to be low until realization of the master plan for the 50-year flood. In this sense, strengthening of the existing flood forecasting and warning system (FFWS) is given high priority to alleviate flood damages and to avoid human losses by floods.
- iii) The cities where the flood protection measure is urgently necessary are: Rio do Sul, Blumenau along two urban streams (Garcia and Velha Rivers) and Itajaí.
- iv) Heightening of the existing flood control dams will become necessary for the 25-year flood mitigation plan. Both dams are able to control smaller with full closure of the gates. However, this gate operation increases the risk of overflowing of the spillway. Heightening of the dams will be necessary to reduce risk of overflowing in the first phase of implementation.
- v) The floodway will solve flooding problems in Itajaí city drastically. However, it is necessary to evaluate the diverse problems such as sedimentation within the floodway channel and on the Navegantes beach and environmental degradation caused by salt intrusion. The urgency level is high, although, more time is necessary to analyze the

solutions from environmental aspect. And it is necessary to consider the usage of the floodway in usual condition.

- vi) In the old Itajaí Mirim River, the current flow capacity is insufficient. Even with smaller floods than the 5-year flood, flooding occurs frequently. So, the urgency level for adoption of flood mitigation measure is high.
- vii) The Garcia and Velha Rivers in Blumenau city are typical urban rivers with high residential concentrations on their margins. The cost of land acquisition and relocation of the existing population represents 97% of the total river improvement costs for the 5 year flood mitigation plan and 89% of the costs for the 10-year flood mitigation plan. Although the urgency level is high, there is a need for time to negotiate and make a consensus with the residence for removal as well as to find a proper location for relocation.
- viii) As for the basin storage (small dam), dam sites were roughly identified based on the available topographical maps with a scale of 1:50,000 (contour interval is 20 m), because the on-going topographical mapping of 1: 10,000 scale by the State Government has been seriously delayed. Although 1:10,000 scale topographical maps are necessary for feasibility design, it might be impossible to use these maps in the second phase for feasibility study due to serious delay of mapping. Therefore, small-scale dam will not be included in the second phase of the current Preparatory Survey.

Based on the above in view, the priority projects for the second phase for feasibility study are recommended as follows:

- Water storage in paddy fields
- Change of the current dam operation method and heightening of the dam (2 dams)
- Utilization of the existing hydropower generation dams for flood control (2 dams)
- Strengthening the existing flood forecasting and warning system (FFWS)
- Installation of floodgates and improving Itajaí Mirim River in Itajaí city

The basin storage (small dams) development which was proposed in the Water Resource Management Master Plan as watershed management project is recommended to be implemented under the responsibility of Itajai River Basin Committee as separate project in parallel with the proposed first phase project of flood mitigation plan (in a meeting on December 7th 2010, the Committee agreed upon these terms). In case the Committee's project is delayed, it is recommended that the small-scale dam development shall be in the second phase of implementation.

16.1.4 Evaluation of the Proposed Flood Mitigation Plan from the Aspects on Environmental and Social Considerations

The evaluation has been made in aspect of implementation cost, social urgent level (which means the inundation frequency of the object area in each measure), environmental and social impacts, negative effect for downstream of the object area, technical difficulty, the time to take positive effect and difficulty for making consensus. The evaluation criteria are as follows; A: easy or negligible negative impact, B: a little difficult or a little negative impact and C: quite difficult or big negative impact. The comprehensive evaluation has done after the first evaluation with score as follows; AA the highest priority or only with small negative impact, A: higher priority or with small negative impact and B: suppose to implement in second phase after solving existing difficulties.

The evaluation and comprehensive evaluation table are as below.

Table-16.1.4 Evaluation of protection measures (1/2)

Evaluation Components	Rain water containing in rice fields	Improvement of operation and heightening dams	Small-scale dams	Flood gate in old Itajai Mirim river	Floodway in Itajai/Navegantes	New flood control dam in Itajai Mirim river
Implementation cost (RS)	33,000 (A)	33,000 (A)	211,000 (B)	44,000 (A)	593,000 (C)	95,000 (A)
Security level of flood	5-year	10-year	5-year	5-year	5-year (without dykes)	50-year
Social urgent level by flood security level	(A) It should be implement earlier although its effect is less than others.	(A) The inundation frequency in Rio do Sul is high and the risk of inundation in Taio is high because of deficiency of dam capacity. The priority of this measure is quite high.	(A) The inundation frequency in Rio do Sul is high, it is urgent to increasing security level. Its water can also be used for irrigation.	(A) The inundation frequency along the old Itajai Mirim canal is quite high, it is urgent measure.	(A) This is the most effective way to protect Itajai city which is the most economically important in the basin. Its necessity and urgent level is quite high.	(C) The urgent level is low because it is not necessary to make until 25-year flood.
Social impacts	(A) It affects to agricultural land, when only flood comes.	(A) The possible social impact made by the heightening of dams is limited as the potential inundated area is as small as 67 ha and currently used as pasture land.	(B) It would be necessary only a few resettlement when the dam uses as agricultural water.	(A) The impact is negligible.	(C) The social impacts are very big because of massive land acquisition, resettlement, dividing social community and construction of new bridge.	(C) This measure is necessary some land acquisitions and resettlements because this is the new installing dam.
Natural environmental impacts	(A) The impact is negligible.	(A) Same as left one	(B) There is little impact of ecosystem because of damming.	(A) The impact is negligible because this measure is for old canal only.	(B) There are many problems which have to do preliminary study about balance of sedimentation, salination, etc.	(B) It can be minimize negative impacts of ecosystem and landscape because the purpose of this dam is only for flood control.
Negative impacts for downstream	(A) Negative impacts will not appear because it is basin storage measure.	(A) Same as left one.	(A) Same as left one.	(A) The impact is negligible because this is the measure for Itajai city, there is no more downstream.	(A) Same as left one.	(A) Negative impacts will not appear because it is basin storage measure.
Technical difficulty	(A) There is no difficulty in implementation.	(A) Same as left one.	(A) Same as left one.	(A) Same as left one.	(B) There are many problems which have to do preliminary study about balance of sedimentation.	(A) There is no difficulty in implementation.
Time to take positive effect	(A) The effectiveness comes according to implementing area although the target area is vast.	(A) The construction period is not so long, but there is no effect before complete the construction.	(A) It takes time to find an appropriate site to fulfill agricultural needs.	(A) The construction period is not so long, but there is no effect before complete the construction.	(B) It takes for a long time to take environmental license, and the construction period will be for 5, 6 years. The effect of this measure will not appear before completion.	(B) It can take a long time to environmental license and construction period is 3-4 years. The effect of this measure will not appear before completion.
Difficulty for making consensus	(A) The demand by relative organization high because this measure comes from CRAVIL's proposal.	(A) There are few contrary opinion and negative effect is small.	(B) This is the dam although its scale is small, it takes time to make consensus.	(A) There are few contrary opinion and negative effect is small.	(B) There are a lot of unclear points of environment impact, it is necessary to have time to study its precise impact.	(C) It can take a long time to make consensus because Itajai committee is opposed for every intersect construction in river.
Priority for F/S 1st phase (Comprehensive evaluation)	(AA measure) The priority for 1st phase is very high, once it is necessary to analyze investment effect.	(AA measure) The priority for 1st phase is very high resulted by comprehensive consideration.	(A measure) It was impossible to find the site for lack of precise map, and it takes time to make consensus for land acquisition and resettlement after the site would be fixed.	(AA measure) The priority for 1st phase is very high resulted by comprehensive consideration.	(B measure) The effect for reducing inundation is clear, on the other hand, it takes long time to make consensus and take environmental license. Therefore, this measure should be implement in 2nd phase.	(B measure) The urgent level is low and it takes time to ready for construction, therefore, this measure should be in 2nd phase.
Evaluation criteria:	Implementation cost: Social urgent level: Social & natural environmental impacts, and impacts on downstream Technical difficulty: Time to take positive effect: Difficulty in making consensus:					
	A: Below US\$ 100,000 A: Highly urgent A: No impact A: Easy A: Short A: Easy					
	B: US\$100,000-300,000 B: Rather urgent B: Rather less impact B: Rather easy B: Rather short B: Rather easy					
	C: over US\$ 300,000 C: Less urgent C: High impact C: Difficult C: Long C: Difficult					

Each result is given the scores in accordance with the following rating: A=2 points, B=1 point, and C= nil. The measures are categorized into the following classes according to the following ranges of score.
More than 15 points: High priority measures (AA), 12-14 points: Priority measures (A), 8-11 points: measures to be implemented after priority ones (B), and less than 7 points: measures to be implemented in future (C)

Source: JICA Study Team

Table-16.1.4 Evaluation of protection measures (2/2)

Evaluation Components	Improvement of river channel in Taio	Improvement of river channel in Rio do Sul	Improvement of river channel in Timbó	Improvement of Itajai-açu river channel in Blumenau	Ring dykes in Ilhota	Improvement of old Itajai Mirim river channel	Improvement of stream channels in Blumenau	
Implementation cost (R\$)	114,000 (B)	268,000 (B)	22,000 (A)	267,000 (B)	70,000 (A)	50,000 (A)	169,000 (B)	
Security level of flood	25-year	25-year	25-year	50-year	25-year	5-year	5-year	
Social urgent level by flood security level	(B) This measure is not urgent because Taio is small city and it is not necessary until 10-year flood.	(B) It is not urgent because this measure is not necessary until 10- year flood.	(B) This measure is not urgent because Taio is small city and it is not necessary until 10-year flood.	(C) This measure is not necessary until 25-year flood. The urgent level is to some extent because Blumenau is big city.	(B) It is not urgent because this measure is not necessary until 10- year flood.	(A) The inundation of Itajai city is happen less than 5-year flood's rain, therefore, this measure is urgent.	(A) Upper stream area of these rivers is more critical from 10-year floods. In 25-year flood, the rest of basin would be inundated. The urgent level is high.	
Social impacts	(B) This measure includes a few resettlement.	(C) This measure is widening river channel, it would need many land acquisition, resettlement and rebuilding of bridge.	(C) This measure includes some land acquisition and resettlement although it is small city.	(C) The most important improvement site is the center of the city, the impact is not only land acquisition and resettlement but also relocate hotels and shops.	(B) There are impacts of dividing society and land acquisition, in total impact is small.	(A) There is no impact for house although the project area is in residential area.	(C) The impact is quite big because this measure is widening river in residential area, it has many land acquisitions and resettlements.	
Natural environmental impacts	(B) There are a negative impact of turbid water only in construction phase.	(A) This measure is not included excavation but widening river and constructing dyke. Negative environment impact is just a few.	(A) This measure is not included excavation but widening river and constructing dyke. Negative environment impact is just a few.	(B) The environment impact is quite big because the construction would be in the center of the city.	(A) There are only impacts by construction.	(A) The impact is small because this is in the old canal.	(B) In the construction phase, construction of dyke would be temporarily with noises in residential area.	
Negative impacts for downstream	(C) This measure can make water flow increasing. The storage measure and measures in downstream have to do prior to this measure.	(C) Same as left one.	(C) Same as left one.	(C) Same as left one.	(A) Floodplain would be conserved with ring dyke, therefore, there is no impacts in downstream.	(A) The impact is negligible because this is the measure for Itajai city, there is no more downstream. There is big time difference of peak time with Itajai-açu river.	(A) The flow amount to Itajai-açu river would be increased, but only the small impact would appear because here is difference of peak time.	
Technical difficulty	(A) There is no difficulty in implementation.	(A) Same as left one.	(A) Same as left one.	(A) Same as left one.	(A) Same as left one.	(A) Same as left one.	(A) Same as left one.	
Time to take positive effect	(B) The effect would be appear according to complete construction, although it takes time to take environmental license.	(B) Same as left one.	(B) Same as left one.	(B) Same as left one.	(B) Same as left one.	(A) The construction period is not so long, but there is no effect before complete the construction.	(B) The effect would be appear according to complete construction, although it takes time to take environmental license.	
Difficulty for making consensus	(C) Itajai committee and residents both have strong feeling of resistance to excavation and dyke.	(C) Same as left one.	(C) Same as left one.	(C) Itajai committee is positive for this measure, however, it is necessary and takes time to make consensus with residents.	(C) It is necessary to explain well to residents and make consensus.	(A) There are few contrary opinion and negative effect is small.	(C) Itajai committee is positive for this measure, however, it is necessary and takes time to make consensus with residents.	
Priority for F/S 1st phase (Comprehensive evaluation)	(C measure) This measure is less priority than basin storage and river improvement in downstream because there is bottleneck in Itajai. It can take time to make consensus, therefore, this measure should be in 2nd phase.	(C measure) It is not urgent and it can take time to make consensus, therefore, this measure should be in 2nd phase.	(B measure) Same as left one.	(C measure) The urgent level is not high and basin storage and the measures of downstream should be done earlier.	(B measure) There is no problem except making consensus, but the urgent level is low.	(AA measure) The priority for 1st phase is very high resulted by comprehensive consideration.	(B measure) It can take time to make consensus with residents, therefore, it should be in 2nd phase although it is urgent measure.	
Evaluation criteria:	Implementation cost: Social urgent level: Social & natural environmental impacts, and impacts on downstream Technical difficulty: Time to take positive effect: Difficulty in making consensus:		A: Below US\$ 100,000 A: Highly urgent A: No impact A: Easy A: Short A: Easy		B: US\$100,000-300,000 B: Rather urgent B: Rather less impact B: Rather easy B: Rather short B: Rather easy		C: over US\$ 300,000 C: Less urgent C: High impact C: Difficult C: Long C: Difficult	

Each result is given the scores in accordance with the following rating: A=2 points, B=1 point, and C= nil. The measures are categorized into the following classes according to the following ranges of score.
More than 15 points: High priority measures (AA), 12~14 points: Priority measures (A), 8~11 points: measures to be implemented after priority ones (B), and less than 7 points: measures to be implemented in future (C).

Source: JICA Study Team

16.2 Selection of Priority Projects for Sediment Disaster Prevention

16.2.1 Structural Measures for Sediment Disaster Prevention

Totally, 67 locations were selected for stabilization measures on roadside slopes. The stabilization measures on the slopes were planned to prevent blocking the roadways during a rain storm like the one in November 2008 (60-year rainfall). The total project cost for implementation of these measures for roadside slope stabilization was estimated at R\$ 54 million and was classified into two large groups in terms of the risk level (annual potential loss) as demonstrated in the table below.

Table 16.2.1 Project Costs for Selected Structural Measures for Sediment Disaster Prevention

Classified by Risk Level	Number of Locations	Project Cost in R\$ (x10 ³)
Risk Level: Large Annual potential loss > R\$ 500,000	13	18,650
Risk Level: Medium Annual potential loss between: R\$ 50,000 and R\$ 500,000	54	35,374
Total	67	54,024

Source: JICA Survey Team

The measures with a high priority level for the first implementation phase were estimated to be 13 locations with high risk level as shown above. In case of the proposed sediment disaster prevention measures, all measures are stabilization of roadside slopes, because no costs will be incurred for the acquisition of land due to the fact that all projects will be executed within the existing road area

16.2.2 Early Warning System for Sediment Disaster and Flush Flood

In the master plan, an installation of totally 53 stations on the municipal government building was proposed in each city. EPAGRI/CIRAM will be responsible for the data storage management and the sequential analysis of the observed data and will calculate the rainfall reference index sequentially based on the predicted rainfall estimated by the WRF model (Weather Research and Forecasting) and when the predicted rainfall exceeds the predetermined reference index for warning, warning will be announced to the public. The estimated costs are R\$ 4 million.

16.3 Cost for Priority Projects (First Phase)

The amount subject to ODA Loan by the State Government of Santa Catarina was planned around R\$ 100 to 150 million. Priority projects were selected below as being the project for the first phase of implementation with a target safety level of the 50-year flood. The costs for land acquisition and relocation of residents will not be the object of ODA loan but will be included in the State budget.

Table 16.3.1 Estimated Cost for the First Phase of Project Implementation

Project Component	Cost (R\$ 10 ³)	Cost excluding Land Acquisition and Relocation (R\$ 10 ³) (for Loan)
Water storage in paddy fields (22,000 ha)	33,000	33,000
Heightening of dams (2 dams)	33,000	33,000
Floodgates in Itajaí Mirim River (2 locations)	44,000	44,000
River improvement Itajaí Mirim River 0.95 km	50,000	17,800
Strengthening of the existing FFWS	4,000	4,000
Road landslide prevention measures (13 locations)	18,650	18,650
Early warning system for sediment disaster and flush flood	4,000	4,000
Total	186,650	154,450

Source: JICA Survey Team

In the first implementation phase of the project, change of the current dam operation method at the two flood control dams (Oeste and Sul dams), as well as utilization of the existing hydropower generation dams for flood control (Pinhal and Rio Bonito dams of CELESC) will be implemented as proposed in the master plan. Therefore, in the second phase of Preparatory Survey for feasibility study, concrete dam operation at these dams will be studied.

Table below shows the expected flood control effects of the first phase implementation by city.

Current situation:

Municipality	5-year	10-year	25-year	50-year
Rio do Sul				
Blumenau				
Blumenau, tributary				
Gaspar				
Ilhota				
Timbo				
Taio				
Itajai				
Itajai, Mirim				
Brusque				

After the 1st phase of implementation:

Municipality	5-year	10-year	25-year	50-year
Rio do Sul				
Blumenau				
Blumenau, tributary				
Gaspar				
Ilhota				
Timbo				
Taio				
Itajai				
Itajai, Mirim				
Brusque				



Inundation

1st phase of implementation:

<Source of funding>

JICA's loan

Rain water containment in rice fields (22,000ha)
Heightening of dams (Oeste and Sul dam)
Flood gates in the old Itajai Mirim canal (2 units)
River improvement in the old Itajai Mirim canal, 0.95km
Strengthening flood forecasting warning system
Improve operation of Oeste and Sul dams
Preventive discharge at the hydro-electric generation dams (2 dams)

SC State government

River improvement of tributary in Blumenau (2 streams)
Small-scale dams

With the construction of the floodway, it will be unnecessary to build dykes which was proposed in the 50-year flood plan, but the floodway by itself can solve the 10 and 25-year flood damage.

Source: JICA Survey Team

Figure 16.3.1 Flood Control Effects of First Phase Implementation by City

Part II
Feasibility Study

PREPARATORY SURVEY
FOR
THE PROJECT ON DISASTER PREVENTION
AND
MITIGATION MEASURES FOR THE ITAJAI RIVER BASIN

FINAL REPORT

**VOLUME II : MAIN REPORT
PART II : FEASIBILITY STUDY**

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Appendix

- Appendix 1 Mininutes of Meeting on Scope of Work
- Appendix 2 Minutes of Meetings on Inception Report

CHAPTER 1 INTRODUCTION

1.1 Background of the Feasibility Study

The JICA Preparatory Study Team submitted the Interim Report to the State Government of Santa Catarina on the 10th December 2010 in accordance with the Scope of Works of the Preparatory Survey. The Interim Report described the Master Plan of Disaster Prevention in the Itajai River Basin that was formulated in the first phase of the Preparatory Survey, which was commenced on the 25th March 2010 as the first field work in Brazil.

As detailed in Chapter 16 of the Part I Master Plan Study, the State Government decided to realize a master plan of the 50-year flood as the final goal of flood security level. In view of the required huge investment and long period for realization, the State Government decided to implement the master plan as a stage-wise development, gradually increasing a flood security level. The State Government also decided to adopt a security level for around 10-year flood level for the first stage of implementation. Along this line, the following priority projects that are subject to feasibility study in the second phase of Preparatory Survey were finally selected by the State Government for the first stage of implementation:

- i) Water storage in the paddy fields
- ii) Heightening of the existing flood control dam and change of gate operation method (2 dams)
- iii) Utilization of the existing hydropower generation dam for flood control (2 dams)
- iv) Strengthening of the existing flood forecasting and warning system (FFWS)
- v) Installation of two floodgates on the Itajai Mirim River in Ttajai city

Together with the above, the following two projects were chosen for the first stage of implementation for realization of sediment disaster prevention master plan.

- i) Slope protection of roads at 13 locations
- ii) Installation of early warning system for sediment disaster and flush flood

1.2 Schedule of the Feasibility Study

The feasibility study was commenced in February 2011 under the work schedule as shown in Figure 1.2.1 below. The field works of the Survey ended in July 2011. The total duration of the second phase of the Preparatory Survey is scheduled to be around 8 months.

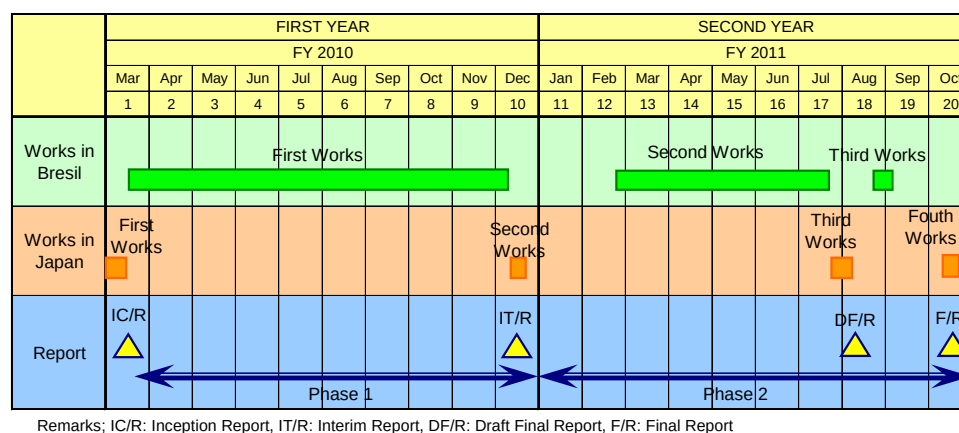


Figure 1.2.1 Overall Work Schedule of the Preparatory Survey

1.3 Change of Executing Agency of the Preparatory Survey

In January 2011, a new administration system was launched under the new Governor in the Santa Catarina State. Along this line, the Defesa Civil was promoted to an independent secretary of the State Government. In April 2011, a new director general was officially inaugurated through approval of the State Congress. In this connection, the executing agency of the Preparatory Survey was changed from FAPESC to the State Secretary of Defesa Civil. However, FAPESC participates in the planning process of the feasibility study.

1.4 Feasibility Study Report

The Feasibility Study Report is prepared as the outcome of the second phase of the Preparatory Survey, describing the whole results of feasibility study on the selected priority projects.

In addition, same as the first phase of master planning, discussions with various State Government institutions and municipal governments as well as workshop and technical seminar were made during the second phase as listed in Table 1.4.1 below.

Table1.4.1 Record of Meetings with Related Organizations During Phase 2

No.	Data	Location	Organization/Interviewee	Agenda
1	2011/2/28	EPAGRI	Althoff Geraldo (General Manager of Civil Defense), Sato (Asst. manager of JICA Brazil), Taked (JICA Brazil)	Courtesy Call to New General Manager and Introduction of Study
2	2011/2/28	Mayor's office of SC State	Raimundo Colombo (Governor), Eduardo Pinho Moreira (Vice- Governor)	Introduction of summary of M/P and F/S
3	2011/2/28	Dep. of Finance	Ubirantan S. Rezende (General Manager of Dep. of Finance), Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
4	2011/2/28	Dep. of International Cooperation	Marcelo J. Trevisani (Dep. of International Cooperation), Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
5	2011/3/1	Dep. of Strategy and Implementation	Paulo Eli Consultor Geral (Deputy of General Manager), Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S and Budget for new Project
6	2011/3/1	Dep. of Administration	Milton Martini (General Manager of Dep. of Administration), Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
7	2011/3/1	Dep. of Planning	Tulio Tavares Santos (Dep. of Planning Deputy of General Manager), Nortun (Manager), Selha (Manager of Urban Development (Ex Mayoer of Gravantal)) Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
8	2011/3/2	FAPESC	Sergio Luiz Gargioni (President), Mario (General Manager), Veran (General Manager), Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
9	2011/3/2	FATMA	Murilo Xavier (General Director), Heriberto Hulse Neto (Manager of Licence)	Introduction of summary of M/P and F/S, How to get the License
10	2011/3/10	Deinfra	Wojcikiewicz (Manager), Roberto Alexandre Zattar (Manager), Antonio Romeo Branco Farias (Manager)	Survey and Geographic Survey and introduction of the plan
11	2011/3/10	Deinfra (Division of Operational)	Celso Luiz Muller de Faria (Manager), Adolar Ferreira Filho	Survey and hearing of this years and the damage of heavy rain int this year
12	2011/3/10	SC State SC Parcerias (Public and Private implementation)	Enio Branco (General Director), Grauco Filho (Manager)	Introduction of summary of M/P and F/S, Private Project

No.	Data	Location	Organization/Interviewee	Agenda
13	2011/3/10	Dep. of Irrigation and Regional Development	Joao Rodrigues (General Manager), Luiz-Ademir Hessmann (Epagri General Director)	Introduction of summary of M/P and F/S
14	2011/3/16	SDR Ituporanga	Adelmo Cesar Santa (General Manager) Daniel Rogelio Schemitt (City chairman)	Introduction of summary of M/P and F/S
15	2011/3/16	SDR Rio Do Sul	Italo Coral (General Manager), Garibaldi Antonio Ayroso (Vice mayor), Othre Mayore and staffs total 20	Introduction of summary of M/P and F/S
16	2011/3/16	SDR Taio	Hugo Lembeck (General Manager),Ademar Dalfovo (Mayor) AMMAVI President, Othre Mayore and staffs total 20	Introduction of summary of M/P and F/S
17	2011/3/16	SDR Ibirama	Osvaldo Tadeu Beltrami (General Manager), Othre Mayore and staffs total 8	Introduction of summary of M/P and F/S
18	2011/3/17	SDR Timbo	Rogério Raul Theiss (General Manager)	Introduction of summary of M/P and F/S
19	2011/3/17	SDR Blumenau	Cesar Bitelho (General Manager), Rufinus Seibt (Vice Mayor), Pernerodo Mayoer, Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
20	2011/3/17	SDR Brusque	Fabricio Satiro de Oliveria (General Manager), Raquel Fabiane Mafra (SDS Community of Itajai)	Introduction of summary of M/P and F/S
21	2011/3/17	SDR Itajai	Fabricio Satiro de Oliveria (General Manager)	Introduction of summary of M/P and F/S
22	2011/3/22	EPAGRI	Pauro Arruda (Manager)	Introduction of summary of M/P and F/S
23	2011/3/22	DEINFRA	Paulo Meller (General Director), William Ernst Wojcikiewics (Manager of Plan and Project)	Countermeasure for Road
24	2011/3/21	State of Councilor	Kennedy Nunes (State Councilor, Defesa Civil Chairperson)	Introduction of summary of M/P and F/S
25	2011/3/23	Itajai City	Jandir Bellini Mayor), Joao Omar Macagnan (General Manager of Dep. of Planning), Everlei Pereria (Director)	Introduction of summary of M/P and F/S, and schemes for flood control
26	2011/3/30	Blumenau City	Joao Paulo (Mayor)	Introduction of summary of M/P and F/S and counter measure for land slide at road
27	2011/3/30	Rio do Sul City	Milton Hobus (Mayor)	Introduction of summary of M/P and F/S and the Itajai Community
28	2011/3/31	SDS	Paulo Bornhausen (General Manager), Edison pereira de lima (Manager of Water Resources)	Introduction of summary of M/P and F/S, and Rader rain gauge
29	2011/4/6	CELESC	Antonio Gavazzoni (Predident), Michel Becker (Director of Technical and Electric Power Supply), Andre Rezende (Manager of Public Relations)	Explanation of M/P and selected projects for F/S, Request for cooperation for project
30	2011/4/19	Civil Defense (Rio do Sul)	Eng. Andoro	Flood forecasting and result of evaluation
31	2011/4/19	CEOPS/FURB (Blumenau)	Prof. Helio Santos	Flood forecasting and result of evaluation
32	2011/4/29	UNIDAVI (Rio do Sul)	70 participants	Workshop for dam operation and early warning system for flood
33	2011/5/05	Defesa Civil (Itajai)	Everlei Pereira (Director, Coordinator)	Explanation of station for hydrology and meteorology
34	2011/5/06	Defesa Civil	Defesa Civil Key Staffs (30 persons)	Seminar for kick off of the department (new organization structure, mandate)

No.	Date	Location	Organization/Interviewee	Agenda
35	2011/5/10	Defesa Civil	Reginete, Frederico (Section Chief)	Explanation and discussion of early warning system
36	2011/5/13	CELESC	Power House Operation Staffs, Daniel Pedro Medeiros Jose Belmontt Verzola	Discussion about function of dam operation
37	2011/6/3	CRAVIL	Harry Dorow (President), Moacir (Engineer), Almir Krueger (Engineer)	Discussion of method for water storage in paddy field
38	2011/6/3	Epagri (Itajai)	Jose Alberto Noldin (Chief of Experimental Center)	Experimental Center EPAGRI (water storage in paddy field)
39	2011/6/8	EPAGRI	200 participants	The 3 rd technical seminar
40	2011/6/9	SC State Association of Engineers	30 participants	Explanation of the project
41	2011/6/9	AMAVI	Wilando Kurth (Environmental Researcher)	Discussion about opinions of the Itajai Committee and environmental assessment of the project.
42	2011/6/9	SDR Blumenau	Prof. Sheila	Discussion about reformation of river forest conducted by the Itajai Committee
43	2011/6/13	Deinfra (Sul dam)	Eng. Henz	Discussion about situation of houses in the reservoir area
44	2011/6/21	Defesa Civil (Itajai)	Everlei Pereira (Director, Coordinator)	Explanation of station for hydrology and meteorology

Source: JICA Survey Team



Workshop on Dam Operation and FFWS in Rio do Sul on the 29th April 2011



Technical Seminar in Florianopolis on the 8th June 2011

CHAPTER 2 FEASIBILITY STUDY ON WATER STORAGE IN PADDY FIELDS PROJECT

2.1 Project Context of the Water Storage in Paddy fields

2.1.1 Background

The paddy fields, accounting an area of 26.295 ha, distribute in all basins, and mainly locate in the higher basin between the Taió to Rio do Sul, Timbó area, and the lower basin among Gaspar to Itajaí. In spite of the paddy fields does not exceed 1, 8% of the total basin, the rice field has an important element for the inundation regulation, being distributed in the margins of the river from higher basin to river mouth. The existence of paddy fields shows significant roll in the control / reduction of the inundations in the lower basin. However, the potentiality to mitigate or attenuate an inundation does not still explore efficiently. On the other hand, in Brazil, the demands tendency, in all of the productive areas, has if more rigorous control, besides in the area of agricultural production. The main norms regulations implicated in the agricultural sector are:

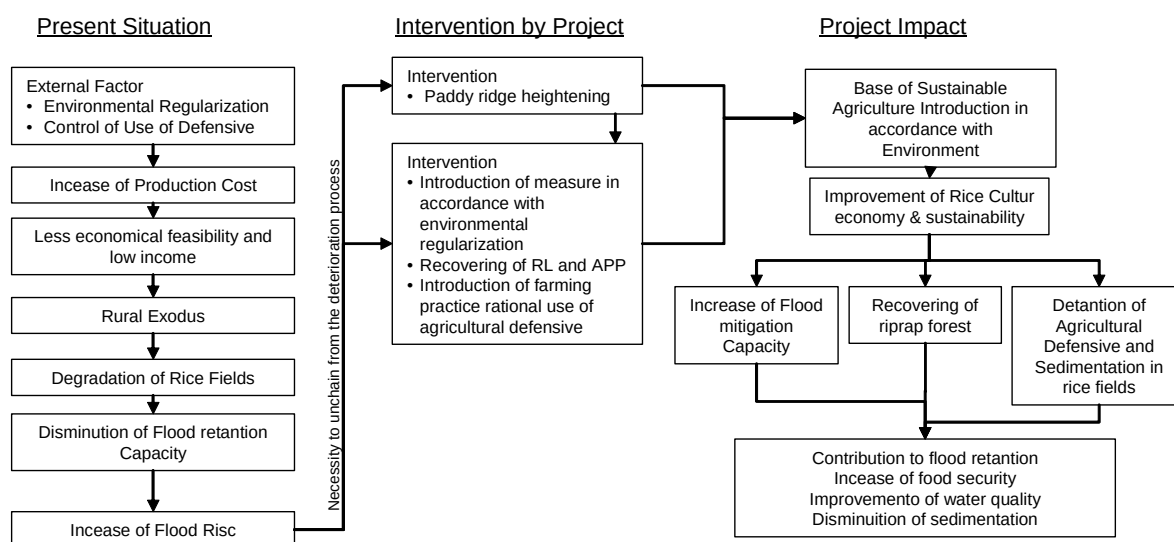
- Land Title regulation in accordance with the Forest Code (require existence of the legal reservation (RL) and the permanent reservation areas (APP), besides of riparian forest)
- Regulation of the use of agricultural defensive

In the forest Code, it forces to obtain the "Certificate of Land Title Regulation" for every rural property that requires the normalizations of the APP and of the RL. Besides, in the agricultural production sector, the consumers' demands in relation to safety foods have been increasing, requesting the certifications and traceability of the productive chain from seedling to commercialization.

This rigidity tendency in the control and quality demand in the productive chains, bring to increase the complexity in the production and consequently, elevation of the productions cost, until provoking rural exodus, because of the deterioration of the agricultural economy. As well as most of the rice farmers of the basin are of small scale farmers who doesn't have capacity to accompany the demands and of quality. Its tendency takes risks of abandoning rice cultivation, consequent abandonment of the paddy and deteriorating in the decrease of the rain retention capacity in the paddy for the loss of ridge of the farming in the point of basin management.

Like this, with the abandonment of the farming caused by the rural exodus, it brings to degradations of the paddy, consequent the disappearance of the paddy ridge, and the loss of the capacity of reduction of the rains retention in the basin. To maintain and to improve the capacity of attenuation of the rains in the paddy, it is necessary to realize the measures and strategies for the producers to stay in the rural area and to motivate the productions through the measures that favor the productions of rice in the Basin.

In this project, through construction of paddy ridge that contribute in the reductions of the floods, the farmers can modernize the productive system, capable to adjust to the forest codes, taking place the necessary activities, such as topographical survey, recoveries of the riprap forests and introduction of the PIA (integral rice production). In following Fig, it is indicated the interrelations between the paddy and the project of heightening of paddy ridge:



Source: JICA Survey Team

Figure 2.1.1 Relation between the Project Water Storage in Paddy fields and Rice Culture

2.1.2 General Policy of Plan

(1) Objective of Plan

This plan, based on the above mentioned background, in purpose to enlarge the flood retention capacity, being used of the paddy fields expanded in the all sub-basins, will heighten paddy ridge and gradually to introduce the rice production with better quality and safety. As measures, it will develop the following activities:

Increase of capacity of reduction of the floods effect	- Elevation of the paddy ridge.
Use of the land in accordance with Environmental Legislation	- Recovery of the riprap forest. - Incentive to use of farm land in accordance with environmental legislation
Safety foods Supply	- Incentive to introduce the Integrated Rice Production

Source: JICA Survey Team

Through the materialization of the elements above, the following effects will be produced:

Construction of paddy ridge	- Increase of the attenuation capacity of the rains in the paddy (for an increase from 40.000.000 to 1.000.000.000 retention m³). - Retention of the defensive used inside of the paddy fields. - Decrease of the soil erosion loss
Recovery of riprap forest	- Transformation of the area to the rice production area balanced with the environmental codes. - Protection of riprap area - Make the bases of to acquisition of "Certificate of legalized lands"
Incentive to use land in accordance with environmental regulation	- No penalty - Improvement to accessibility to Official Agricultural Credit
Strengthening of PIA	- Offer of healthy and safe foods. - Maintainable and financial Stability of the producers through the production of valued rice

(2) Extents of Plan

The extent of the plan is expansion of the rice field in the Itajaí basin. In the following Table, it is indicated the basin area, the paddy area and the percentage regarding the total area.

Table 2.1.1 Sub-basin area, Rice field's area and percentage of rice field's area

	Basin (km ²)	Paddy fields (km ²)	Percentage
Total	15,221	262.95	1.76%
Itajaí do Oeste	3,014.9	99.45	3.30%
Itajaí do Sul	2,026.7	19.64	0.97%
Itajaí do Norte	3,353.8	10.64	0.32%
Benedito	1,500.3	30.20	2.01%
Luis Alves	580.0	19.64	3.39%
Itajaí Açú	3,358.6	60.80	1.81%
Itajaí Mirim	1,678.9	22.57	1.34%

Source: JICA Survey Team

(3) Implementation method for the Project of Water Storage in Paddy fields

Considering the nature of this type of measure that depend on the paddy fields and the inundation risk falling directly to the producers, the project seeks to benefit both side, so much of production and of inundation mitigation in the same time, without only sacrificing the producers, exploring the paddies potentialities in the mitigation of flood and improvements of the productive infrastructures through the construction of paddy ridge heightening. At the same time, as the compensatory measures of the paddy fields, it will be implemented the introduction of the Integrated rice production (PIA) that the producers can be adjust to the environmental demands, guaranteeing them financial means for so much, facilitating them the obtaining of the CRF.

Inside of this plan, the government will finance the construction of paddy ridge heightening works, and the producers will participate in their activities of implementing the paddy ridge in their property. The government's contribution and of the producers in the heightening of the paddy ridges will be the following:

Table 2.1.2 Activity of the Project Rain Containment in the Paddy Fields

	Governments Support	Producers Contribution
Plan	- Support for formation of the Term of Agreement of the producers. - Support to organizations of the associations. - Support to the obtaining of C.R.F. - Topographical survey - Formulation of the Plan / Project (amount of works, calendar of the works, determination of the participation)	- Agreements between the producers and Establishment of the associations of the producers. - Arrangements of the registrations of the participants' registers. - Agreement among the producers in the accomplishment of the Plan. - Contract of the Execution of the Project
Heightening of paddy ridge	- Dispatch of consultants - Definition of the methodologies of project implementation. - Disbursement of Construction Cost of Heightening of Paddy Ridge (80%) - Supervision of the works	- Execution of the Construction of Heightening of Paddy Ridge - Co-payment of Construction Cost (20%)
Recovering of riprap forest		- Placement of that material in the margins of Rio. - Planting of nursery plants
Adjustment for Environmental legislation	- Certification of the property registration. - Survey of properties. - Emission of APP, R.L. - Establishment of the reach of APP	- Title of the property. - Certificate of Land title
Promotion of the PIA	- Technical Orientation for the PIA	- Introduction of PIA

Source: JICA Survey Team

Due to the paddy fields extend for the whole basin, and there are approximately of 2.000 farmers, there is complexity of the implantation of this plan to make format the implementation plan if it implement in contract base. Besides, because of the characteristics of this plan, and having a lot of

stages of processes in materialization, it is suggested that the execution is executed in the following way:

Government	Producers
- Lend of services and consultancies for the implementation of the Plan. - Disbursement of construction Cost (80%)	- Construction of paddy ridge heightening. - Provision of riprap forest area - Co-payment of Construction Cost

2.2 Project of the Rain Containment in the Paddy fields

2.2.1 Outline

(1) Scheme for the retention of flood water in the paddy fields

It is foreseen to execute the heightening of the paddy ridge (currently 10 cm) for more 10 to 30 cm, hoping to increase the rain water retention capacity for more 2,000 ~ 3,000 m³ per hectare, as well as it is indicated in following figure;

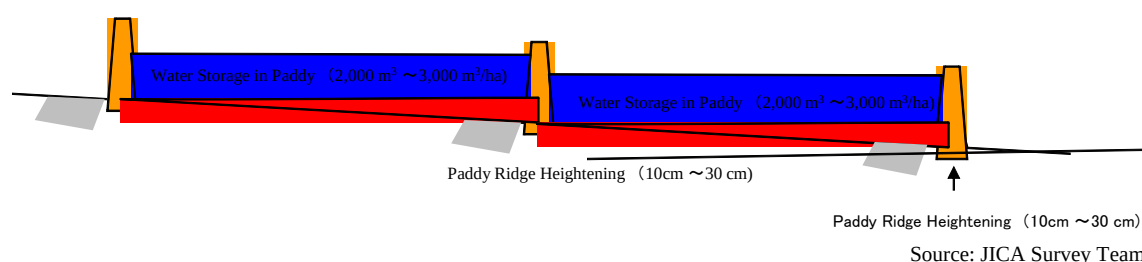
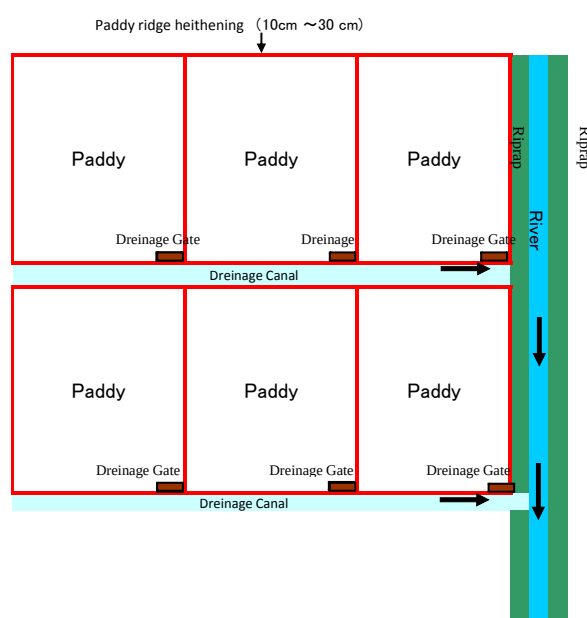


Figure 2.2.1 Retention Methodology of Flood water in paddy fields

The paddy ridge heightening works will be realized in the margins of the suitable paddy with red lines in following Fig. For not accompanying the damage in the rice production, the gates will be installed capable to control/mitigate the effects of floods, especially in the times of flowering season period of rice when larger risk of loss of the products exists.



Source : JICA Survey team

Figure 2.2.2 Retention of rain in paddy fields

(2) Definition of the flood depth and height of paddy ridge

The rice culture, being the certain resistant culture for flood, it allows to accomplish the control of the floods, through the floods of the fields with the appropriate water managements. However, vulnerable times exist as in the period 20 days before flowering season in that the culture can be

damaged by the excess of water. The required height of paddy ridge will be defined, being considered the heights of rice, to minimize the damages that can be caused by the floods by this project. The depths of projected floods depth are the following ones;

- During the period of non cultivation, it settles down 30 cm of water depth. From the period of 20 days before the formation of the ears of rice, until the time of flower of these, the maximum depth will be of 30 cm, being the normal depth of 20 cm.
- After the seedling, given the fact of the young plants does not support for a long time be submerged, one should not leave submerged for more than 4 consecutive days

The height of the heightening is of 30 cm, to make possible the installation of floodgates and to guarantee the depth of until 30 cm of the water.

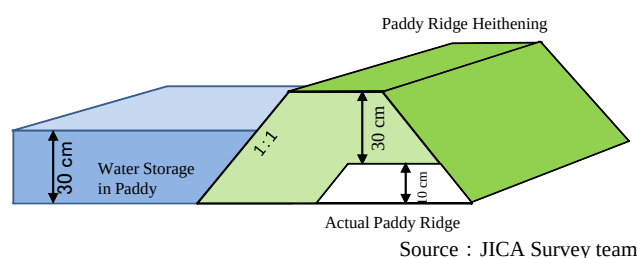


Figure 2.2.3 Cross section of Paddy Ridge

The amount of work for the paddy ridge is the following ones:

$$\text{Present } (0.5+0.7)/2 \times 0.1 \text{ m} = 0.06 \text{ m}^3$$

$$\text{After heighten: } (0.5+1.3)/2 \times 0.4 \text{ m} = 0.36 \text{ m}^3$$

$$\text{Difference of earth volume: } 0.30 \text{ m}^3$$

(3) Extents of Project Area

The extent of the Project will be the areas where appropriate rice field expansion exists inside of the entire paddy areas expanded in the Basin. As the first phase, it is considered 5,000 ha of the paddy expanded in the basin. The objective areas of project will be selected in the basic study phase and it will be settled down the following goals:

Paddy Areas: 26.295 has

Objective Project Area: 20.000 has

First phase Area of the Project: 5.000 has

(4) Heightening of Paddy Ridge and required work quantities

The dimensions of the works were estimated, being taken the area of Agronomic as sampling. The estimated amounts of works are;

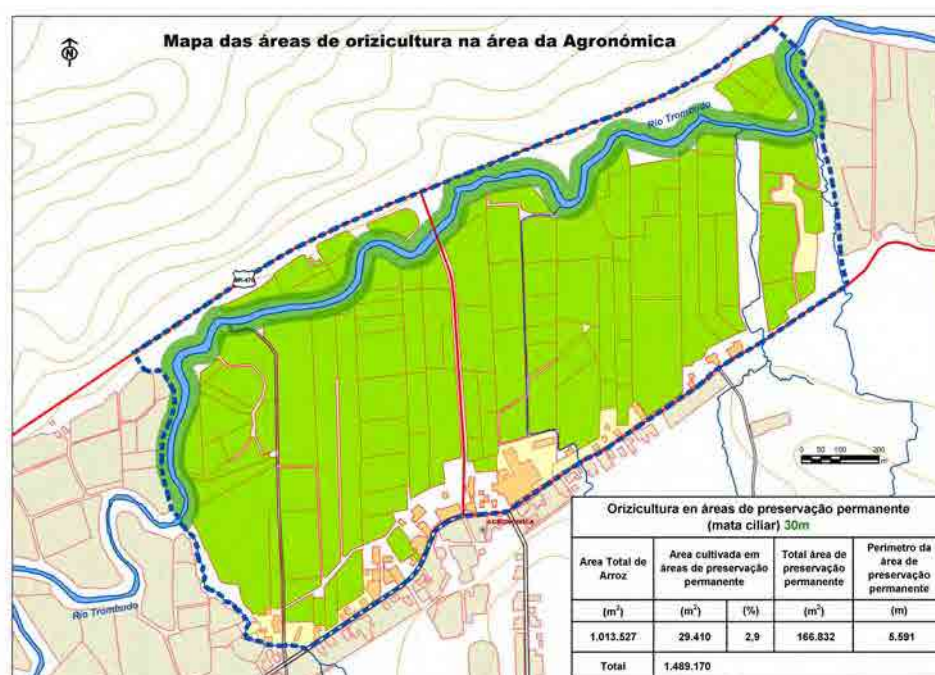
Table 2.2.3 Agrônômica – Quantities of necessary works

Item	Present	Projected	Cost/ha
Total Area			
Paddy Ares	101.4 ha		
Extension of ridge	29.4 km		
Number of farm	106		
Area of Riprap forest		0.03 ha/ha	R\$ 5,000/ha
Length of paddy ridge	m/ha	300 m/ha	
Required volume for heightening of Paddy ridge		90 m ³ /ha	R\$ 3.150/ha
Extension of medium paddy	ha	1 ha	
Required Gate		1 per ha	R\$ 250/ha
Specific riprap Forest area for 1 hectare	16.6 ha	0.16 ha/ha	
Length of riprap forest	5,600 m	55 m/ha	

Note: The cost of paddy ridge heightening works was estimated (90 m³/ha x R\$ 35/m³ = R\$ 3.150 /ha) and of riprap forests were estimated (Nursery Plant 1.000 x R\$ 3,0 / plants + Fence)

Source: JICA Survey Team

In following Fig, the Agronomic area as a sample is indicated, in order to estimate the amounts of works requested for this measure;



Source: JICA Survey Team

Figure 2.2.4 Paddy Fields in AGRONOMICA

The estimated costs of the project, included topographical survey, formulation of the plan, environmental licensing and the environmental regulation are:

Table 2.2.4 Estimated required budget in a Contract Base

Item	Quant.	Unit	Unit Price (R\$)	Total Value (R\$1,000)
Work for heightening of paddy ridge	5,000	Ha	3,400	17,000
Recovering of riprap forest	200	Ha	5,000	1,000
Subtotal				18,000
Design of paddy ridge	20,000	Ha	100	2,000
Detailed design and Bidding assistance	5,000	Ha	200	1,000
Construction Supervision	5,000	Ha	600	3,000
Topographic Survey	5,000	Ha	100	500
Emission of C.R.F	500	Family	100	500
Support to Environmental Regularization	500	Family	200	1,000
Training	500	Family	1,000	500
Total				26,500

Note: The cost of measures of contention of floods in the paddy was esteemed in the following form: Works of heightening (R\$ 3.150 / ha) + Floodgate (R\$250/unit). The Cost of riprap forest was estimated in the following form: Plants (1.000 x R\$3.0 / unit) + fence

Source: JICA Survey Team

Implementation Method

The work of the heightening/preparation of the paddy ridge will be executed by the producers, and the implementations work methodology is as follows:

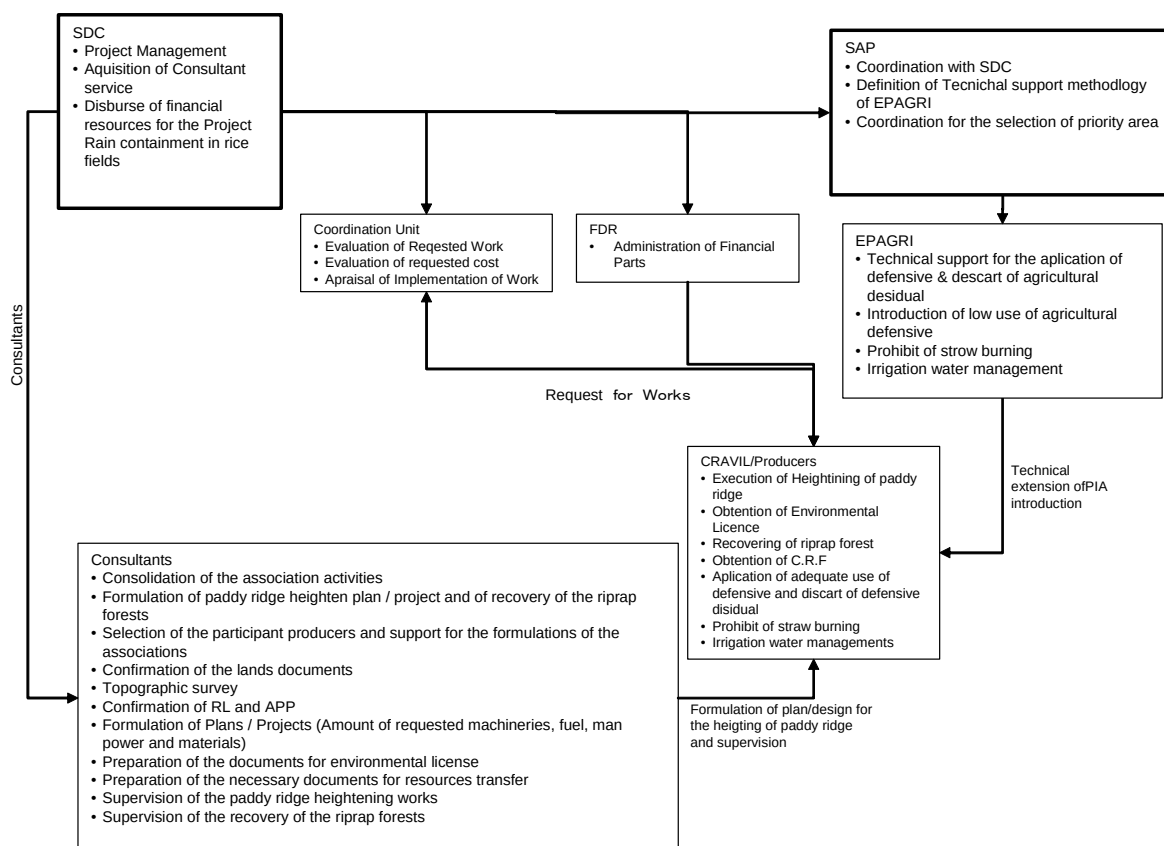
- Promotion to the producers to participate in the project of containment of rains in paddy fields, through the explanations of its benefits and activities to be accomplished by the project.
- Formation of the Agreement among the producers on implementation of the project.
- Realization of the Study, preparation of the Projects and necessary topographic survey.
- Project Design/Estimation of Cost
- Estimation of Cost
- Request for the implementation of Works for the Coordination Unit
- Request for FDR
- Evaluation of the Project, Appraisal and Contract for the Execution of the Project
- Construction by producers
- Disbursement of Construction Cost (80%)

It is foreseen to promote the understanding of the producers, in agreement, projects and survey. This type of service will be accomplished through support activity of contracted consultancy. The construction of paddy ridge heightening work will be carried out by producers.

2.2.2 Organization of Project Implementation

(1) Process

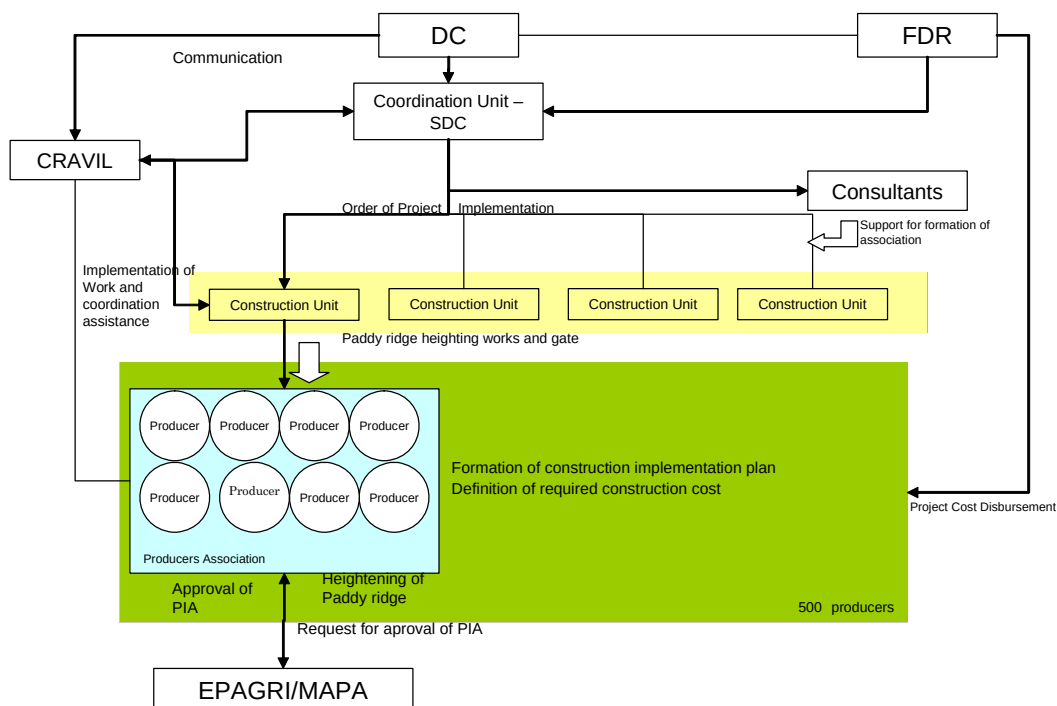
The implementation of the project will have as base, the rational and economical use of the budget, with the wide participation of the rice producers in the work. The State government will disburse the construction cost for the work, as well as consultancy services and training. Below, it is the organization chart of the implementation of the works:



Source: JICA Survey Team

Figure 2.2.5 Organization Chart

The executive organization of this project is the State through the Secretariat of Civil Defense (SDC). For the implementation of this project, the SDC will be acquired the Constructor through the bidding.



Source: JICA Survey Team

Figure 2.2.6 Project Implementation Flow

(2) Consultancy Service

The Consultancy of this operation will have the following attributions:

- To determine the outline of execution of the whole plan.
- To chooses of the candidate farmers and organization of the associations (final objective, 500 families of farmers).
- Verification of the participants' (final objective, 500 families of farmers) land titles situation.
- Verification of land title documents
- Topographic Survey and verification of Legal Reserve and Riprap Forest Area
- Detailed design and Cost Estimation
- Cost estimation
- Obtaining of the environmental license.
- Preparation of application document for appraisal
- Supervision and orientation of the work of heightening of walls (paddy ridge).
- Supervision of the countermeasures of APP

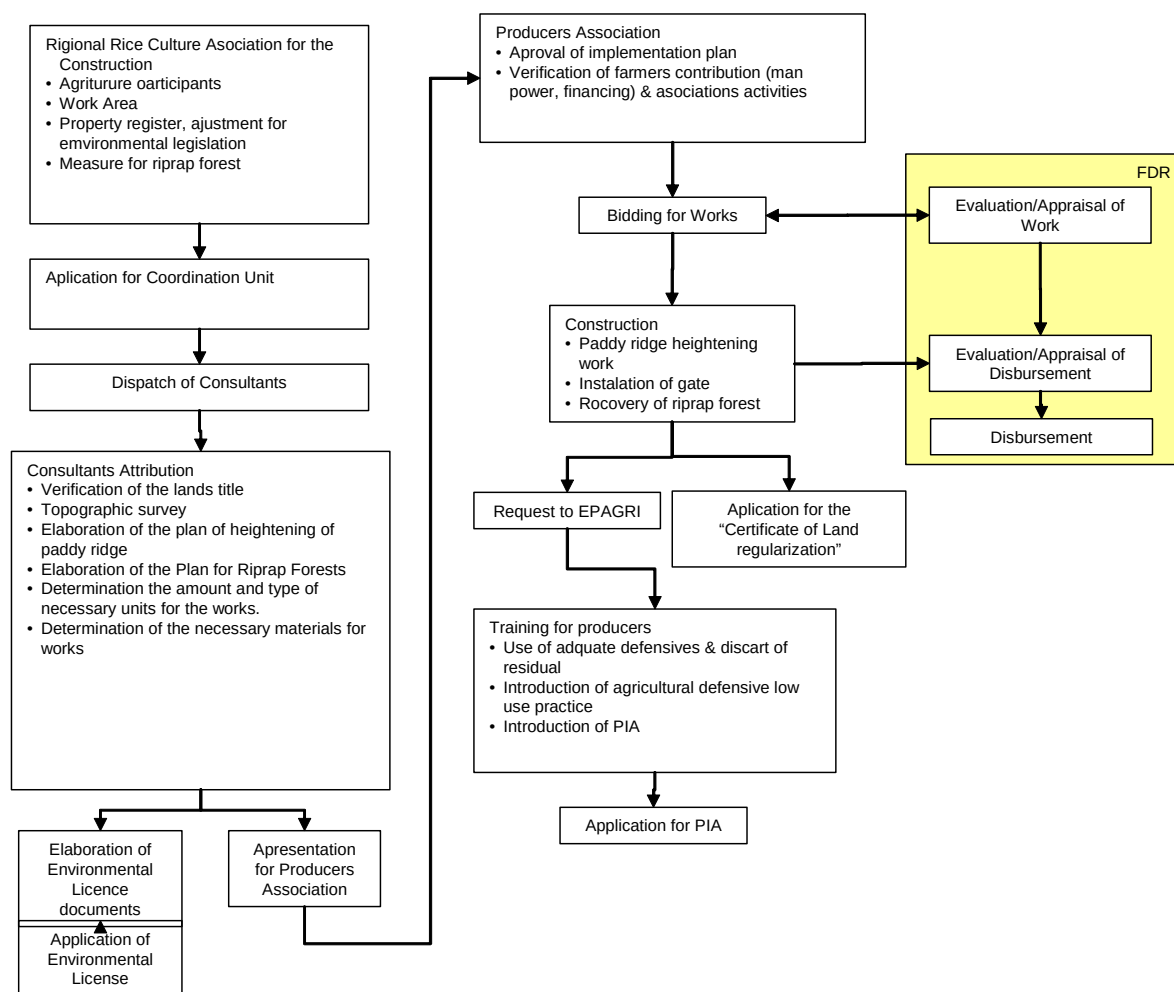
(3) Technical support for the introduction of PIA

With support of the EPAGRI/SAP, the following necessary activities will be implemented for the introduction of the PIA

- Managements of defensive use and appropriate discard of package of defensive.
- Introduction of low defensive use agricultural.
- Prohibition of the burnings of the straw.
- Administration of water resources

2.2.3 Project Implementation Guide

The process of the Project Contain of the rains in the paddy fields will be implemented in the following forms:



Source: JICA Survey Team

Figure 2.2.7 Project Implementation Process

(1) Assembly of the rice producers of the area for the execution of the works

The assembly of the rice producers of the area, with objective of obtaining support of the municipal districts, will be established at the level of the each municipal district, town or irrigation scheme established already, and it will be unit responsible of the implementation of the work. Like this, each unit of those assemblies will be, hereafter, them unit of implementation of the construction of paddy ridge works, administering the system and also making the devolution of the financing.

It is desirable that each unit has a minimum of 10 families, so that there is a harmonic work in the works. Each assembly will have to decide on the following items:

- Participants of the project.
- Area where the project will be accomplished.
- Outline of the registrations of the land (for adaptation to the environmental legislation).
- Measures are taken with regard to the riprap forest.
- Place from where will leave earth.

- Administration Methods and supervision and choice of the leadership of the association.
- Methods for the devolution of the financing of the FDR

(2) Requirement of work for the Coordination Unit of the Project

In the Project of containments of rains water in the paddy fields, each association will make request to the Coordinating Unit of the Project for its implementation. The coordinating Unit will establish the order of service of each work and execution, in view the applications done by each area and area. The coordinating Unit will do, also, allocation of the consultants, in order to make design of paddy ridge heightening, cost estimation and make request for the FDR for the implementation of the Project.

(3) Paddy Ridge construction works and recovery of riprap forest

To execute the paddy ridge works and recoveries of the riprap forests will be accomplished the following activities;

- Verification of the lands registrations.
- To execute the measurement (topographic survey).
- To elaborate the project of construction of paddy ridge.
- To elaborate the project of the riprap forest.
- Project of earth (for the paddy ridge) retreat.
- To determine the amount of machines and the necessary days of use.
- Methods of reproduction of seedlings.

The measurement area will be basically of those foreseen for the heightening of paddy ridge, lands that are out of the Project, the costs for measurement will be covered by the proprietors. As for the riprap forests, through the verification of the land registrations, will be divided in areas of individual responsibility and community. The plan of borrow pit as for the earth will be resolution item in the assemblies of each unit, as for the place from where will be removed, and means of providing resources for such. It is also due to calculate the amount of workers, the number of necessary machines, the cost, the necessary materials, to base the applications to the CIDASC and the FDR.

As for the recovering of the riprap forest, it is just due not to foresee the species and varieties of the nursery plants, production and planting, but also from where the resources will come for so much.

(4) Application for obtaining of the environmental authorization

The allocated consultants will elaborate the document and necessary applications to the obtaining of the environmental license; especially, close to the FATMA (General office of the Environment of the State).

(5) Last confirmations of the Assemblies of the rice producers associations

Through the assemblies, it will be verified the following points:

- Lines as for the methods and means of the elevation of the barriers (of the heightening

of paddy ridge).

- Methods for restoration of the riprap Forest, and their limits.
- Preparation of the document for the application for the implementation of the work
- (6) Evaluation/Appraisal of requested document for the implementation of works and preparation of contract documents

The Coordination Unit will evaluate the appropriation of the construction cost requested by the producers and, after the appraisal of the document, it will be transferred the request for the FDR. Also, the Coordination Unit will make contract document subscribing the responsibility of farmers and implementation schedule, including the responsibility in the contention of rain water in their paddy fields.

- (7) Start of Works by producers and request for the disbursement

The Rice producer will carry out the paddy ridge heightening works and riprap forest recovering. The cost for the work will be requested for the disbursement.

- (8) Evaluation of construction cost and disbursement

The Implementation Agency will evaluate requested construction cost and after the appraisal of the requested document will be disbursed through the FDR. The disbursed amount is 80% of the construction cost.

- (9) Training for Producers

To optimize the effects of the works in this basin, besides improving the quality of the water the producers they will receive the following trainings:

- Use of defensive / discard of residues and packing.
- Introduction to the low defensive use agriculture.
- Prohibition of burnings of the straw.
- Practice of the agriculture with low use of defensive.
- Handling of water

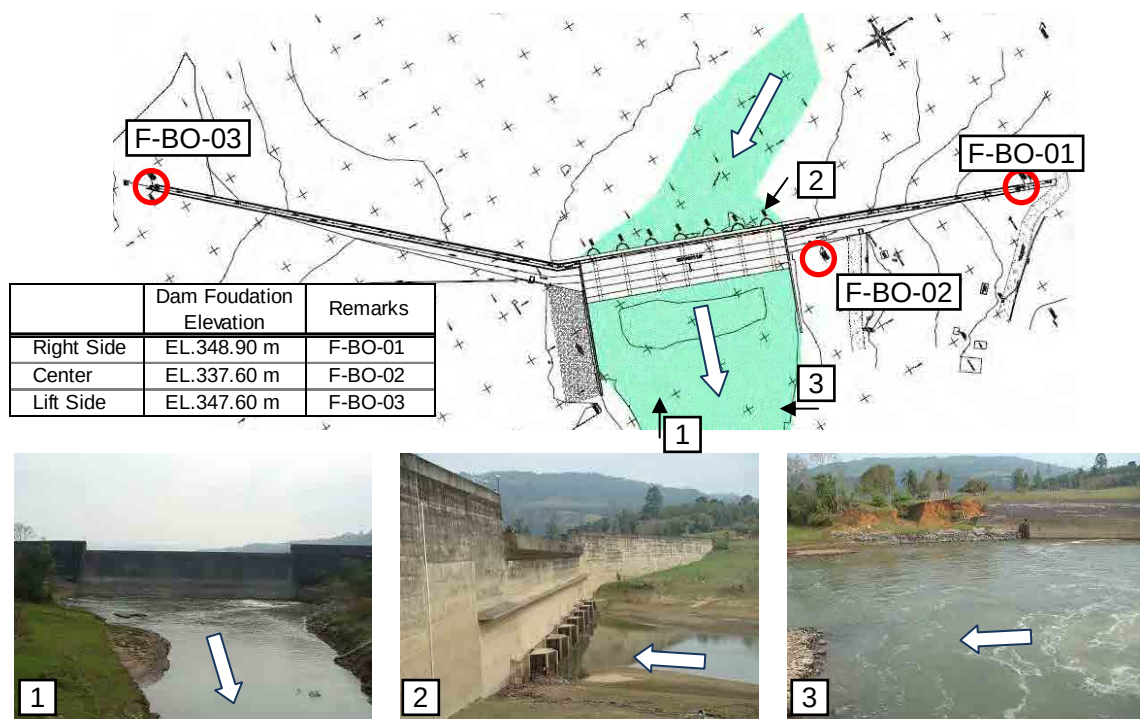
CHAPTER 3 FEASIBILITY STUDY FOR HEIGHTENING OF EXISTING FLOOD CONTROL DAMS AND MODIFICATION OF DAM OPERATION

3.1 Background of Dam Heightening

Heightening of the Oeste and Sul dams becomes necessary at the safety levels for the 25- and 50-year floods, respectively. For smaller probable floods, such as the 10-year flood, both dams are able to control the 10-year flood safely with full closure of the gates. However, this gate operation increases the risk of overflowing of the spillway. So, heightening of the dams becomes necessary to reduce the risk of overflowing. Due to this reason, heightening of these dams was proposed in the Master Plan.

3.2 Field Investigations

The topographic survey was carried out at two dams to confirm major structural dimension of both dams, which was basically required for feasibility level design for heightening. In addition, geological survey was carried out to estimate the foundation profile of the dams. Drillings were carried out at three (3) locations at the Oeste dam and one (1) location at the Sul dam as shown below.



Source : JICA survey team

Figure 3.2.1 Location Map of Drilling Survey at the Oeste Dam

(1) Engineering Geology at the Oeste dam

The location of drilling points and outcrop, geological structure and distribution of geology are shown in the Fig.3.2.3. Drilling survey was performed at the left side of the existing concrete dam body (No: FB-O-01, total depth: 30.6 m), the central base dam (No: F-BO-02, 26.0 m) and the right side of the existing concrete dam body (No: F-BO-03, 25.5 m) with standard penetration tests, that were performed before reaching to the bedrock. Based on the results of drilling survey and detailed site investigation, the unconfined compression strength of fresh bedrock is estimated about 30M N/m², classified as medium strong rock. In crack zone, crack

spacing is more than 5 cm. According to the existing result of shearing test for similar rock, shear strength is estimated as $\tau = 1.0 + \sigma \tan 38^\circ$ (MN/m²).

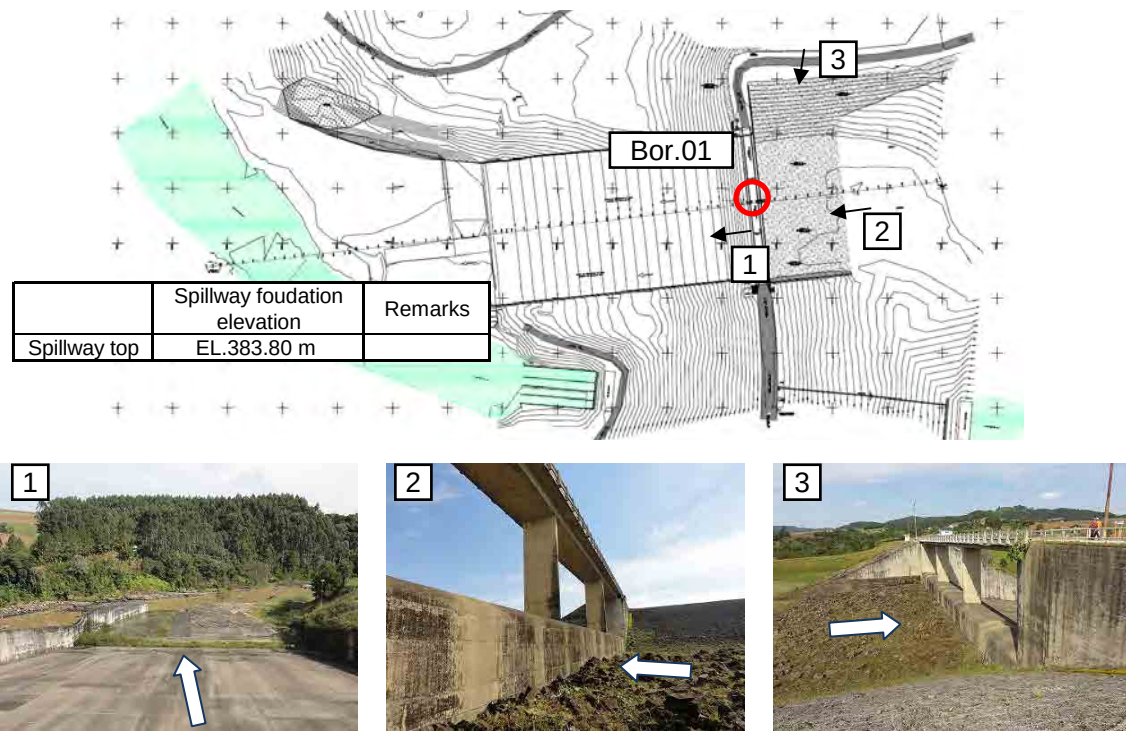


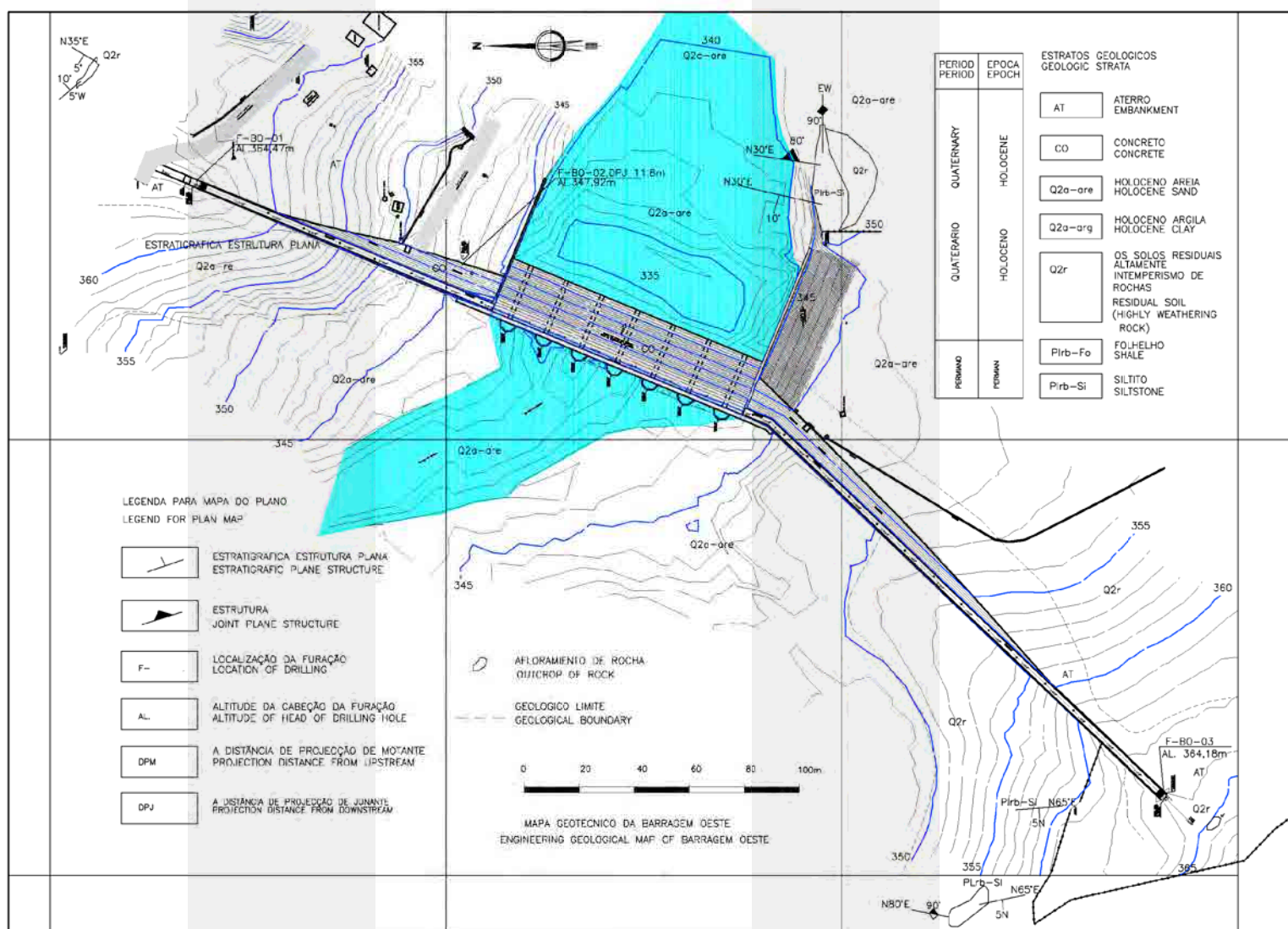
Figure 3.2.2 Location Map of Drilling Survey at the Sul Dam

(2) Engineering Geology at the Sul dam

The location of drilling point and outcrop, geological structure and distribution of geology are shown in the Fig.3.2.4. The drilling was performed at the top of spillway (No: F-BS-01, total depth: 20.0 m) in order to verify the quality of concrete and condition of bedrock at the spillway.

The unconfined compression strength of fresh bedrock is estimated about 30MN/m², medium strong rock. In crack zone, crack spacing is more than 5cm. According to the existing result of shearing test for similar rock, the strength of shear is estimated as $\tau = 1.0 + \sigma \tan 38^\circ$ (MN/m²).

The details of site geology and results of the survey are described in the Supporting Report Annex C Geology.



Source: JICA Survey Team

Figure 3.2.3 Geological Map for the Oeste Dam



Figure 3.2.4 Geological Map of the Sul Dam

3.3 Feasibility Design for Civil Structures

3.3.1 Criteria for Design

The following design criteria and standard were applied. The feasibility design was carried out mainly based on the first Brazilian standard, supported by other standards.

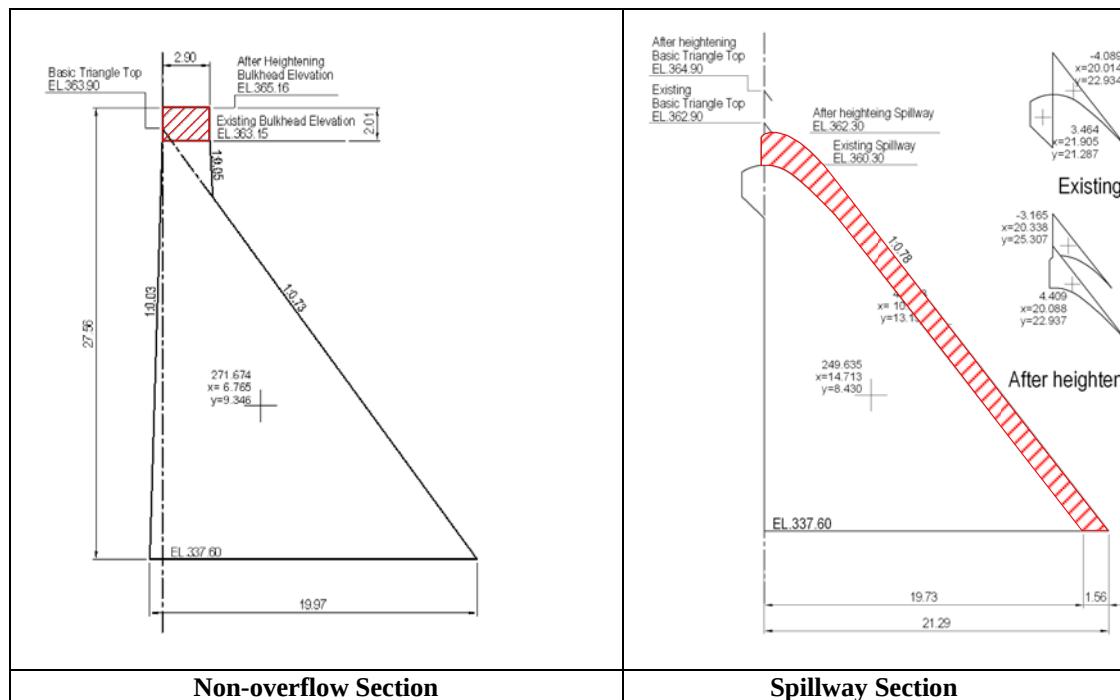
- i) CRITÉRIOS DE PROJETO CIVIL DE USINAS HIDRELÉTRICAS Outubro/2003
- ii) Technical Standard for River and Sabo Facilities, Ministry of Construction of Japan, 1997
- iii) Design of Small Dams, Bureau of Reclamation, Department of The Interior, USA, 1987

3.3.2 Feasibility Design

(1) Oeste dam

1) Non-overflow and Spillway Sections

It appeared by the topographic survey and hydraulic calculation of the design discharge that the non-overflow section of the dam body should be heightened by 2.01 m, although the spillway section is by 2.0 m. Figure 3.3.1 shows the designed sections. As seen, the shape of spillway crest is relatively sharp because of its sharpness of the crest.



Source : JICA Survey Team

Figure 3.3.1 Designed Sections of the Oeste Dam

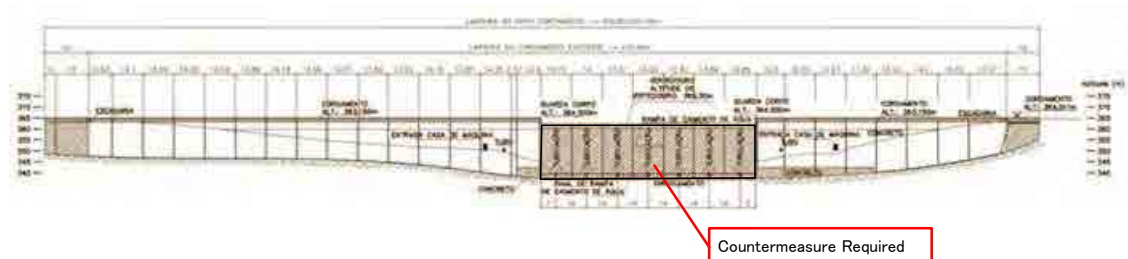
2) Stability Analysis against Overturning due to Heightening

Non-overflow section

Stability analysis was carried out to confirm the stability against overturning due to heightening, dividing the non-overflow section into several sub-sections. It appeared that all of the sub-sections are sufficient for the required safety factor of 1.10, which is required for the structure against overturning.

Spillway section

It appeared that spillway section is insufficient for the required safety factor. The facing concrete at the downstream slope was thus proposed in the whole section of spillway. The downstream slope is set at 1:0.78.

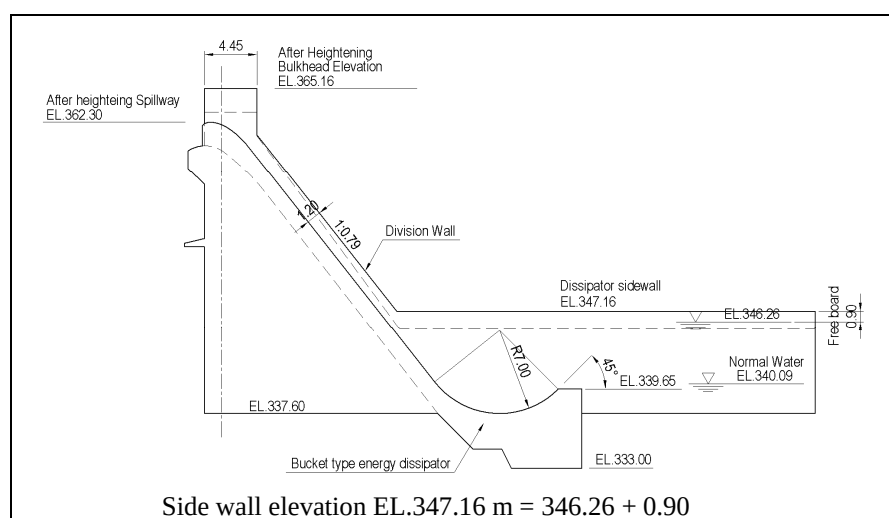


Source: JICA survey team

Figure 3.3.2 Proposed Countermeasure against Overturning at the Spillway Section of Oeste Dam

3) Energy Dissipater

No energy dissipater is provided at the Oeste dam. The energy dissipater is generally installed at the outlet of spillway to dissipate large energy of the overflowed water of spillway. Heightening of the spillway might cause larger energy since the overflow head becomes higher. From the hydraulic viewpoints, it was proposed to install the dissipater. The proposed dissipater is of the submerged bucket type considering that river water level immediately downstream of the dam is always high enough as illustrated below.

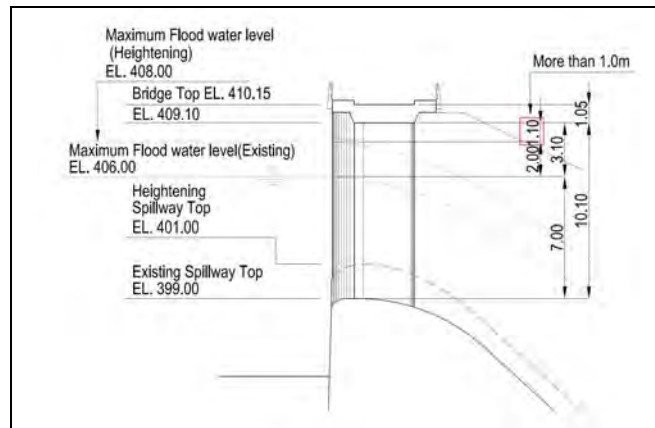


Source : JICA Survey Team

Figure 3.3.3 Proposed Energy Dissipater at the Oeste Dam

(2) Sul dam

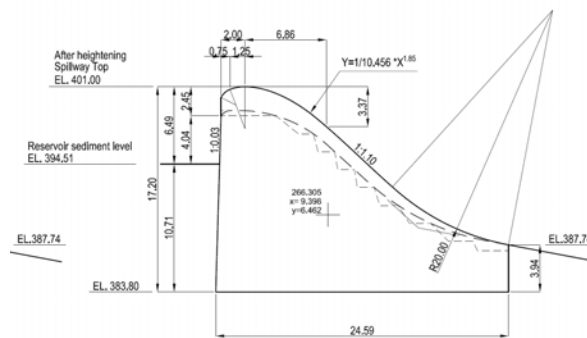
The Sul dam is proposed to heighten only the spillway section by 2.0 m because of sufficient freeboard to the dam crest after heightening as illustrated in Figure 3.3.6. As shown, the maximum overflow depth of design discharge of 2,570 m³/s (= 10,000-year flood) is 7.0 m under the present spillway. However, even though the spillway is heightened by 2.0 m, there would be more than 1.0 m space as a freeboard.



Source : JICA Survey Team

Figure 3.3.4 Comparison of Overflow Depth of Design Discharge on the Spillway of Sul Dam

Figure 3.3.5 presents the designed spillway profile for heightening. The design calculations are detailed in the Supporting Report F.



Source : JICA survey team

Figure 3.3.5 Proposed Spillway Section at the Oeste Dam

3.4 Feasibility Design of Conduit Gates

3.4.1 Site Investigation of the Existing Conduit Gates

(1) Objectives for Site Investigation

Since the conduit gates of both Oeste and Sul dams were constructed more than 40 years ago, it is concerned that the strength of conduit gates has been weakened due to long-term corrosion.

It is not clear about the design criteria, design condition, the material used and the dimensions because of no the design calculations available at this moment. Therefore the site investigation was carried out for the following purposes:

- i) To clear the current condition of the gate and operation system
- ii) To measure the plate thickness of bonnets of gates and conduit pipes, and
- iii) To make an interview to the site manager concerning the operation system and maintenance record.

(2) Site Investigations

The current condition of the gates is clarified as shown in the following Table 8.2.1. Large water leakage was found at the both dam gates. It might be due to that the water leakage was caused by dismantling the bonnet flanges at the time of overhaul in 1983. A lot of sand has been accumulated in the pits. Although the accumulated sand and leakage water might not affect to the gate operation directly, drain pumps might be effected to cause trouble.

(3) Measurement of plate thickness of bonnets of gates and conduit pipes

The results of measurement are summarized in the following Table 3.4.2. Although the overhaul of conduit gates at both the dams have been undertaken in 1980s, it was found that no corrosion is observed and the conduit is sound condition. The result to measure the plate thickness and gates is that the values of corrosion are supposed to be 0.1 to 0.2 mm. Therefore the loss of the corrosion is estimate a little.



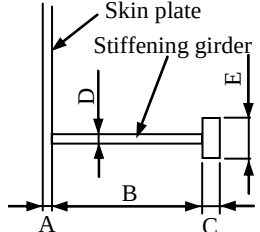
Photo: The Current Condition of Gates
(Left: Oeste Dam, Right: Sul Dam)

Table 3.4.1 Current Condition of Gates

Check item	Oeste Dam	Sul Dam
Water leakage	- Water leakage was observed at the flange of all gates. - Water leakage was observed at the expansion joints of all gates.  No.1 slide gate	Water leakage was observed at the flanges and expansion joints of all gates.  No.4 expansion joint
Oil leakage	No oil leakage was observed from the hydraulic unit and cylinder.  Hydraulic unit	No oil leakage was observed from the hydraulic unit and cylinder.  Cylinder of No.5 slide gate
Dirt	Dirt caused by water leakage was observed at all gates.  Dirt due to leakage Pit of No.5 slide gate	No dirt was observed for all gates because the pits were covered with the leakage water.  Leakage water in pit (No.2 gate)
Damage	No damage was observed at the gates.	No damage was observed at the gates.

Source: JICA Survey Team

Table 3.4.2 Results of Measurement

Item	Oeste Dam	Sul Dam	Remarks
Plate thickness of conduit pipe	Upstream: 5.93mm Downstream: 6.51mm	Upstream: 9.17mm Downstream: 8.66mm	—
Plate thickness of stiffener girder	A: 12.50mm (12.7mm) B: 100.00mm (100.0mm) C: 20.00mm (20.0mm) D: 12.80mm (12.7mm) E: 65.0mm (65.0mm)	A: 12.58mm (12.7mm) B: 122.00mm (123.0mm) C: 26.00mm (25.4mm) D: 16.20mm (16.0mm) E: 100.00mm (100.0mm)	

Source: JICA Survey Team

3.4.2 Criteria for Design

The standard of ABNT NBR 8883:2008 in Brazil to the gate design was applied. Therefore, the strength of the existing gates and conduit pipe were analyzed using the said standard.

3.4.3 Study on Repairing the Conduit Gates

Even if the water level is raised up by 2.0 m, the existing gates have enough strength, judging from the calculations. The reason is due to that the corrosion-speed is slow and the thickness of margin (which was designed against the long-term corrosion, and it is supposed that about 1.0 mm) is still remain even 40 years passed. Thus it is proposed that the existing facilities should be satisfied even the dam heightening.

3.5 Modification of the Operation

3.5.1 Basic Approach

(1) Reference Point for Operation of Dams

The heightening of Oeste dam and modification of the operation can cope with the 10-year flood in Taio city, but can not achieve the 5-year safety in Rio do Sul city without basin storage (small dams). Therefore, Taio city should be selected as the reference point to modify the operation manual of Oeste dam.

On the other hand, the present safety level of Ituporanga city is more than 10-year flood. But the present safety level of Rio do Sul city along the Rio Itajai do Sul is less than the 10-year flood. Therefore, Rio do Sul city along the Itajai do Sul River should be selected as the reference point to modify the operation manual of Sul dam.

(2) Target Flood Protection Level

In the M/P, heightening of the dams is planned for the 50-year flood. But the safety of the downstream river shall be provisionally achieved for the 10-year flood by the projects of first stage. Therefore, the operation manual should be also prepared provisionally for the 10-year flood. When floods larger than 10-year flood occur, flood discharge might overflow from spillways. However, present situation in which flood discharge overflows once in approximately 5 years from spillways of both Oeste and Sul Dams will be improved.

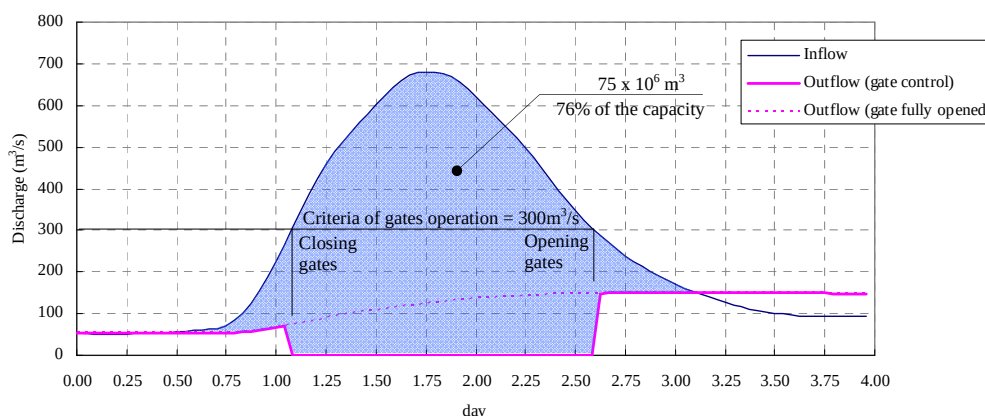
3.5.2 Method of Flood Control

(1) Flood Control Method at the Oeste Dam

If all the gates are fully opened during the 10-year flood, maximum flood discharge in Taio city is estimated 520 m³/s. This discharge exceeds the current flow capacity of 440 m³/s in Taio city. Therefore, the required peak cut for the 10-year flood at the Oeste Dam is estimated 80 m³/s.

Additionally, it is desirable to close fully the gates during the flood as long as possible, expecting flood control effect in Rio do Sul city and simplification of the operation.

The criteria of opening and closing gates would be set at 300 m³/s of the flood inflow into the reservoir, considering more than 20% of the storage capacity as a margin capacity in view of uncertainty of variety of the rainfall distribution and the occurrence of extraordinary floods.



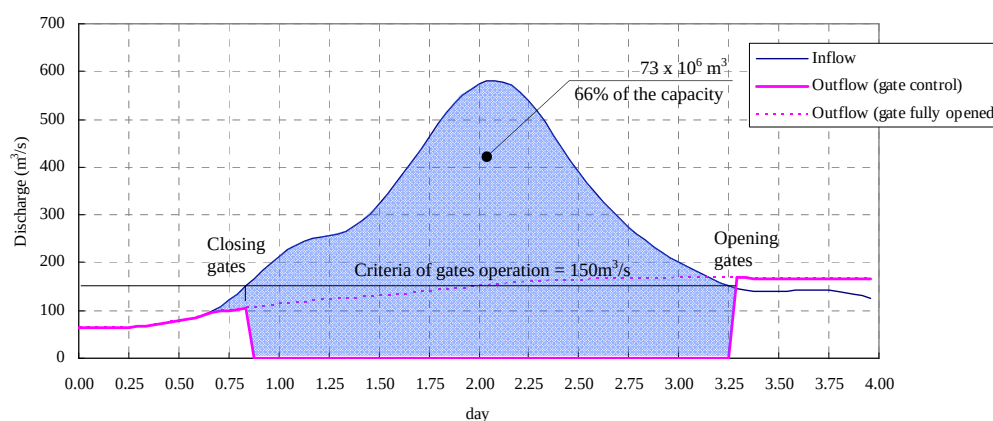
Source: JICA Survey Team

Figure 3.5.1 Method of Flood Control at the Oeste Dam

(2) Flood Control Method at the Sul Dam

If all the gates are fully opened during the 10-year flood, maximum flood discharge in Rio do Sul city in the Itajai do Sul River is estimated 570 m³/s. This discharge exceeds the current flow capacity of 440 m³/s in Rio do Sul city. Therefore, the required peak cut for the 10-year flood at the Sul Dam is estimated 130 m³/s.

The criteria of opening and closing gates would be set at 150 m³/s of the flood inflow into the reservoir. As storage volume for 10-year flood shall be 73 x 10⁶ m³, the margin capacity shall be 34% of storage capacity in view of uncertainty of variety of the rainfall distribution and the occurrence of extraordinary floods.



Source: JICA Survey Team

Figure 3.5.2 Method of Flood Control at the Sul Dam

(3) Method of Gate Operation

The method of gate operation mentioned above would be simple, but gate operator need to know the inflow discharge. The inflow discharge shall be estimated by the following equation.

$$Q_{in} = \frac{\Delta V}{\Delta t} + \bar{Q}_{out}$$

where, Q_{in} : inflow into the dam (m^3/s)

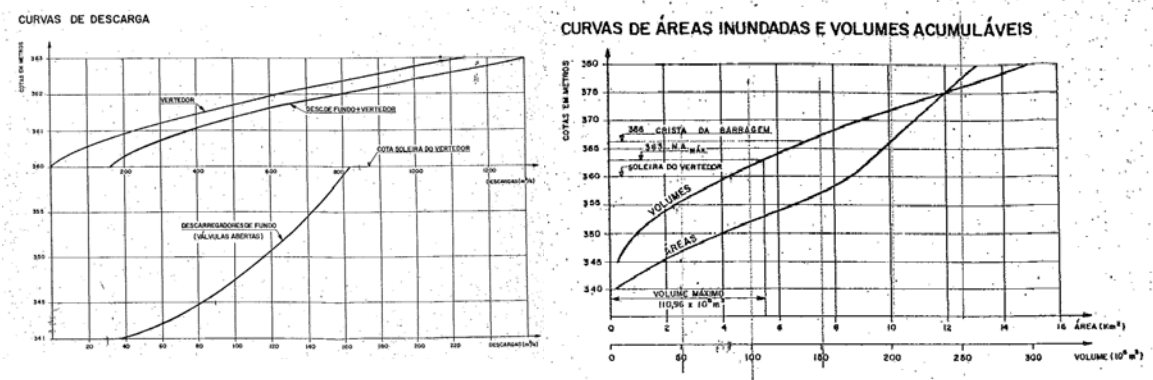
ΔV : increasing volume of reservoir storage during Δt (m^3)

$\bar{Q}_{out}$: average outflow during Δt (m^3/s)

Therefore, the gate operator should obtain the accurate data of reservoir water level and outflow through the conduits every 30 minutes or 1 hour to operate the gates properly. In this connection, the gate operators should also prepare the rating curve showing relationship between reservoir water level and storage volume, and the rating curve among reservoir water level, gate opening and outflow rate.

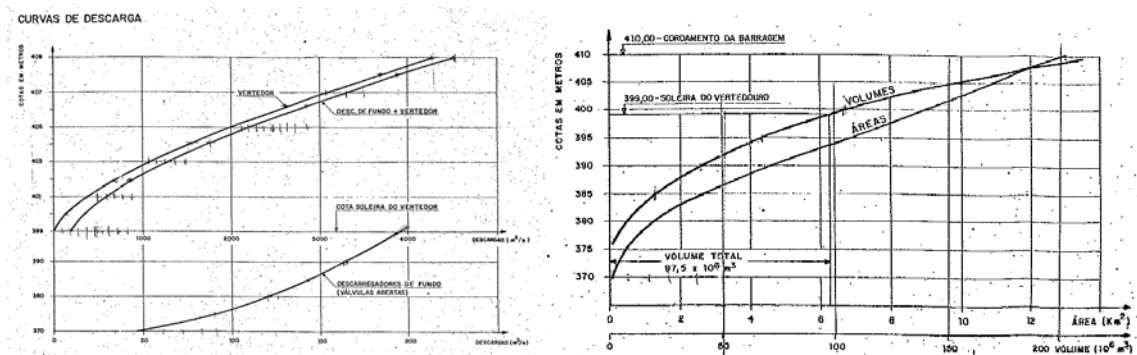
Figures 3.5.3 and 3.5.4 show those rating curves of the Oeste and Sul dams. But these drawings have not been considered gate opening, and might be fairly old and subject to confirmation from as-built drawings from the manufacture or the completion documents. Therefore, these rating curves should be reviewed at the project of the dams heightening.

Figures 3.5.3 and 3.5.4 also present the relationships between water levels and accumulated reservoir volumes. But these relationships have not been updated, though these relationships are also important to grasp inflow discharge into reservoirs. The dam management department (DEINFRA) should confirm the relationship regularly by periodic topographic survey of reservoirs.



Source: Drawings (Obras Existentes de Conrole de Cheias, Barragem Oeste), CAEEB MME/DNAEE

Figure 3.5.3 Rating Curves between Water Level and Storage Volume, Outflow of Oeste Dam



Source: Drawings (Obras Existentes de Conrole de Cheias, Barragem Sul), CAEEB MME/DNAEE

Figure 3.5.4 Rating Curves between Water Level and Storage Volume, Outflow of Sul Dam

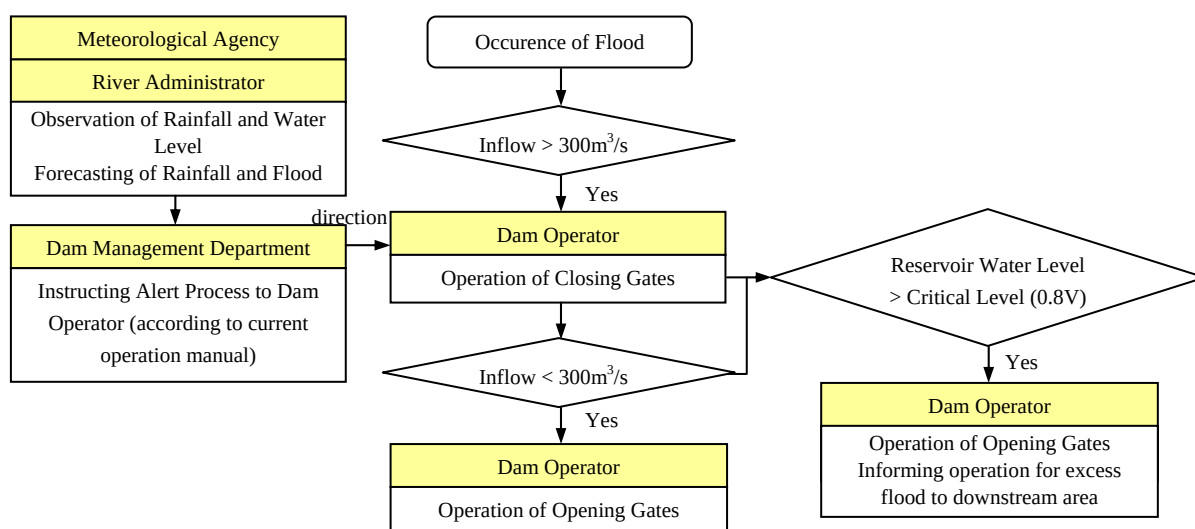
DEINFRA would be considered to be responsible for the existing flood control dams heightening projects and management after the projects implementation. In current operations of these dams, one person in charge of the dam operation is living next to dam body, and is engaged in ordinal dam

management and gates operation for flood control. In flood time, a manager of DEINFRA in charge of dam management comes from Florianopolis to support and instruct the operator for gates operation of flood control. When floods come, the operator has to watch scales in the reservoir to understand reservoir water level. Therefore, it is appropriate that the operator and the manager check the reservoir water level, outflow discharge, situation of downstream river in the interval of a hour to calculate accumulated reservoir volume, inflow discharge and to operate the gates.

3.5.3 Operation Against Extraordinary Floods

If extraordinary floods exceeding the design flood (hereinafter called “excess flood”) attack the dam during the operation of flood control, the operator should stop the normal operation of flood control. The excess flood may cause overflowing from spillway and rapid rising of the water level in the downstream river. The operator should make effort to mitigate the rising rate of the water level and reduce damages in the downstream area, as summarized below.

- i) All of the gates should be slowly opened in order, when reservoir water level reaches the critical level. The water level considering 80% of the reservoir capacity is generally adopted as the critical level. This operation may mitigate the rising rate of water level in the downstream area, when the stored water is spilled out from the spillway.
- ii) The operator should inform the operation of gates opening and possibility of overflowing in advance with the warning sirens to the people who lives along the downstream river from Taio to Rio do Sul.



Source: JICA Survey Team

Figure 3.5.5 Flowchart of Gates Operation (in case of Oeste Dam)

3.6 Increasing of Discharge Capacity in Sul and Oeste Dams

A huge flood attacked the Itajai River basin from 6th to 9th in September 2011, after the Feasibility Study carried out from February to July. As some problems such as insufficient discharge capacity of the outlets in Sul and Oeste Dams were revealed during the flood, the study team proposed increasing of the discharge capacities in these dams as follows, at the time when study team submitted the draft final reports in September.

Defesa Civil of the SC State reported that there was a lot of rainfall of around 200 mm over the Itajai River basin in average for 4 days during the flood. In this study, basin mean probable 4 days rainfall are estimated to be 188 mm for 25-year, 209 mm for 50-year. Therefore, if the report is accurate, the probability of the flood may be estimated to be 30 to 40-year. This estimation seems correct because maximum water level in Blumenau during the flood was reported to be 12.9 or 13.0 m, while the water levels of memorial floods in Blumenau were recorded to be 15.8 m in 1983 flood (around 70-year flood), 15.5 m in 1984 (around 70-year), 10.6 m in 1992 (around 30-year), and 11.0 m in 2001 (7-year).

On the other hand, the record by the operator in Sul Dam shows that the rainfall from 6th to 9th in September reached 220 mm, and DEINFRA of the SC State reported that around 300 mm rainfall was recorded at some gauging stations in the catchment area of the Sul Dam. It is inferred that a huge storm attacked this area. During this flood, flood discharge overflowed both Oeste and Sul Dams.



Overflow of Oeste Dam



Source: DEINFRA

Inundation in Taio City

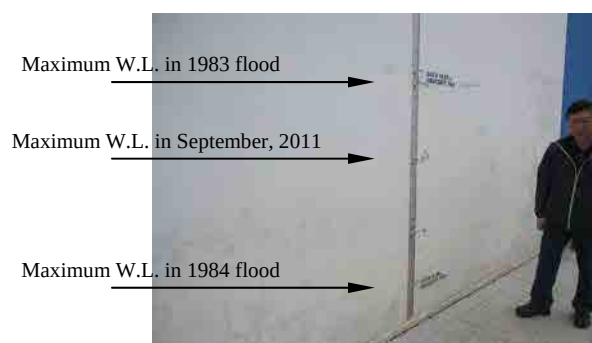


Damage in Rio do Sul City



Source: JICA Survey Team

Damage in Rio do Sul City



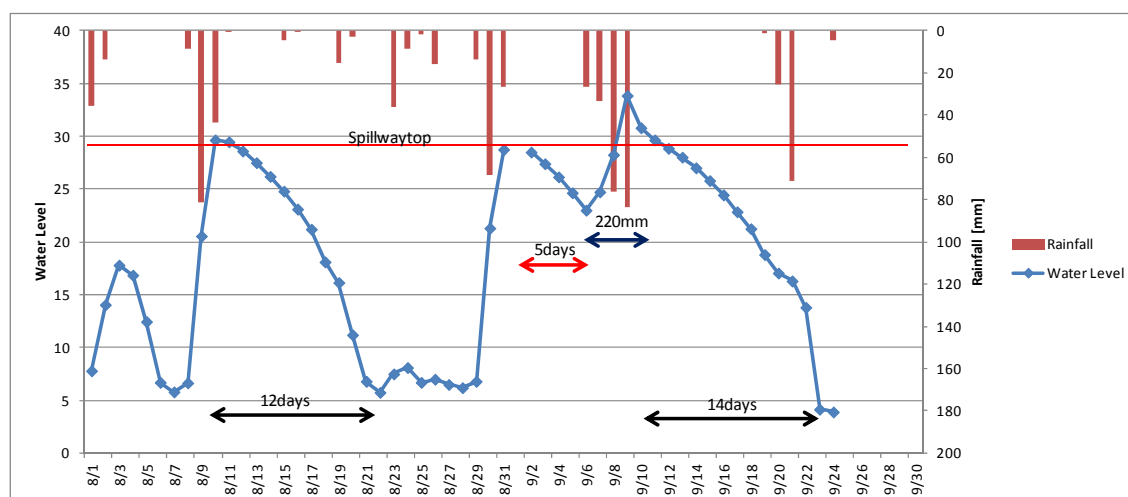
Source: JICA Survey Team

Flood Mark in front of the City Hall of Rio do Sul

Table 3.6.1 shows the variation of daily rainfall and water level at the Sul Dam from August to September in 2011.

- Large rainfall occurred on 10th and 30th in August, 6th to 9th in September.
- Reservoir water level in Sul Dam reached to the spillway top. Lowering of the maximum reservoir water level to normal level required 12 days and 14 days in the case of the floods on 10th in August and 6th in September.
- The floods of 6th in September attacked 5 days after the previous flood. The reservoir water level remained high at the time of the flood attack
- During the food from 6th in September, maximum water level at the Sul Dam was spillway top +5.0 m. The maximum outflow discharge from the spillway and conduit of the Sul Dam was estimated to be around 1,600m³/s.

The overflows from both dams might be considered to be unavoidable. However, the discharge capacity of the conduits in both dams, 190 m³/s for Sul Dam and 160 m³/s for Oeste Dam, should be evaluated to be relatively insufficient against the catchment area of both dams (1,042km² for Oeste Dam, 1,273 km² for Sul Dam).



Source: JICA Survey Team

Figure 3.6.1 Variation of Daily Rainfall and Water Level at Sul Dam from August to September in 2011

Additionally, this flood destroyed the gate operation house at the downstream of the Sul Dam, washed away the panel for gate control, and made the gallery under the dam body impassable. Fortunately, the operator of the Sul Dam repaired the gallery, and made the gate operation possible.

However, such the trouble is considered to be a serious problem, because any damages of the structure under the dam body would directly cause collapse of the dam.

According to the hearing from the operator of the Sul Dam, the causes of the trouble are considered as follows,

- Flood water overtopping from the spillway flowed backward, and destroyed the downstream wall of the operation house. Spillway. Moreover, the flood water destroyed upstream slide door and reached the dam body.
- Outflow from the reservoir through the conduit gate under the dam body crashed the upper wall of the concrete channel, and the uplift or negative pressure destroyed the upper wall concrete.



Source: JICA Survey Team

Damage of the Gate Operation House at Downstream of Sul Dam

Considering the problem mentioned above, increasing of the flow capacity of the conduits of the Sul and Oeste Dams by additional conduits was proposed and agreed at the Counter Part Meeting in September, 2011, in order to improve safety and flood control function of the dams.

As for the Sul Dam, an additional conduit will be installed under ground of the right bank of the Sul Dam as tunnel type, and as for the Oeste Dam will be installed in new block of the dam which will be constructed on the left abutment of the dam.

The capacity of the additional conduits should be same as existing conduits, that is why,

- i) Velocity for lowering water level of the reservoirs will be doubled by both existing and additional conduits.
- ii) Additional conduits will work as substitutes of the existing conduits.

The general features of the additional conduits are as follows,

- i) **OesteDam:** the additional conduit and control gate will be installed in the new dam block on the left abutment, and the conduit will be connected to the energy dissipator of the dam by new open channel;
- Design discharge: $180\text{m}^3/\text{s}$
 - Control gate: width 5.0m x height 4.4m
 - Bottom elevation of the gate: EL.350.4m
 - Connecting open channel: channel width 5.0m x length 180m
- ii) **Sul Dam:** the additional conduit will be installed under ground of the right bank of the dam as tunnel type, flood control gate will be installed at the entrance of the tunnel, flood water will be discharged to the downstream river through the tunnel by gravity.
- Design discharge: $200\text{m}^3/\text{s}$
 - Control gate: $3.9\text{m} \times 3.9\text{m}$
 - Bottom elevation of the gate: EL.380m
 - Tunnel type channel: length 430m, diameter 6.0m, gradient 1/60

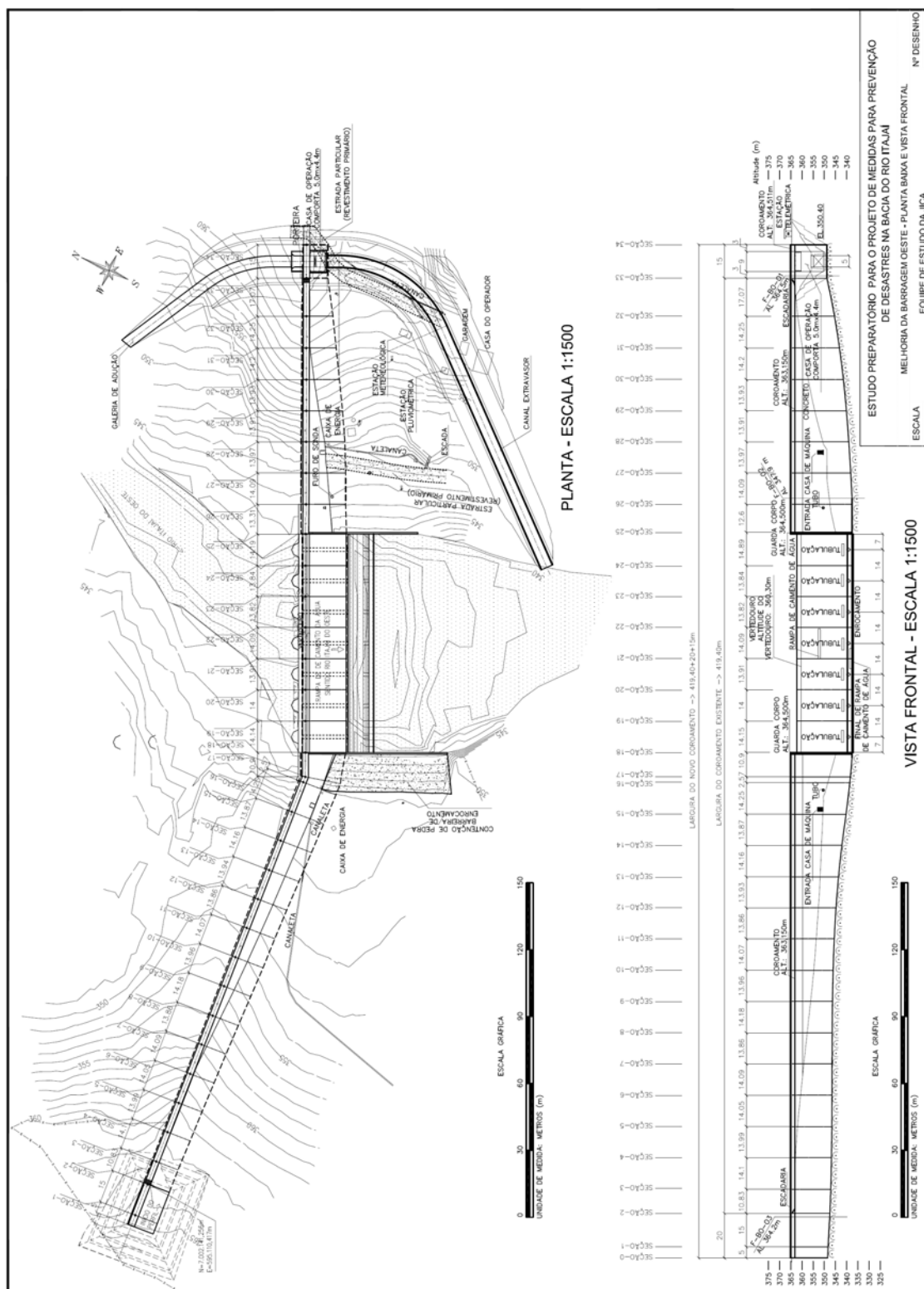


Figure 3.6.2 Heigtening of the Oeste Dam and Additional Conduit (1/2)



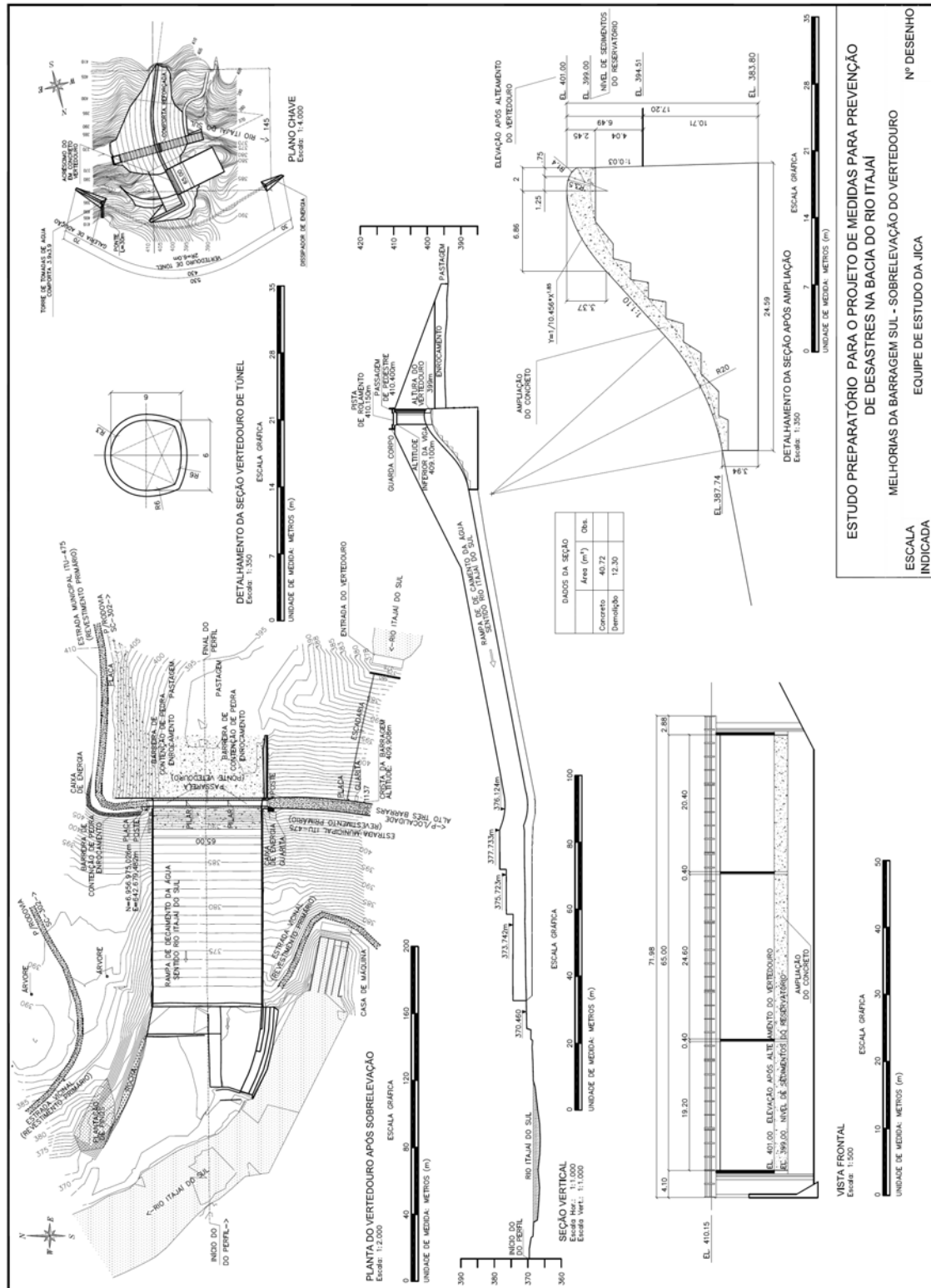


Figure 3.6.4 Heightening of the Sul Dam and Additional Conduit

CHAPTER 4 FEASIBILITY STUDY FOR MODIFICATION OF OPERATION OF EXISTING HYDROPOWER DAMS

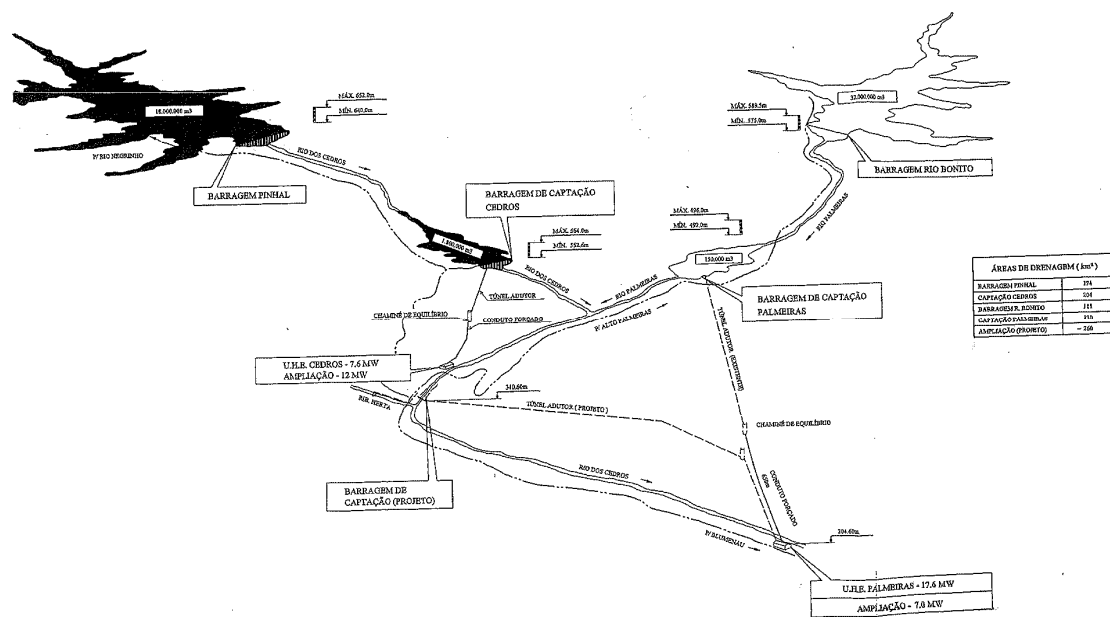
4.1 Background of Modification

In the master plan, the existing two hydropower generation dams of CELESC in the Rio dos Cedros River, named the Rio Bonito and Pinhal dams, were proposed to be used for flood control by means of pre-releasing when an impending flood is predicted. As described in sub-section 8.4.2 in Part I, the proposed pre-releasing aims at creation of flood control space in reservoir by means of lowering the reservoir water level by releasing the stored water before flood inflow into the reservoir.

The target city of pre-releasing is Timbo city, where the Rio dos Cedros city joins the Benedito River. The current flow capacity of the Benedito River in Timbo city is around 860 m³/s, although the 10-year flood discharge is around 920 m³/s. Therefore, the flow capacity is insufficient for the 10-year flood. On the he hand, the 10-year flood inflow into both dams is 210 m³/s. The total outflow from both dams should be jointly controlled not to exceed 140 m³/s to satisfy the current flow capacity in Timbo city by use of the created flood control space in reservoir by the pre-releasing.

4.2 General Features of Two Dams

Figure 4.2.1 shows the current hydropower generation system by CELESC in the Rio dos Cedros River. As shown in the figure, the system comprised two water storage reservoirs (Rio Bonito and Pinhal dams), two intake dams, and two hydropower stations.



Source: CELESC

Figure 4.2.1 General Features of Two Dams

Tables 4.2.1 and 4.2.2 present the general features of both dams.

Table 4.2.1 General Features of Rio Bonito Dam

		Features	Remarks
Dam	Dam type	Rock fill	
	Year of completion	1963	
	Height of dam	19.0 m	
	Crest elevation of dam	About EL.592 m (uncertain)	Visual estimation
Reservoir	Catchment area	119.8 km ²	
	Total volume	32,000,000 m ³	
	Maximum water level	EL.589.5 m	Not based on the IBGE system
	Minimum water level	EL.583.5 m	Not based on the IBGE system
Intake	Elevation of bottom	EL.573.7 m	Not based on the IBGE system
	Gate size	Height 3.0 m x Width 2.6 m	
	Gate type	Sluice gate (hoist type)	
	Gate control	Gate can be controlled to any opening positions by local control with electric power	
Spillway	Crest elevation	EL.587.3 m	Not based on the IBGE system
	Gate type	Flap gate (hoist type)	
	Gate size	Height 2.2 m x Width 9.0 m x 2 gates	Crest of gate : EL.589.5 m
	Gate control	Gates can be controlled to any opening positions by local control with electric power	

Source: CELESC (from existing materials and interview)



Spillway Gate (left) and Intake Tower (right) of Rio Bonito Dam

Table 4.2.2 General Features of Pinhal Dam

		Features	Remarks
Dam	Dam type	Earth and rock fill type	
	Year of completion	1949	
	Height of dam	19.0 m	
	Elevation of dam top	About EL.654 m (uncertain)	Visual estimation
Reservoir	Catchment area	179.9 km ²	
	Total volume	18,000,000 m ³	
	Maximum water level	EL.652.0 m	Not based on the IBGE system
	Minimum water level	EL.641.0 m	Not based on the IBGE system
Intake	Elevation of bottom	EL.638.2 m	Not based on the IBGE system
	Gate size	Height 2.6 m x Width 1.35 m x 2 gates	
	Gate type	Sluice gate (rack type)	
	Gate control	Gates can be controlled to any opening positions by local control with electric power	
Spillway (with gate)	Crest elevation	EL.651.0 m	Not based on the IBGE system
	Gate type	Sluice (rack type)	
	Gate size	Height 1.0 m x Width 4.0 m x 2 gates	Crest of gate : EL.652.0m
	Gate control	Gates can be controlled to any opening positions by local control with electric power	
Spillway (without gate)	Crest elevation	EL.652.0 m	Not based on the IBGE system
	Crest length	53 m	

Source: CELESC (from existing materials and interview)



Spillway (left) and Intake Tower (right) of Pinhal Dam

4.3 Study on Pre-releasing

4.3.1 Current Operation for Floods

The operators of hydropower plant are usually on standby in the office at the Palmeiras power station, and two operators visit each dam once or twice a day for gate operation and inspection of the dam facilities. When flood is predicted to occur, one operator stands by at the dam throughout the flood for gate operation.

When a flood is forecasted to occur in the upper Rio dos Cedros River basin, CIRAM informs the forecasted information to CELESC, and CELESC decides to release the stored water to lower the reservoir water level by 50 cm from the maximum water level based on their own judgment. CELESC tries to maintain this reservoir water level during the flood to avoid overflowing from the spillway.

4.3.2 Modification of Dam Operation for Pre-releasing

(1) Possible Pre-releasing Discharge from Two Dams

According to the available H-Q curves at both dams, the total discharge capacity under the condition of full gate openings are around 190 m³/s at the maximum reservoir water level of EL. 589.5 m for the Rio Bonito dam, and 80 m³/s at the maximum reservoir water level of EL. 652 m for the Pinhal dam, respectively.

On the other hand, the estimated base flow into each dam reservoir is around 10 to 20 m³/s in flood season. Therefore, the possible pre-releasing discharges are considered to be around 170 m³/s for the Rio Bonito dam, and 60 m³/s for the Pinhal dam at the maximum reservoir water level.

(2) Required Flood Control Volume for Pre-releasing

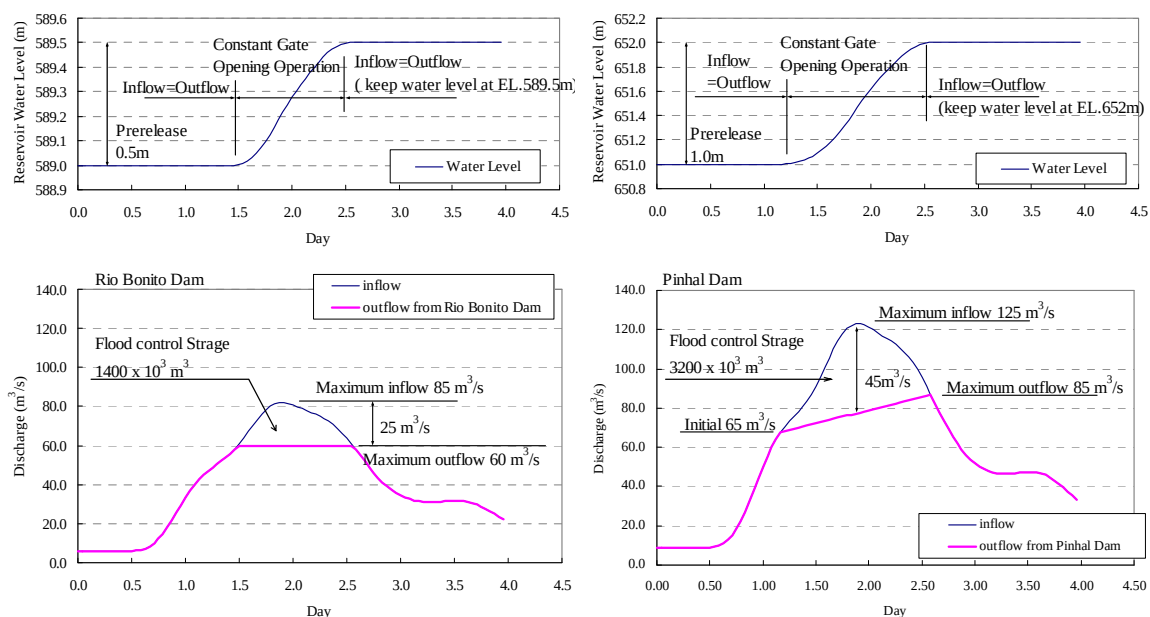
In order to regulate the outflow discharge from both dams not to exceed 140 m³/s for the 10-year flood with a peak discharge of 210 m³/s, the required flood control volume to be created by pre-releasing was examined by simulation of reservoir operation at both dams. The results of examination are summarized in Table 4.3.1. As indicated in this table, the required volume for pre-releasing was estimated to be 1.4 million m³ for the Rio Bonito dam and 3.2 million m³ for the Pibhal dam, respectively. Figure 4.3.1 shows the simulation results of the proposed flood control operations at both dams. The details of examination of described in the Supporting Report B Flood Prevention Plan.

Table 4.3.1 Required Flood Control Volume to be Created by Pre-releasing at Two Dams

	Rio Bonito Dam	Pinhal Dam
Maximum water level in operation	EL.589.5 m	EL.652.0 m
Drawing down by pre-releasing	0.5 m	1.0 m
Water level after pre-releasing	EL.589.0 m	EL.651.0 m
Volume for flood control by pre-releasing	1.4 x 10 ⁶ m ³	3.2 x 10 ⁶ m ³
Maximum inflow discharge	85 m ³ /s	125 m ³ /s

Maximum outflow discharge	60 m ³ /s	85 m ³ /s
Reduction of discharge at the peak time of inflow	25 m ³ /s	45 m ³ /s
Operation of gates during flood control Gate opening of the spillway Gate opening of the intake	Constant opening 0.5 m 2.6 m	Constant opening 1.0 m 2.6 m
Operation of gates before flood control	Keep the water level at EL. 589 m (inflow = outflow) by operating intake gate	Keep the water level at EL. 651 m (inflow = outflow) by operating intake gate
Operation of gates after flood control	Keep the water level at EL. 589.5 m (inflow = outflow) by operating spillway gate	Keep the water level at EL. 652 m (inflow = outflow) by operating spillway gate

Source: JICA Survey Team

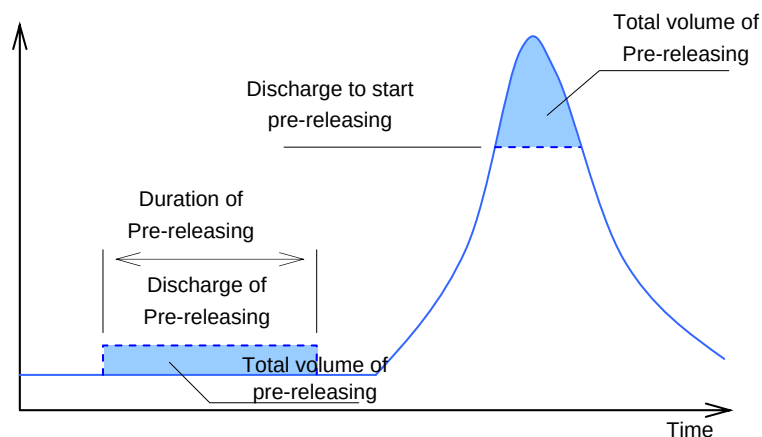


Source: JICA Survey Team

Figure 4.3.1 Operation of Rio Bonito Dam and Pinhal Dam for Flood Control

(3) Operation Method of Pre-releasing

Based on the required flood control volume by pre-releasing in the above, pre-releasing discharge and duration of pre-releasing shall be determined as illustrated in Figure 4.3.2.



Source: JICA Survey Team

Figure 4.3.2 Illustration of Pre-releasing Method

The possible pre-releasing discharge from the Pinhal dam is around 40 to 60 m³/s at the water level of EL. 651 to 652 m. Assuming that the duration of pre-releasing is 18 hours, the required pre-releasing discharge at both dams were estimated as follows:

- Required duration for pre-releasing:	18 hours
- Average pre-releasing discharge:	Rio Bonito dam $1400 \times 10^3 \text{ m}^3 / 18 \text{ hours} = 22 \text{ m}^3/\text{s}$
	Pinhal dam $3200 \times 10^3 \text{ m}^3 / 18 \text{ hours} = 50 \text{ m}^3/\text{s}$
Total	72 m ³ /s

As the pre-releasing increases the flow in the downstream reaches, the operators at the dams and river administrator should pay attention to the security of riparian residents along in the downstream reaches as follows:

- i) For preventing overflowing from the river channel by pre-releasing, river water level along the downstream reaches should be monitored in Timbo and Rio dos Cedros cities.
 - ii) Warning of pre-releasing should be announced to the residents along the downstream reaches by sirens before the pre-releasing.
- (4) Judgment for Pre-releasing
- 1) Current rainfall forecast

For rainfall forecast, CIRAM currently uses both the ETA model of INPE and WRF model of USA for the coming 5 days. The grid scale of the analysis is 40 km x 40 km, and 20 km x 20 km, respectively.

But the accuracy of the forecasting has not been satisfactory, as the meteorological radar is installed only in Urubici city, far from Timbo and Rio dos Cedros cities (see Figure 4.3.3).

At present, Defesa Civil, EPAGRI, and SDS intend to establish a new rainfall and flood forecasting system with satellite data from INPE. Accuracy of the flood forecast is expected to be improved by the new system.

- 2) Judgment for pre-releasing

When the flood discharge is forecasted to be more than the current flow capacity in Timbo city (5 to 10-year floods), pre-releasing shall be determine to be executed. One of the criteria of the judgment may be the rainfall of the 5-year probable rainfall (150 mm/4 days). In addition, after the first judgment, the forecasting and judgment should be repeated continuously by updating the hydro-meteorological information.

Determination of judgment for pre-releasing shall need more detail study during the implemetation stage.

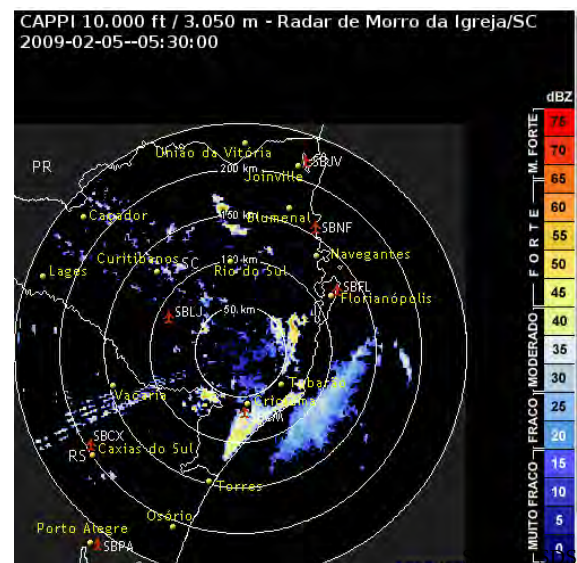
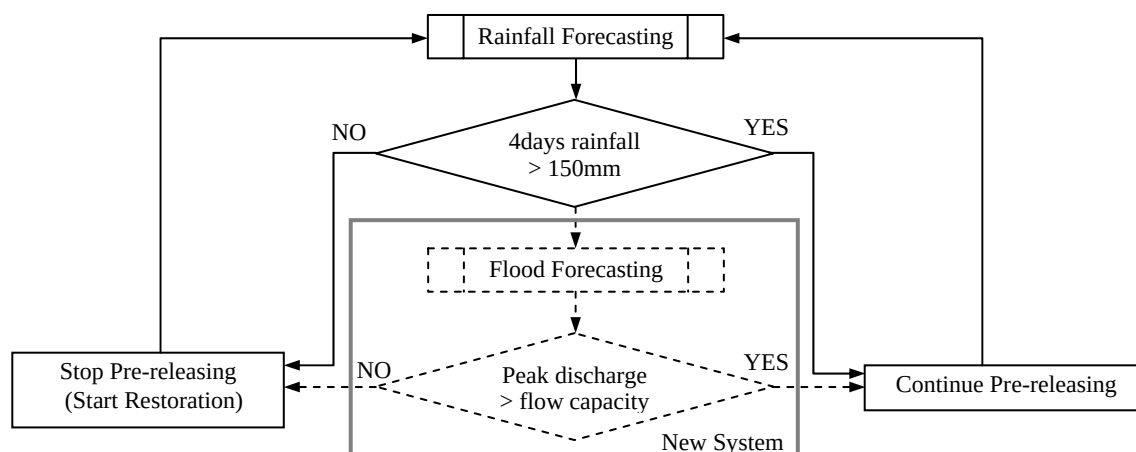


Figure 4.3.3 Location of Meteorological Radar and its Cover Area



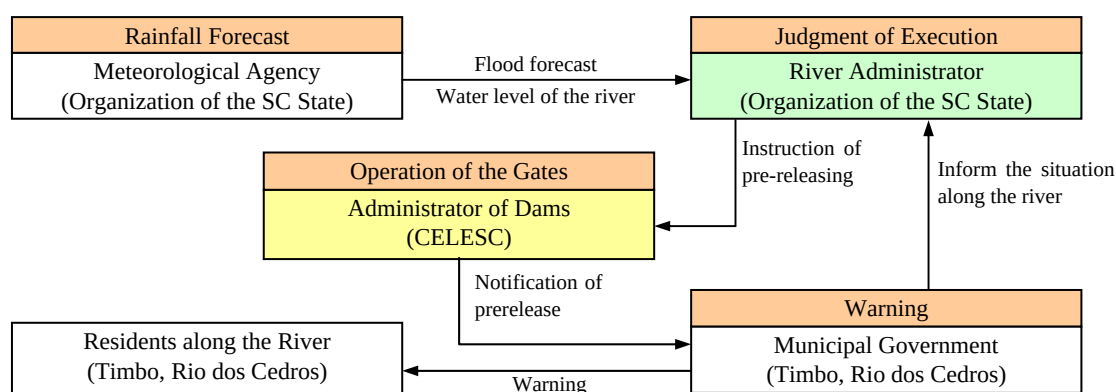
Source: JICA Survey Team

Figure 4.3.4 Flowchart of Judgment for Pre-releasing

4.4 Recommendation of Organization for Operation

Figure 4.4.1 presents the recommendation of the organization for executing the pre-releasing in the existing hydropower dams.

- i) As the river administrator shall be responsible for the judgment and operation of the pre-releasing, he instructs the execution of pre-releasing to CELESC based on the flood forecast by CIRAM and monitored water levels along the Rio dos Cedros River.
- ii) CELESC should inform the pre-releasing to the municipal governments (Timbo and Rio dos Cedros cities) in advance and municipal governments should alarm the residents along the river.
- iii) If any flood attacked to the catchment area of both dams though the pre-releasing was executed, lowered water levels of the dam reservoirs might not restore. The State organization responsible for flood management and CELESC should discuss and decide the regulation of such compensations.



Source: JICA Survey Team

Figure 4.4.1 Recommendation of Organization for Dam Operation

CHAPTER 5 FEASIBILITY STUDY ON FLOODGATES IN ITAJAI MIRIM RIVER

5.1 Characteristic of Floods and the Current Flow Capacity in Itajai Mirim River

5.1.1 Topographical Characteristics of Itajai Mirim River

(1) Itajai Mirim River

Itajai city is a famous port city located at the mouth of Itajai River. An urban area in Itajai city is located in the downstream area of the BR-101 (federal highway), and the upstream area of the BR-101 is mainly used for farmland and pasture.

The Itajai Mirim River is one of large tributaries of the Itajai River which joins the Itajai River at the urban center of Itajai city. The Itajai Mirim River originally flowed down with meandering through Itajai city, but the shortcut channel was constructed in 1970s. In this Chapter, the original channel is referred to “the Old Mirim” and shortcut channel is to “the Canal”.

The Canal diverges from the Old Mirim in the upstream of the BR-101, and meets again with the Old Mirim at about 1km upstream of the confluence with the Itajai River. And small tributary named the Canhanduba River drains into the Old Mirim.

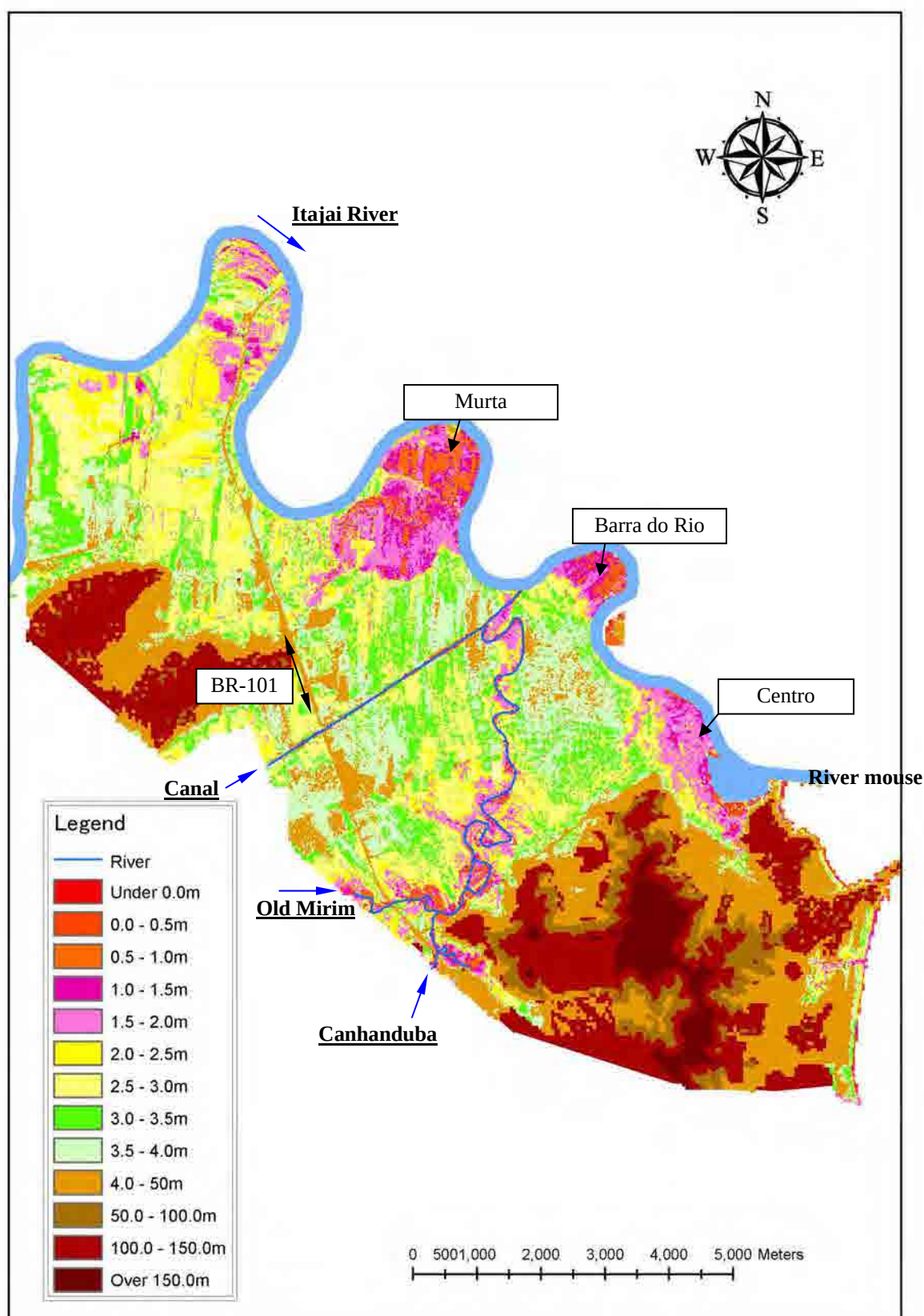
(2) Topography of Itajai Mirim River

Figure 5.1.1 presents the distribution of ground elevation in Itajai city based on the 1/2,000 topographical map prepared by the municipal government of Itajai city. As indicated in this figure, riparian area along the Old Mirim is generally low varying EL.1.0 to 3.0 m. On the other hand, the area along the Canal is relatively higher elevation in around EL.3.0 to 4.0 m. Though the Canal has larger flow capacity, the Old Mirim has caused frequent flooding and inundation to its riparian area. Two floodgates on the Old Mirim which were proposed in the M/P aim at mitigation of inundation along the Old Mirim.

5.1.2 Flood Characteristics of Itajai Mirim River

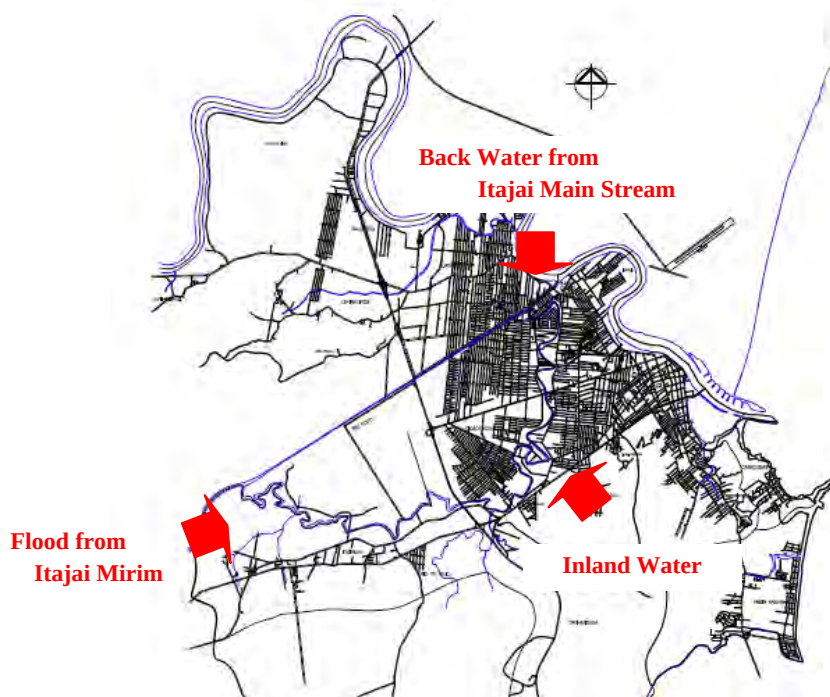
(1) Causes of Inundation in Riparian Area along the Old Mirim

There are mainly three causes of the inundation in Itajai city along the Old Mirim as illustrated in Figure 5.1.2. The first one is the flood from the upstream basin area of the Itajai Mirim River, the second one is the backwater from the Itajai River, and the third one is the inland water due to rainfall over this area.



Source: Municipal Government of Itajai city

Figure 5.1.1 Distribution of Ground Elevation in Itajai City



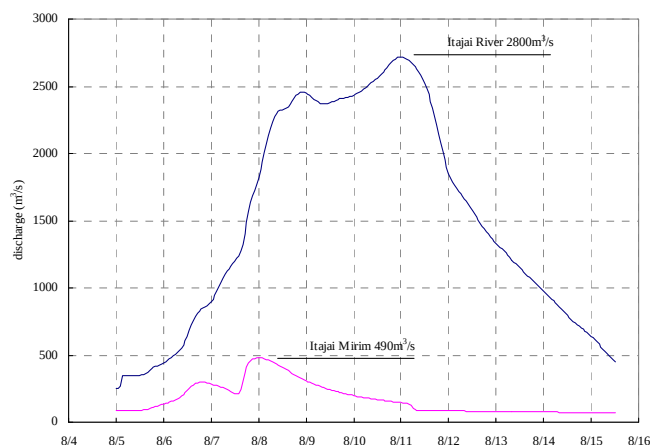
Source: JICA Survey Team

Figure 5.1.2 Causes of Inundation along the Old Mirim

(2) Probable Floods in Itajai City

Hydrographs of 10-year floods of both the Itajai and Itajai Mirim Rivers in Itajai city are shown in Figure 5.1.3. The characteristics of the hydrograph is described below.

- The peak discharge of the Itajai River come about three days later from the peak of the Itajai Mirim,
- The duration of the flood in the Itajai River is much longer than in the Itajai Mirim.



Source: JICA Survey Team

Figure 5.1.3 10-year Flood Hydrographs Itajai and Itajai Mirim Rivers

In the feasibility design, the 50-year flood was applied to for the floodgate design. This is based on the consideration that once the gate is constructed for the 10-year flood, it would be difficult to be modified for the 50-year flood in the future.

5.1.3 Estimation of Flow Capacity of the Itajai Mirim River

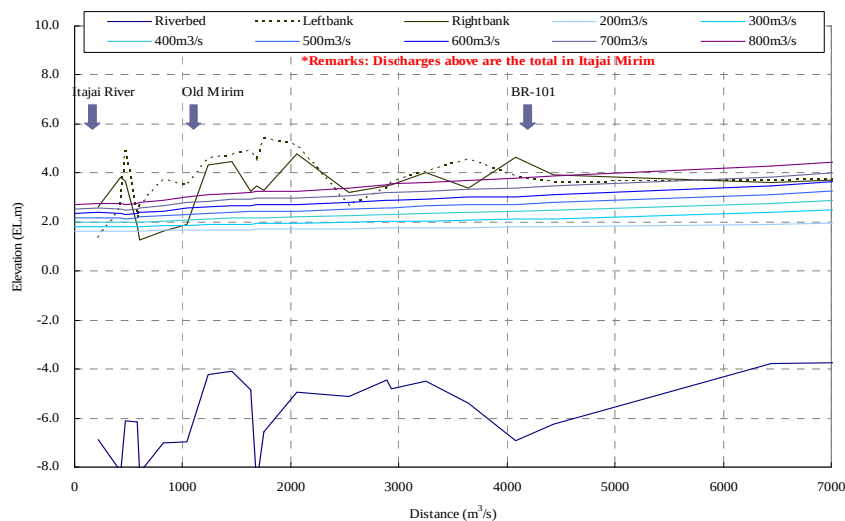
(1) Flow Capacity

The Flow Capacity of the Itajai Mirim River was estimated by the non-uniform flow calculation. As the boundary condition at the lowest end of river channel, calculation starting water level was set at the average high tidal level of EL. 1.49 m. Roughness coefficients of the Itajai River, the Canal and the Old Mirim were assumed respectively 0.030, 0.032 and 0.040. The discharge distribution rate between the Canal and the Old Mirim was determined through several trial

calculations to obtain the same water level at the upstream bifurcation point of the Itajai Mirim River.

a) Canal

- The flow capacity on the right bank of the downstream stretch (from 0.6 to 1.0 km) is extremely low. It is considered that inundation would occur even when the discharge is less than 200 m³/s. The flow capacity in this stretch is evaluated lower than the 5-year flood discharge.
- River bank elevation of the stretch around 2.5 km also is low (about 3.0 m). The flow capacity of this stretch is estimated to be about 600 m³/s in the Itajai Mirim (378 m³/s in the Canal). This is equivalent to about 20 to 25-year flood discharge.
- The upstream stretch of the BR-101 along the Canal has also low riverbank, and the flow capacity of this stretch is equivalent to about 15 to 20-year flood discharge.
- Other stretch has the flow capacity of more than 800 m³/s (504 m³/s in the Canal). The flow capacity in this stretch is more than 50-year flood discharge.

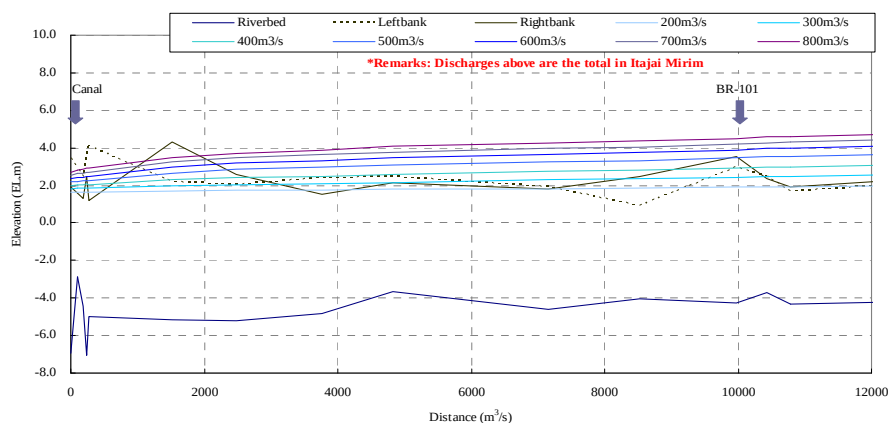


Source: JICA Survey Team

Figure 5.1.4 Water Levels by Discharge in the Canal

b) Old Mirim

- Riverbank elevation is very low except the right bank stretch around 2.5 km.
- The flow capacity varies 200 to 400 m³/s in the Itajai Mirim River (52 to 124 m³/s in the Old Mirim), which is evaluated to be less than 5-year flood discharge.
- The elevations in the stretch of 0 to 300 m on the right bank, and around 8.5 km on the left bank are extremely low. According to Defesa Civil of Itajai city, flooding occurs even in times of spring tide and small flood.



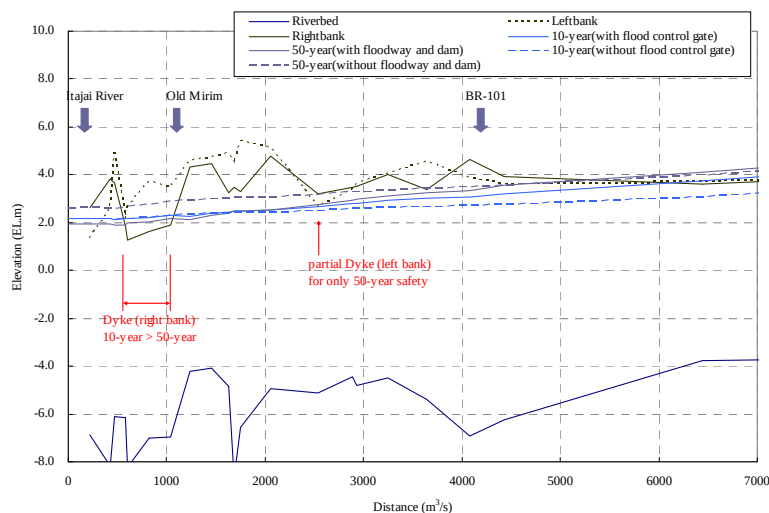
Source: JICA Survey Team

Figure 5.1.5 Water Levels by Discharge in the Old Mirim

(2) Water Level by Probable Flood

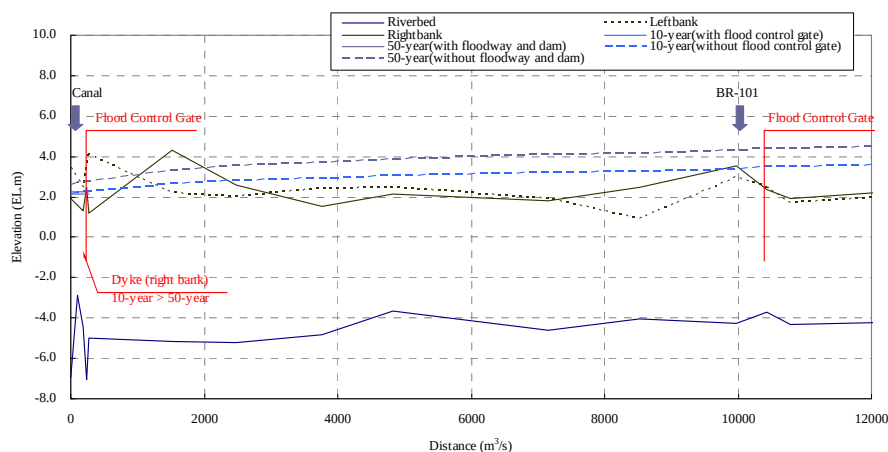
Figures 5.1.6 and 5.1.7 present the water levels due to the 10 and 50-year floods.

- In the stretch of around 0.5-1.0 km from the confluence of Itajai River, height of the right bank is lower than the water level of 10-year flood. The left bank of the stretch around 2.5 km in the Canal is lower than the water level of 50-year flood.
- Both banks along the Old Mirim are lower than the water level of 10-year and 50-year flood except the stretch from 0 to 2 km.



Source: JICA Survey Team

Figure 5.1.6 Water Levels by 10 and 50-year Floods in the Canal



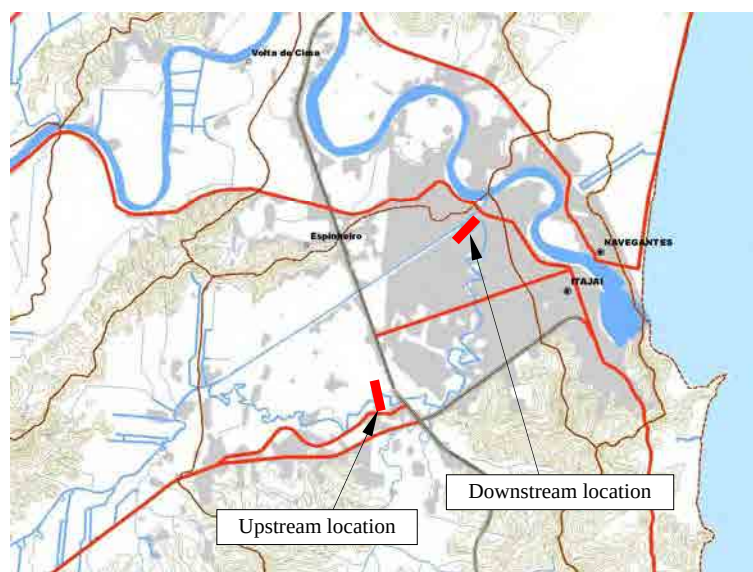
Source: JICA Survey Team

Figure 5.1.7 Water Levels by 10 and 50-year Floods in the Old Mirim

5.2 Function, Operation and Effectiveness of Floodgates

5.2.1 Function of Floodgates

Floodgate was proposed to be installed at two locations on the Old Mirim as shown in Figure 5.2.1 below. The gates of upstream and downstream locations are herein called the “downstream gate” and “upstream gate”, respectively. The upstream gate would prevent the flood from the Itajai Mirim River from entering the urban area. And the downstream gate would avoid the intrusion of backwater from the Itajai River.



Source: JICA Survey Team

Figure 5.2.1 Location Map of Floodgates in Old Mirim

The upstream floodgate should be located in the nearby upstream reach of the crossing point of the Old Mirim and BR-101. However, if location of the upstream floodgate will be changed to be near the bifurcation of Old Mirim and Canal considering future landuse by the government of Itajai city, appropriate drainage facilities such as pump stations should be proposed newly in order to avoid inundation in Itajai urban area due to inflow from the Canhanduba River and other small tributaries.

5.2.2 Operation of Floodgates

(1) Basic Procedure of the Operation

1) The upstream gate shall be closed when flood discharge exceeds the flow capacity of the Old Mirim as illustrated in Figure 5.2.2.

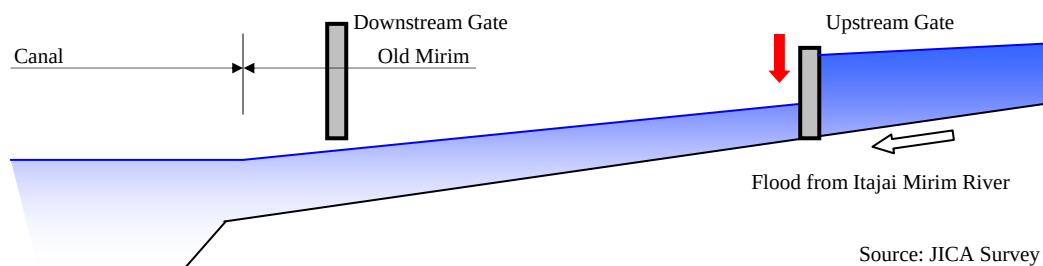


Figure 5.2.2 Operation of Flood Gates (1/3)

2) When the water level at the downstream end of the Itajai Mirim River reaches 1.7m in elevation, the downstream gate shall be closed.

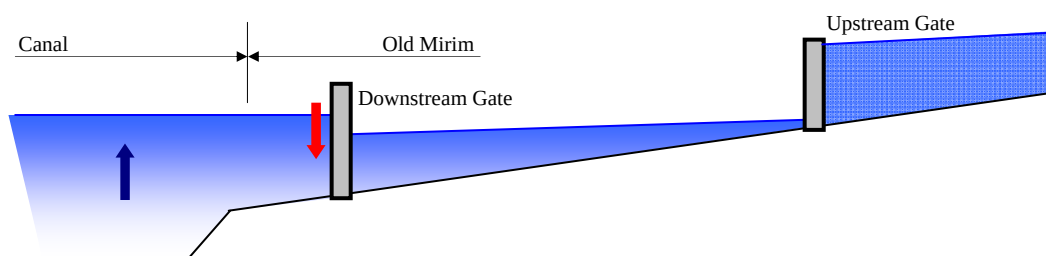


Figure 5.2.2 Operation of Flood Gates (2/3)

3) When the water level at the downstream end of the Itajai Mirim River falls down and becomes equivalent to the water level in the Old Mirim, the downstream gate shall be opened.

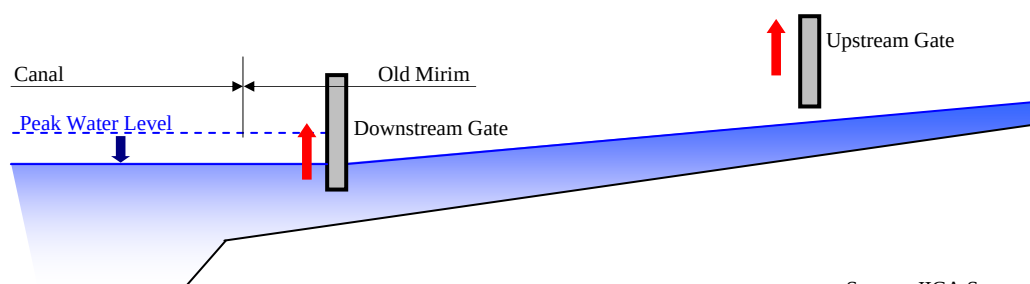


Figure 5.2.2 Operation of Flood Gates (3/3)

The water level of Old Mirim must not be higher than Canal when the downstream gate is closed. As mistakes of the gates operation may cause man-made inundation, the operation rules of floodgates should be elaborated carefully.

(2) Operation of Floodgates for 10-year Flood

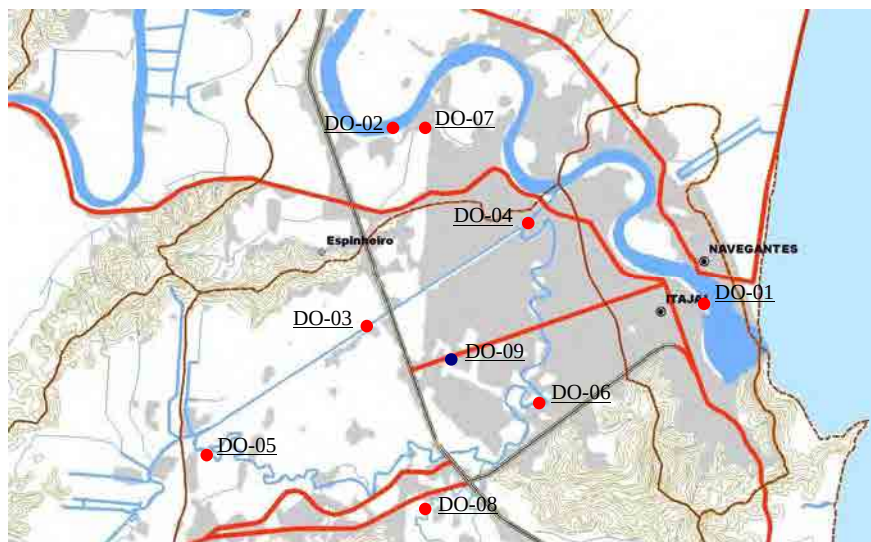
1) Necessity on Hydrological Information for Operation

The upstream gate would be closed when the discharge from the Itajai Mirim reaches to the flow capacity of the Old Mirim, in this respect, operation needs the information on the water level of the Old Mirim in the urban area (in the downstream area of the BR-101).

On the other hand, the downstream gate would be closed when the water level at the downstream end of the Old Mirim reaches to the critical water level. Therefore, the operation of

downstream gate also needs the information on the water level at the downstream end of the Old Mirim.

Civil Defense of the municipal government in Itajai city has already installed 9 gauging stations (with 9 water level gauges and 8 rainfall gauges) in February 2011. Location map is shown in Figure 5.2.3. Both the gauges “DO-06” and “DO-04” will be used for operation of both floodgates.

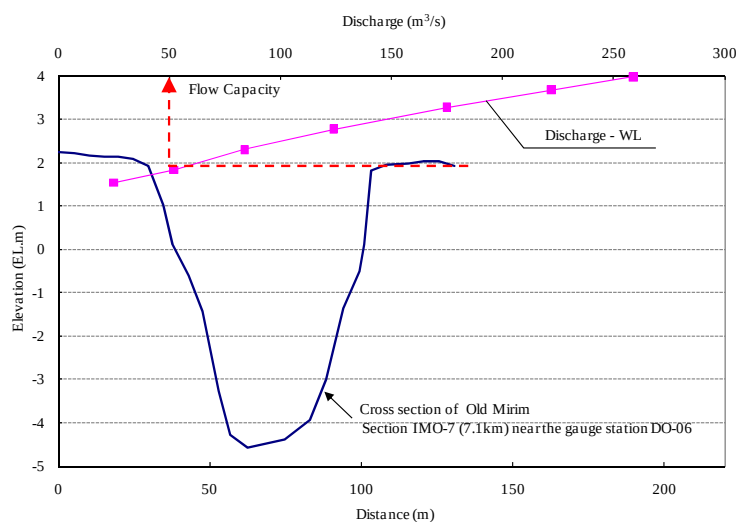


Source: JICA Survey Team

Figure 5.2.3 Location of Water Level and Rainfall Gauges Installed by Itajai City

2) Water Level of the Gates Operation

When the flood discharge into the Old Mirim reaches to the flow capacity of the Old Mirim, the pstream gate should be closed as shown in Figure 5.2.5. The flow capacity is equivalent to the water level of 2.0 m at the gauge DO-06 as shown in Figure 5.2.4.

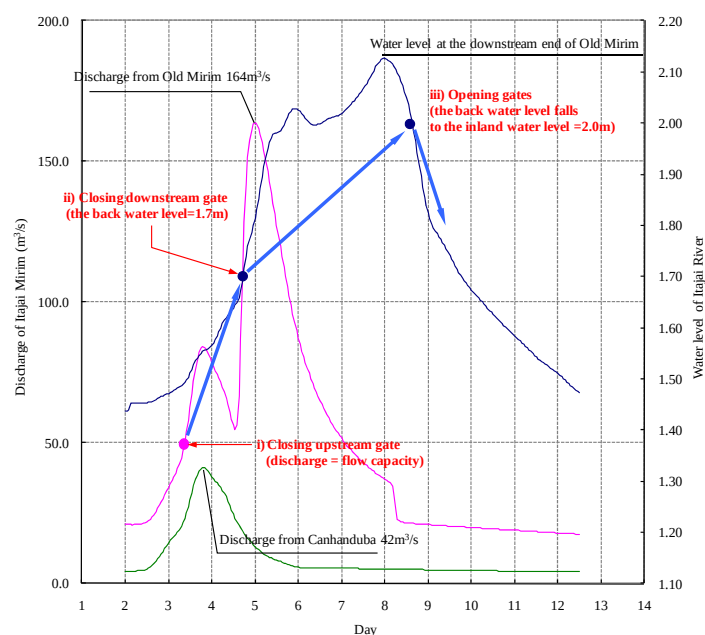


Source: JICA Survey Team

Figure 5.2.4 Relation of Water Level and Discharge at the Gauge DO-06

When the water level at the downstream end of the Itajai Mirim River reaches to EL.1.7 m, the downstream gate should be closed (see Figure 5.2.5).

When the water level at the end of the Itajai Mirim River falls down to be equal to the water level in the Old Mirim after the peak of the water level of the Itajai River, both the downstream and upstream gates will be opened in this order (see Figure 5.2.5).



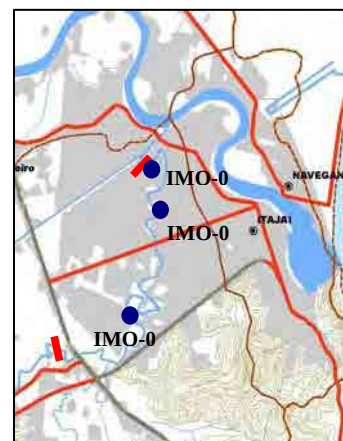
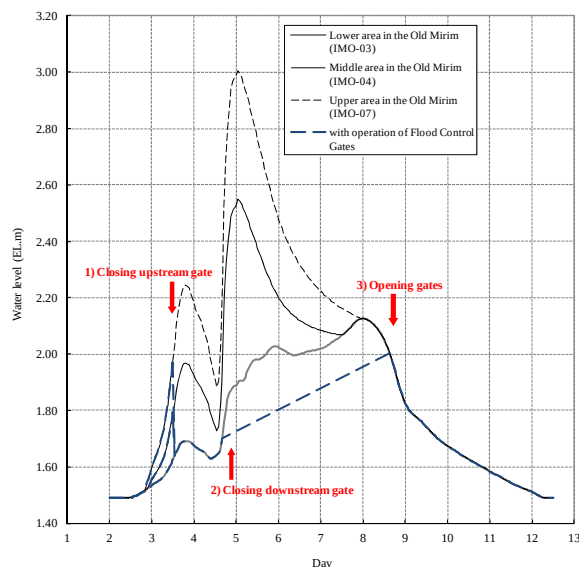
Source: JICA Survey Team

Figure 5.2.5 Operation of Floodgates for 10-year Flood

5.2.3 Effectiveness of Floodgates for 10-year flood

Effectiveness of floodgates for the 10-year flood is indicated in Figure 5.2.6. Maximum water levels at IMO-03, IMO-04, and IMO-07 without the floodgates are about EL.2.1 m, EL.2.5 m, and EL.3.0 m. And the maximum water level with operation of flood gates is EL.2.0m.

Furthermore, the floodgates will be also able to reduce the duration of high inland water level.



Source: JICA Survey Team

Figure 5.2.6 Effectiveness of Flood Gates Operation for the 10-year Flood

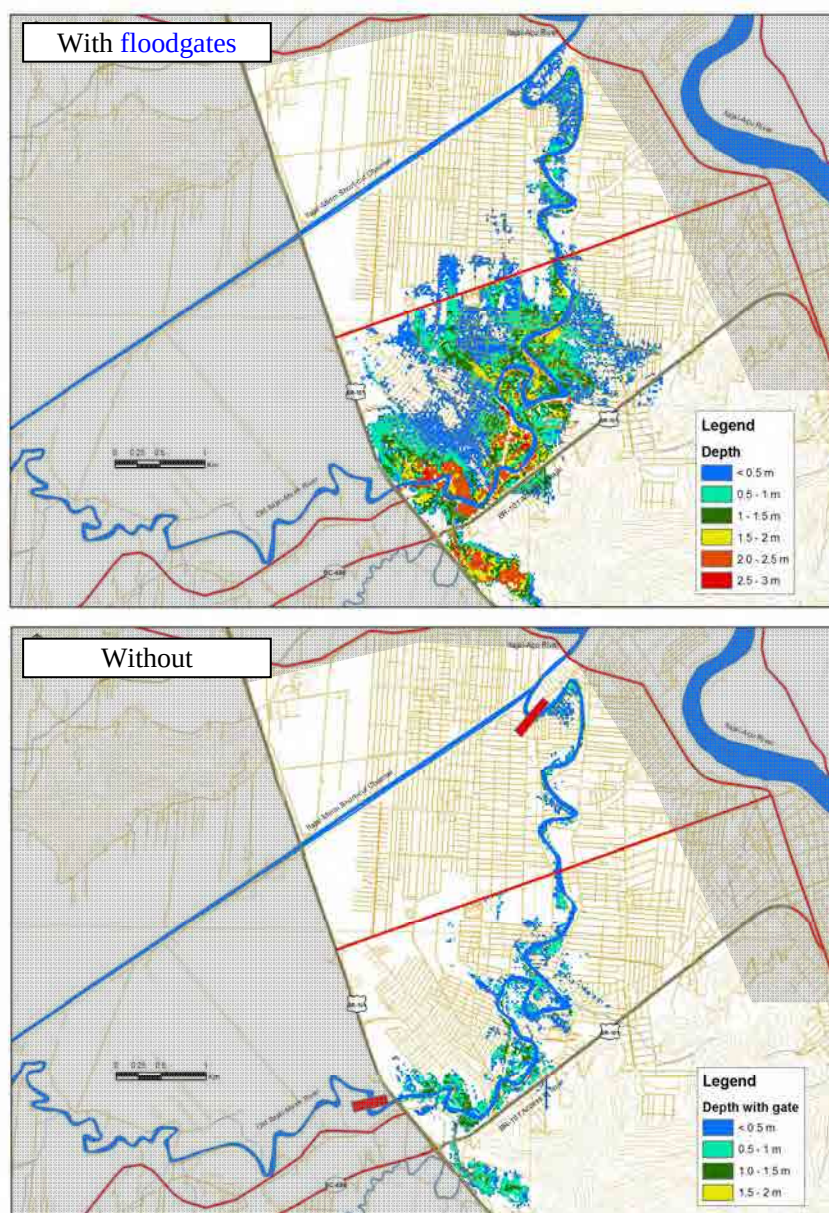
Inundation area and depth in the downstream area of BR-101 along the Old Mirim with and without the floodgates are illustrated in Figure 5.2.7. The effectiveness of the flood gates is evaluated in Table 5.2.1. Figure 5.2.8 shows the estimated inundation area along the lower reaches of Old Mirim River by probable floods.

Table 5.2.1 Estimated Inundation Area along the Lower Old Mirim

Inundation depth (m)	Area (m ²) without gate control	Area (m ²) with gate control	Effectiveness (m ²)
< 0.5	2,216,400	564,400	1,652,000
0.5 – 1.0	1,299,600	527,600	772,000

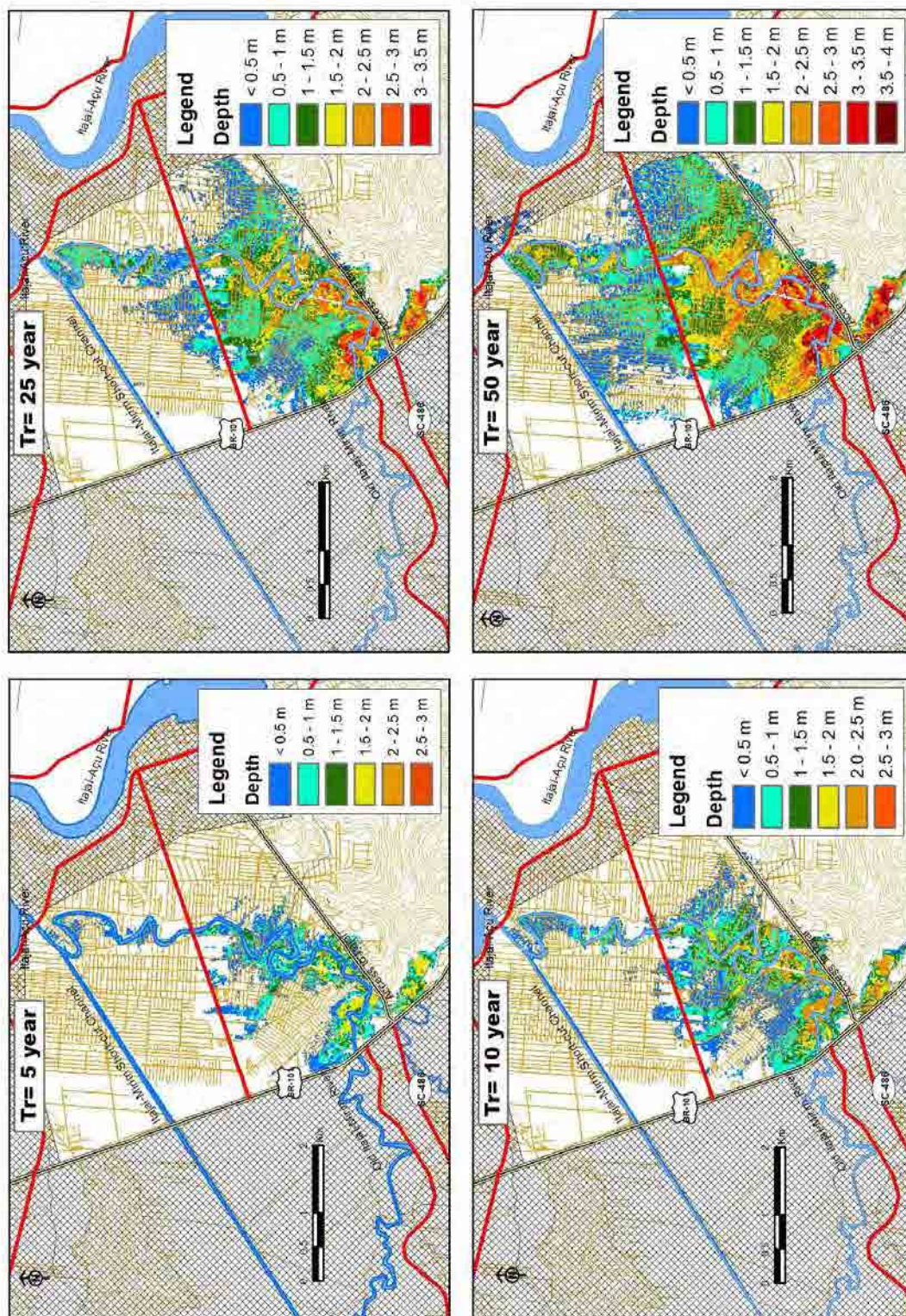
1.0 – 1.5	848,800	242,000	606,800
1.5 – 2.0	431,600	22,000	409,600
2.0 – 2.5	441,200	0	441,200
2.5 – 3.0	40,000	0	40,000
Total	5,277,600	1,356,000	3,921,600

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.2.7 Estimated Inundation Area along Old Mirim with and without Floodgates



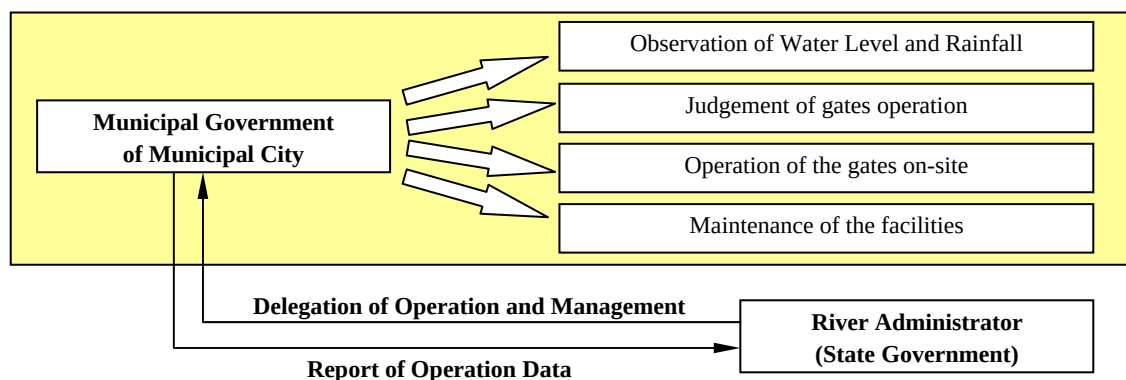
Source: JICA Survey Team

Figure 5.2.8 Estimated Inundation Area along the Lower Reaches of Old Mirim by Probable Flood

5.2.4 Recommendation of Organization for Operation

The operation of floodgates needs hydrological information only around Itajai city, and operation of the floodgates affects to only Itajai city area. The operation shall be executed by the municipal government of Itajai city. The flood management department of the State Government should be responsible for the implementation of the project (construction of the floodgates), study and

instruction of the gates operation method, supervision of the actual operation by Itajai city in flood time, preparing the maintenance plan and obtaining the budget for maintenance.



Source: JICA Survey Team

Figure 5.2.9 Recommendation of Organization for Operation

5.3 Feasibility Design of Floodgates

5.3.1 Geological Conditions

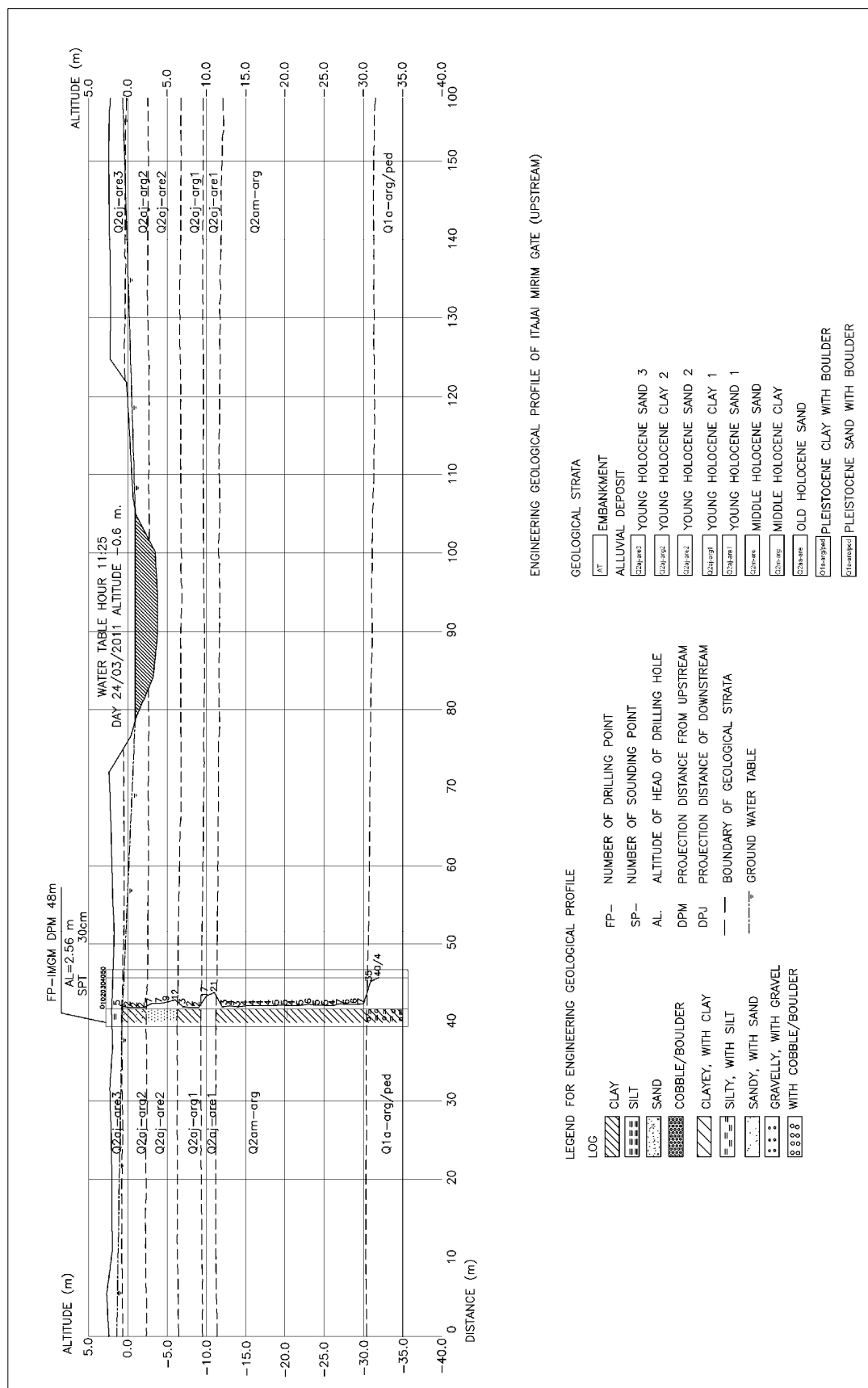
The proposed sites of both floodgates are in the alluvial plan on the Old Mirim River. Figure 5.3.1 shows the engineering geological profile at both locations. These profiles are prepared based on the results of drilling survey (the survey was carried out under the Preparatory Survey as field investigation in April-June 2011) and site reconnaissance. The geology of both sites is alluvial deposit in Quaternary System from surface to more than 38 meter deep, although the depth of bottom of the alluvial deposit is not confirmed.

Engineering properties such as N-values, angle of internal friction, unit weight were determined for each stratum based on the results of standard penetration test and empirical values. Tables 5.3.1 and 5.3.2 present the determined engineering properties by stratum for feasibility design.

Table 5.3.1 Determined Engineering Property of Each Stratum for the Upstream Floodgate

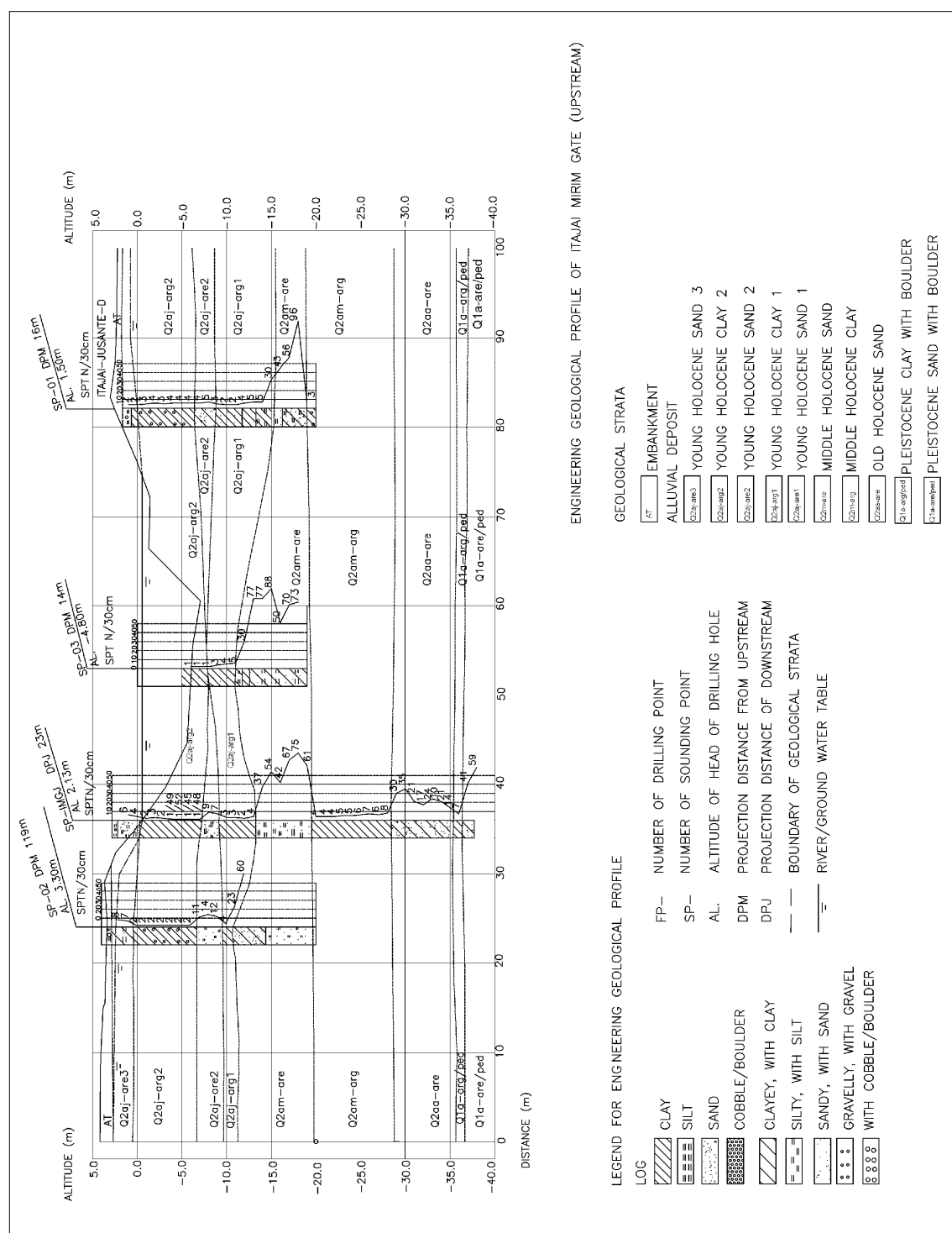
Symbol	Name of Strata	SPT N-Value Average (blows/ 30cm)	SPT N-Value Standard deviation (blows/ 30cm)	SPT N-value Adopted (blows/ 30cm)	Soil Strength c: cohesion (kN/m ²) φ: angle of internal friction (degrees)	Unit weight saturated γ _{sat} kN/m ³
Q2aj-are3	Young Holocene sand 3	4.5	0.7	4.2	C=0, φ=28	15
Q2aj- arg2	Young Holocene clay 2	2.2	0.4	2.0	C=13, φ=0	18
Q2aj- are2	Young Holocene sand 2	7.6	2.3	6.5	C=0, φ=29	16
Q2aj- arg1	Young Holocene clay 1	2.2	0.4	1.8	C=11, φ=0	17
Q2aj- are1	Young Holocene sand 1	16	4	14	C=0, φ=31	18
Q2am-arg	Medium Holocene clay	4.5	1.2	3.9	C=24, φ=0	19
Q1a- arg/ped	Pleistocene clay	109	130	23	C=100, φ=0	21

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.3.1 Engineering Geological Profile of Itajai Mirim Floodgate (Upstream)



Source: JICA Survey Team

Figure 5.3.2 Engineering Geological Profile of Itajai Mirim Floodgate (Downstream)

Table 5.3.2 Determined Engineering Property of Each Stratum for the Downstream Floodgate

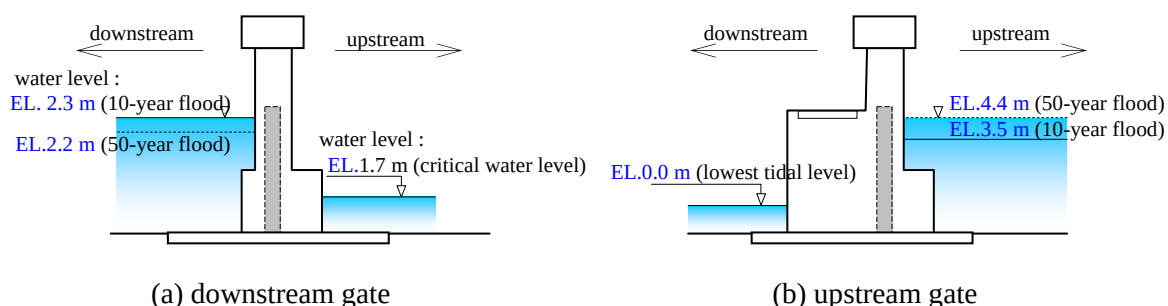
Symbol	Name of strata	SPT N-Value Average (blows/ 30 cm)	SPT N-Value Standard deviation (blows/ 30 cm)	SPT N-value Adopted (blows/ 30 cm)	Soil Strength c: cohesion (kN/m ²) φ: angle of internal friction (degrees)	Unit weight saturated γ _{sat} kN/m ³
AT/Q2aj-are3	Embankment/ Young Holocene sand 3	5.8	1.4	5.1	c=0, φ=29	15
Q2aj- arg2	Young Holocene clay 2	2.1	0.9	1.7	c=11, φ=0	17
Q2aj- are2	Young Holocene sand 2	8.4	4.5	6.2	c=0, φ=29	15
Q2aj- arg1	Young Holocene clay 1	3.3	1.2	2.7	c=17, φ=0	18
Q2am-are	Medium Holocene sand	57	29	43	c=0, φ=40	20
Q2am-arg	Medium Holocene clay	4.9	1.5	4.2	c=26, φ=0	18
Q2aa- are	Old Holocene sand	21	6.8	18	c=0, φ=32	18
Q2aa- are	Old Holocene clay	6.0	1.4	5.3	c=33, φ=0	18
Q1a- are/ped	Pleistocene sand with boulder	41	14	25	c=0, φ=35	19

Source: JICA Survey Team

5.3.2 Design Criteria and Design Conditions

Due to absence of Brazilian design standard for a floodgate, Japanese technical standard for river and sabo facilities was employed for current feasibility design.

Figure 5.3.2 shows design water levels of two floodgates. Aspects to be noted are that due to stage-wise implementation of the flood mitigation plan, gate structures are designed for the 10-year flood at the first stage, although civil structures of floodgate are designed for the 50-year flood.



Source: JICA Survey Team

Figure 5.3.3 Design Water Levels of Floodgates

As mentioned in sub-section 5.1.3, some stretch along the right bank in the Canal has insufficient flow capacity for the 10-year flood discharge. Dyke should be provided to prevent overflowing from this stretch. The height of the dyke is determined from the water level of the 10-year flood. The water level of the 50-year flood is lower than that of 10-year flood because of provision of the floodway.

5.3.3 Feasibility Design

(1) Civil Structure

Main features of the designed floodgates are summarized in Table 5.3.3 below. Figures 5.3.3 and 5.3.4 show the general layout plan of floodgates.

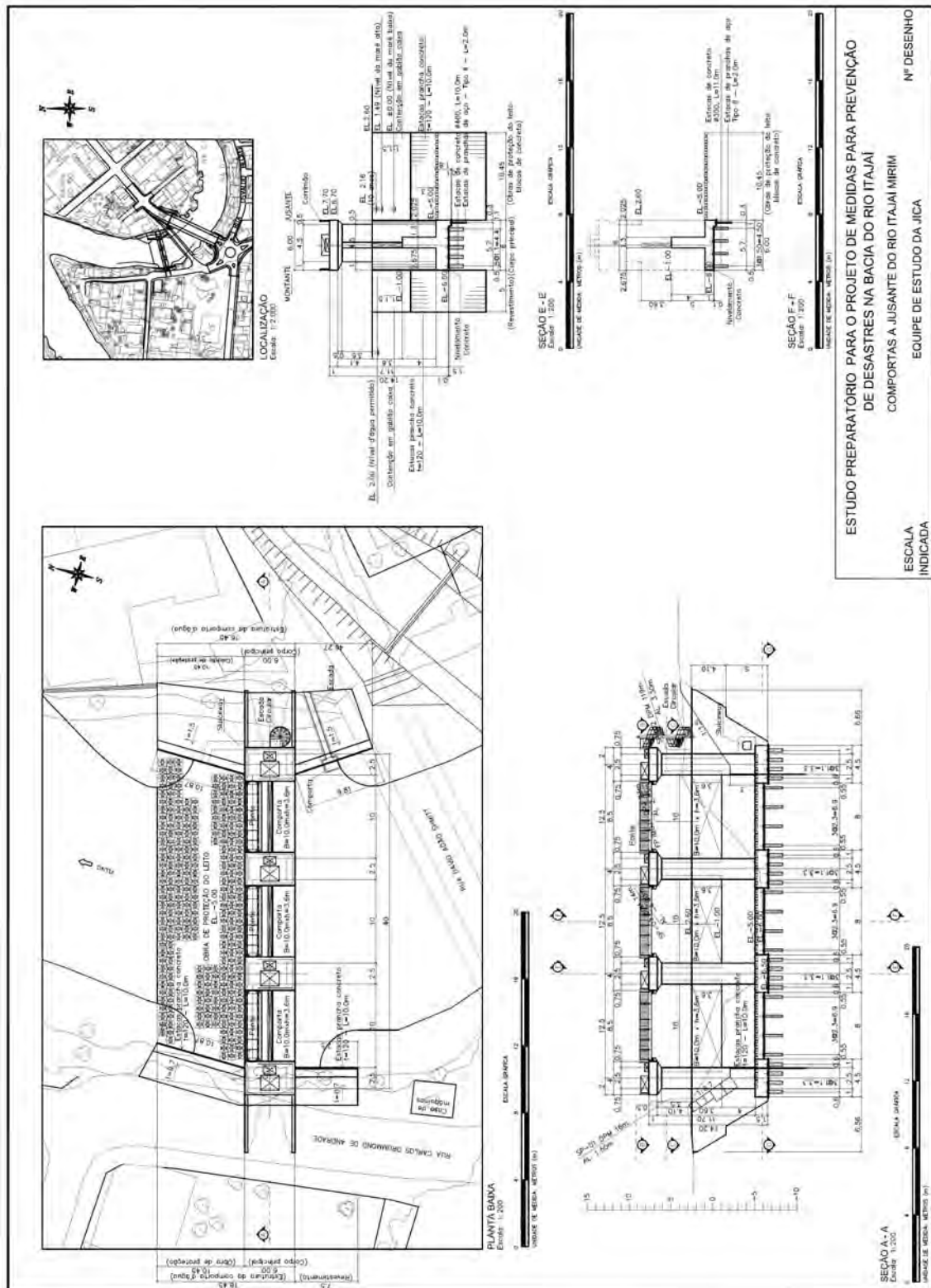
Table 5.3.3 Main Features of Floodgates

Gate	Downstream Gate	Upstream Gate
Nos. of Gate	3	3
Span of Gate	12.5 m	12.5 m
Foundation Elevation	EL.-5.0 m	EL.-4.3 m
Bottom Elevation of Gate	EL. -1.0 m	EL. -1.0 m
Main Structure	Separate slab and pier	Separate slab and pier
Gate Pier	EL. 7.70 m 6.00 m wide 14.20 m high	EL. 12.00 m 11.20 m wide 17.80 m high
Gate Operation System	On the top of pier	On the top of pier
Apron Length	6.0 m	8.0 m
Sheet Pile for Seepage	Downstream 2.0 m Upstream None	Downstream 2.5 m Upstream 5.5 m
Revetment	Downstream 10.0 m Upstream 10.0 m	Downstream 10.0 m Upstream none
Stair	Installed	Installed
Foundation	Pile foundation Pier :L=11.0 m ϕ 400 mm Slab :L=11.0 m ϕ 300 mm	Pile foundation Pier :L=27.0 m ϕ 400 mm Slab :L=27.0 m ϕ 300 mm

Source: JICA Survey Team

Technical factors considered in the feasibility design were as follows:

- i) It appeared through the drilling survey that bearing layers were located under the riverbed 12 m deep at the downstream floodgate and 30 m deep at the upstream floodgate. Therefore, pile foundation was proposed for both floodgates.
- ii) The lowest riverbed elevations are around EL.-6.8 m at the downstream floodgate and EL.-4.5 m at the upstream floodgate. As shown in Figure 5.3.2, the design top elevations of gate are EL.2.3 m at the downstream floodgate and EL.3.5 m at the upstream floodgate, respectively. In order to reduce the cost of gates, gate height was minimized by providing the convex part of the concrete foundation.
- iii) Considering local navigation by small boat on the Old Mirim River and the mean low tide elevation of EL. 0.00 m, the crest elevation of convex part was set at EL.-1.0 m at both floodgates.
- iv) Considering the existence of local scouring at the foot of bank, especially at the downstream floodgate section located immediately downstream of the existing bridge, the elevations of foundation were determined EL.-5.0 m at the downstream floodgate and EL.-4.3 m at the upstream floodgate, respectively.



Source: JICA Survey Team

Figure 5.3.4 General Layout Plan of Downstream Floodgate (1/2)

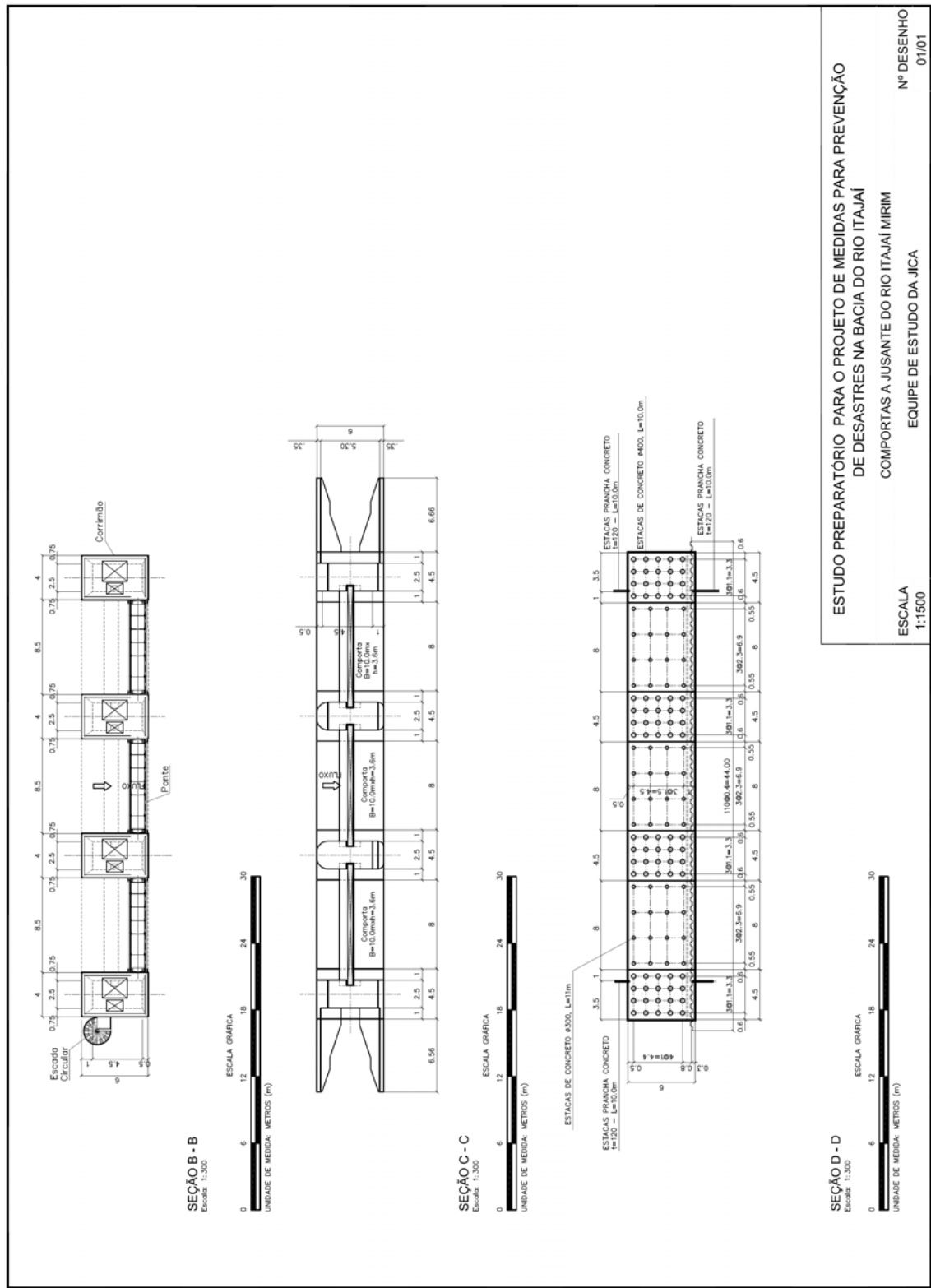
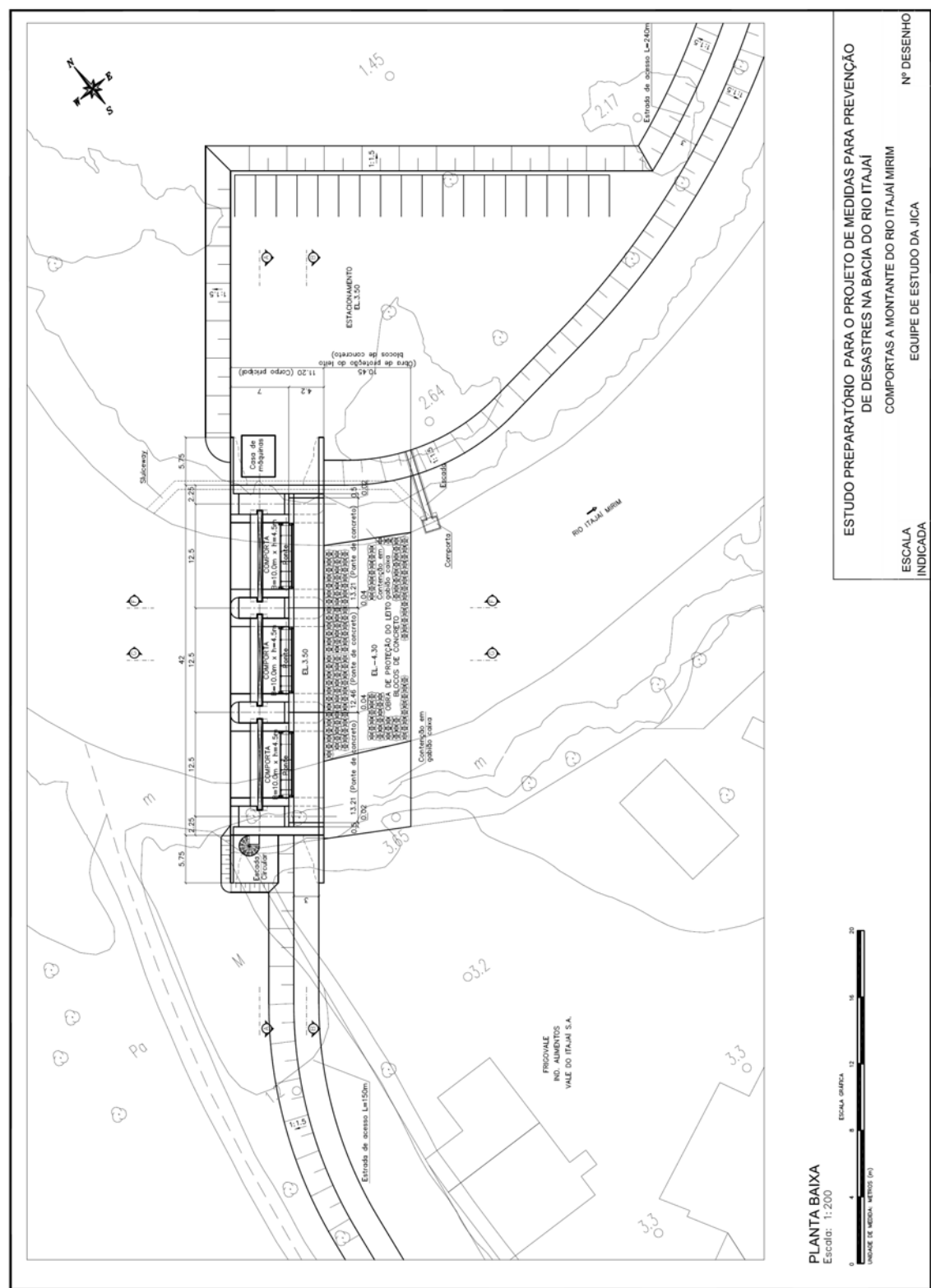


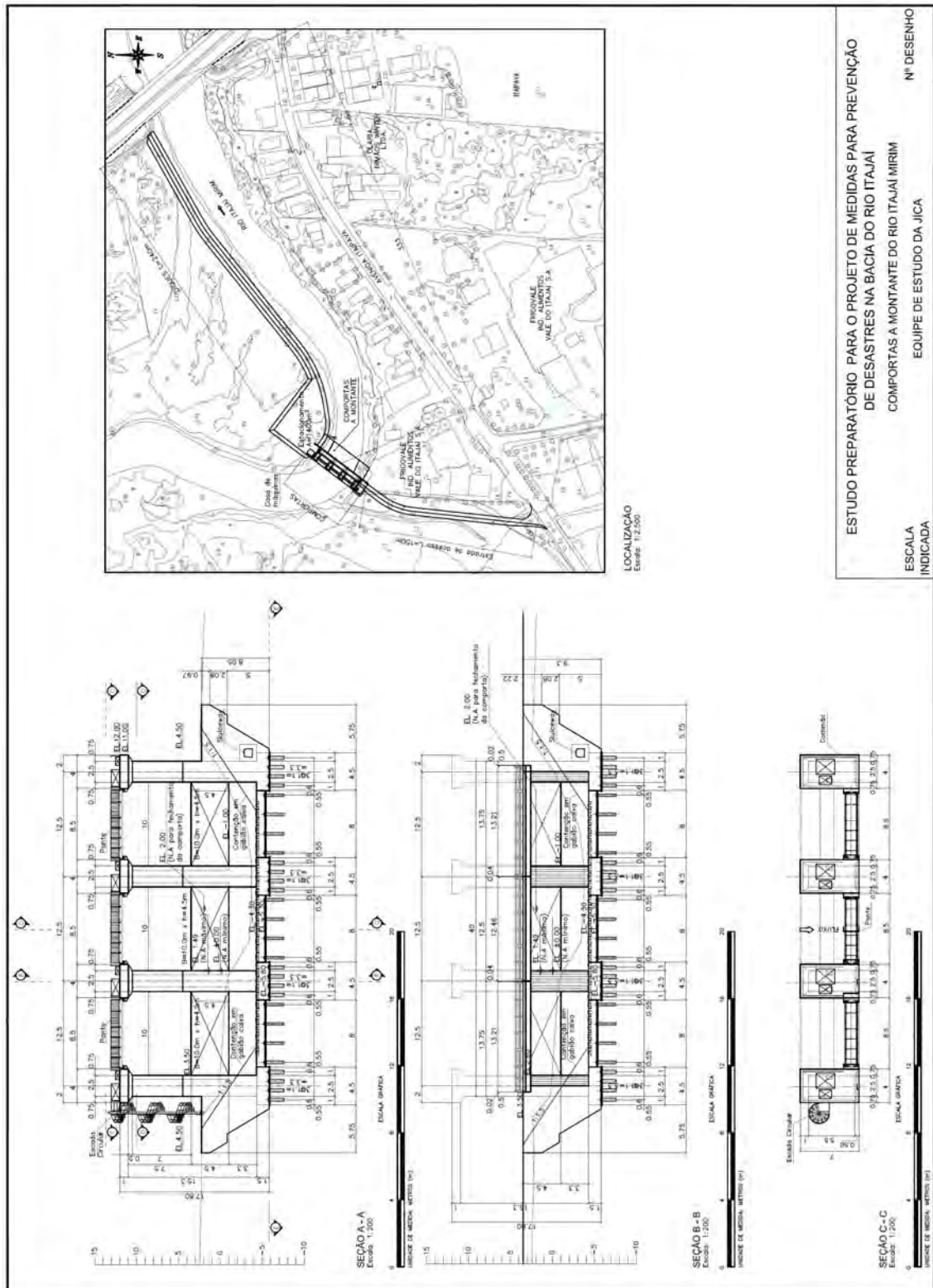
Figure 5.3.5 General Layout Plan of Downstream Floodgate (2/2)

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.3.6 General Layout Plan of Upstream Floodgate (1/3)



Source: JICA Survey Team

Figure 5.3.7 General Layout Plan of Upstream Floodgate (2/3)

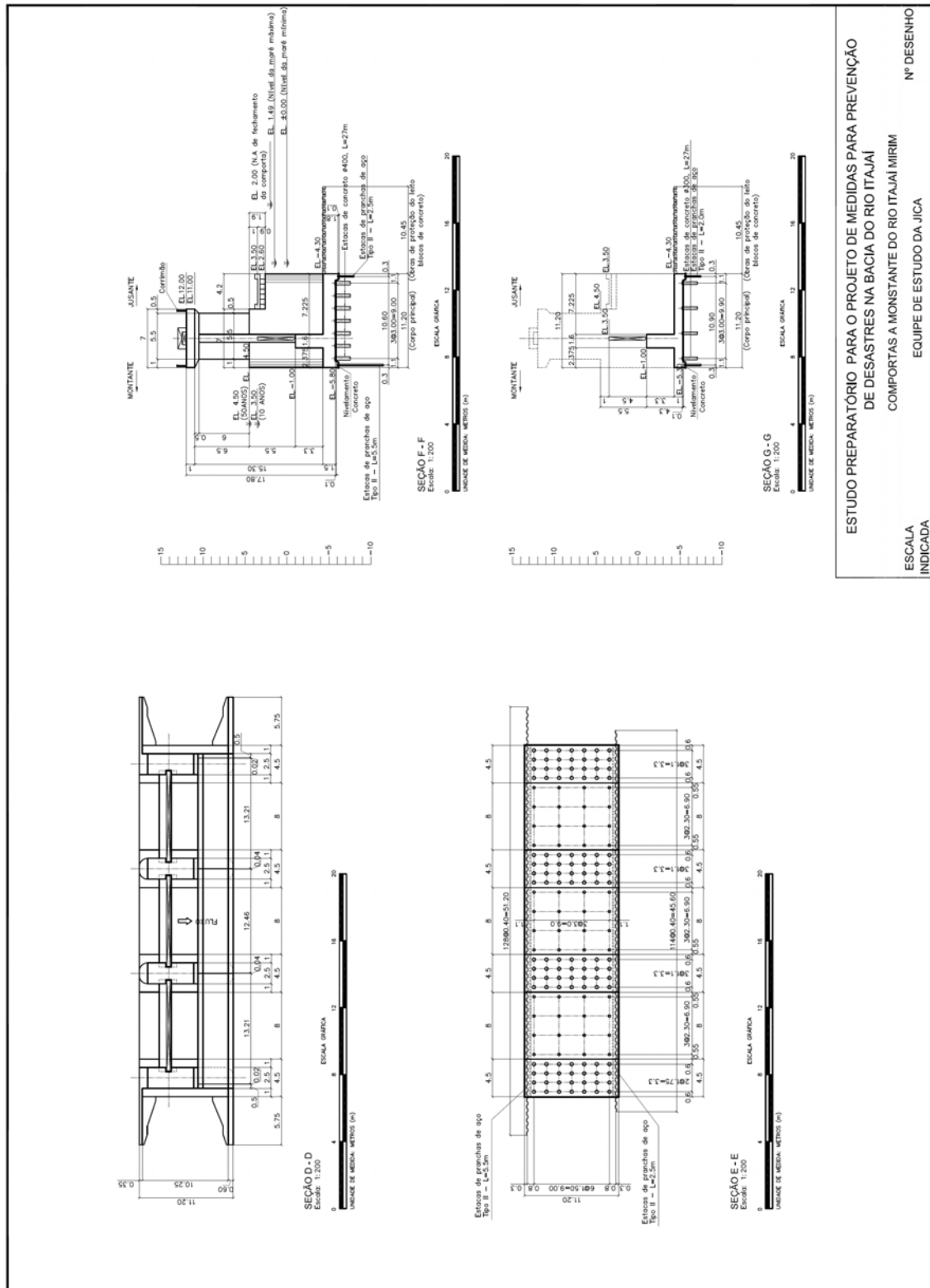


Figure 5.3.8 General Layout Plan of Upstream Floodgate (3/3)

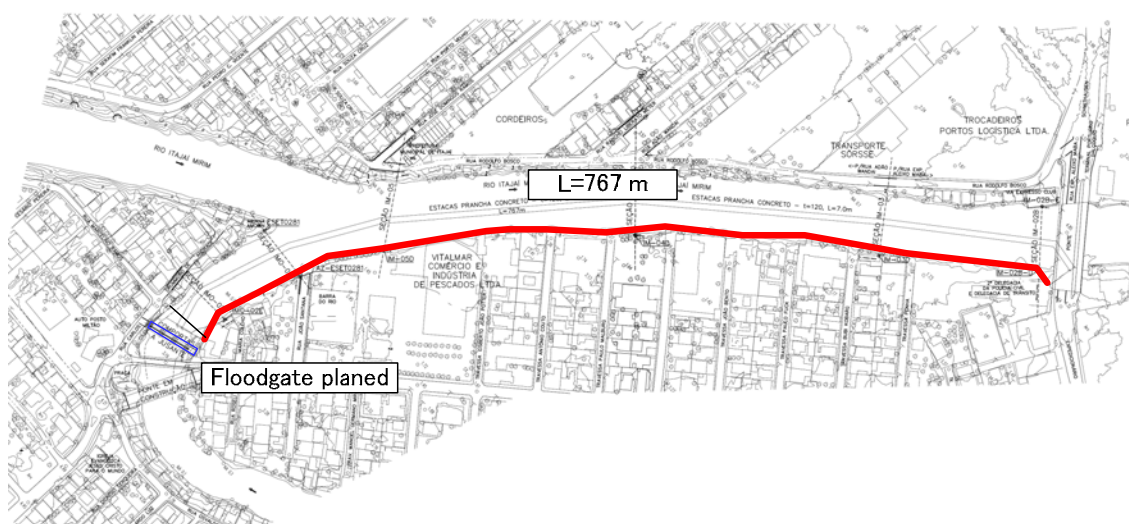
Source: JICA Survey Team

(2) Backwater Dyke

Around 1.0 km long river stretch along the Itajai Mirim River between the confluence with the Itajai River and the downstream floodgate is subject to backwater effect of the Itajai River. The river cross section survey along the Itajai Mirim River has revealed the following findings (see Figure 5.1.6):

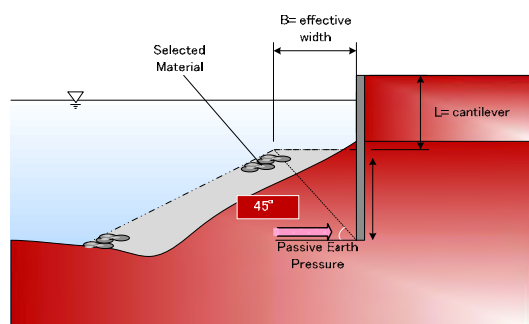
- i) The existing road (the Rodolfo Bosco Avenue) on the left bank has sufficient elevation to the design water level of 10-year flood and functions as a dyke.
- ii) In the stretch of around 0.5-1.0 km from the confluence of Itajai River, height of the right bank is lower than the water level of 10-year flood.
- iii) There are several residences immediately riverside on the right bank, where residents have been adapting to the backwater effects due to floods from the Itajai mainstream and tidal level fluctuation by providing brick walls on the riverside and stilt residences with raised floor.

Although the backwater dyke was proposed to provide embankment on both the banks in the Master Plan due to limited availability of river section data, concrete sheet piling was conceived as the alternative for backwater dyke on the right bank (see Figures 5.3.5 and 5.3.6 below) with the main focus on minimizing social issues such as relocation of residences. With provision of backwater dyke by means of sheet pile, no relocation of residences is required.



Source: JICA Survey team

Figure 5.3.9 Objective Stretch of Backwater Dyke at the Downstream Floodgate



Source: JICA Survey team

Figure 5.3.10 Image of Sheet Piling as Backwater Dyke

(3) Gate

The fixed wheel gate is proposed because of its plate girder structure or box girder structure. Comparing with the box girder structure, the plate girder structure is selected as the type of gate because of the following reasons.

- i) With the ratio of gate height and clear span is 3:1, the box girder structure type is not recommended for high costs.
- ii) Interviewing with the maker in Brazil, the box girder structure is not common in Brazil.

The type of hoist is selected as “1M-1D” (M:Motor, D:Drum) since its type is consisted from a few component parts and the initial and maintenance cost is minimized.

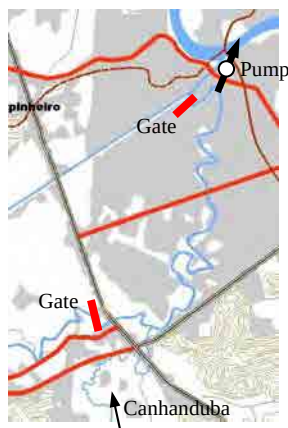
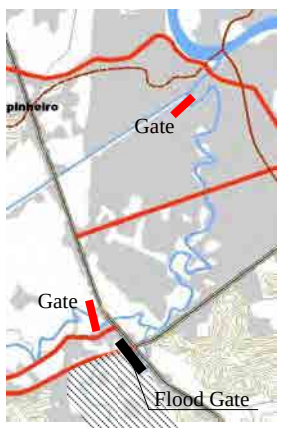
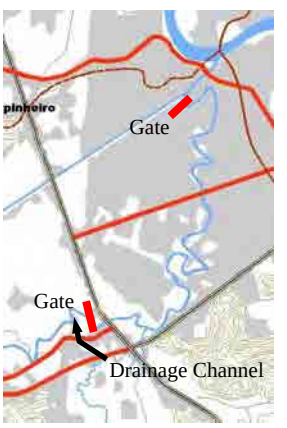
The floodgates are proposed to locate in the tidal area. Thus they are likely to be rusted by seawater. The countermeasure against the corrosion is considered as two methods; using of stainless steel material instead of the mild steel and painting itself. In Brazil, the cost of stainless is higher (6 times) than the mild steel. Thus there are few cases to use for the gates, and it is proposed for the gate itself that is floodgates. Accordingly, the floodgate is to be fabricated by the mild steel and the painting.

5.3.4 Local Drainage

(1) Drainage of Canhanduba River

The inflow from the Canhanduba River must be drained by appropriate measure with discharge of about 7.0 m³/s to maintain the inland water level not exceed EL.2.0 m which is the allowable water level not to bring local damage and not to disturb evacuation in the lower area along the Old Mirim. A drainage channel shall be recommendable based on the comparison results of drainage methods as shown in Table 5.3.4 below.

Table 5.3.4 Comparison of Drainage Methods for Inland Water from Canhanduba River

Method	Pumping Station from Old Mirim to Itajai River	Floodgate and Retarding Pond	Drainage Channel from Canhanduba to Old Mirim
Location			
Cost	High	Medium	Low
Impact	No impact	Retarding pond might affect the upstream agricultural area along the Canhanduba River.	No impact
Evaluation	Not recommendable	Not recommendable	Recommendable

Source: JICA Survey Team

(2) Drainage of Stored Water in the Old Mirim

As flood water levels in the upstream of the BR-101 along the Canal were estimated lower than the Old Mirim by non-uniform flow calculation, the flood water from the Old Mirim flows into the Canal naturally when the upstream gate is closed. Therefore, closing of the upstream gate may not affect the upstream area of the Old Mirim as illustrated in Figure 5.3.7 (ii).

However, if there is some topographic obstruction like mound or slightly elevated ground between the Old Mirim and the Canal as illustrated in Figure 5.3.7 (iii), inundation water level in the upstream area along the Old Mirim would increase because of the retention effects. It is strongly recommended that the impact to the inundation level in the upstream area of the BR-101 shall be studied by two-dimensional inundation analysis by use of 1:10,000 scale topographical maps which is under preparation by the State Government.

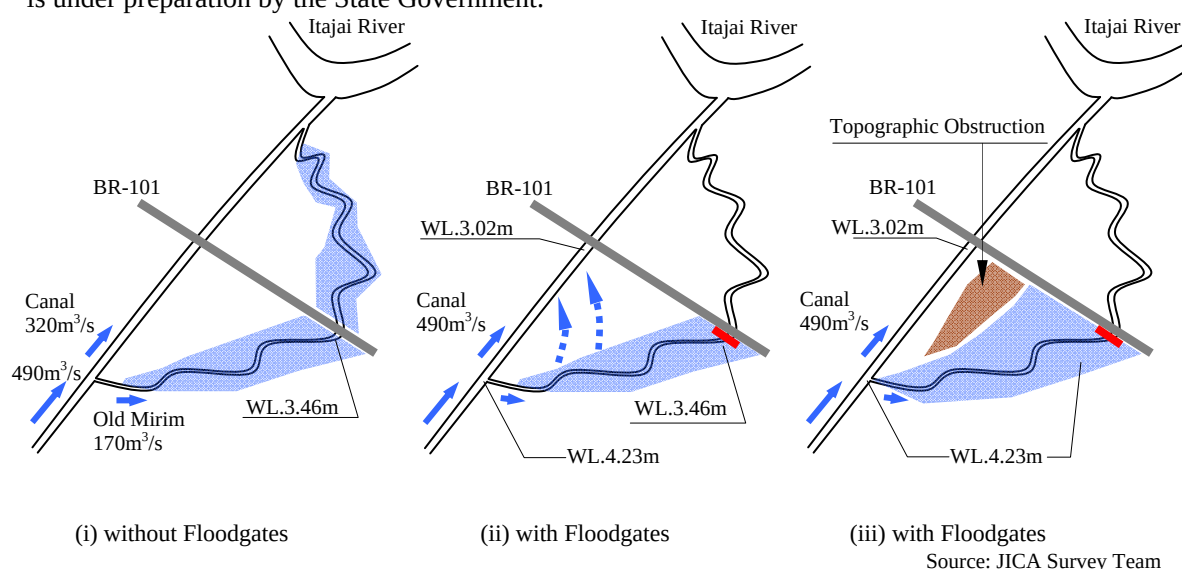


Figure 5.3.11 Necessity of Drainage in the Upstream Area of BR-101

CHAPTER 6 FEASIBILITY STUDY FOR STRENGTHEN OF EXISTING FFWS

6.1 Summary for Feasibility Study

The master plan for mitigation measures against the flood disaster was proposed to strengthen the existing FFWS including 16 new gauging stations (See Part I, M/P Table 8.5.1). The following items shall be studied in this F/S.

- i) Verification for existing flood forecasting system
- ii) Cost analysis for strengthening for proposed FFWS

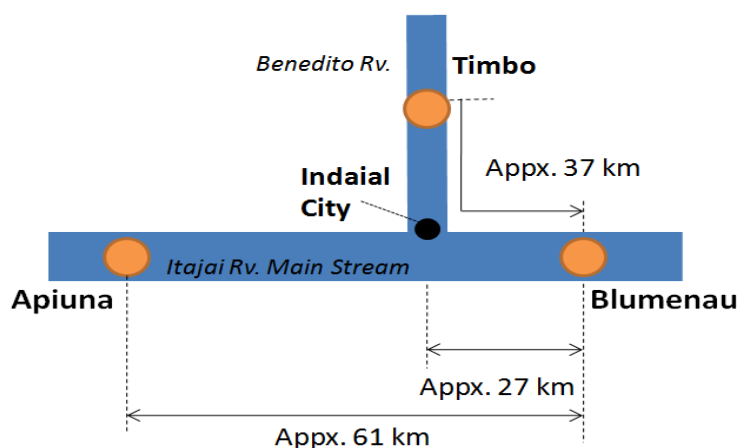
6.2 Verification of Existing Flood Forecasting Method

Existing FFWS is not systematically planned and conducted for total Itajai River Basin. Especially the flood forecasting is only conducted at Blumenau (by FURB) and Rio do Sul (by City Defesa Civil) but the Rio do Sul is still in “Trial and Error” stage.

In this section the present flood forecasting formula at Blumenau and Rio do Sul shall be verified. For Itajai city which is one of the most important cities along the Itajai River basin, the flood forecasting method shall be proposed in this section. For other cities and towns, it is important to maintain that the present warning system due to the river water level shall be adopted using existing gauging stations and additional gauging stations which are proposed under the study.

6.2.1 Verification of Existing Flood Forecasting Formula at Blumenau

The forecasting flood water level at Blumenau is computed based on the correlation of the water level (ARIMAX Model Method) at Blumenau, Apiuna and Timbo. The schematic diagram for gauging stations of Blumenau, Apiuna and Timbo is shown in Figure 6.2.1. Apiuna and Timbo are approximately located in 61 km along Itajai River and 37 km along Benedito River upstream respectively from Blumenau.



Sorce: JICA Study Team

Figure 6.2.1 Schematic Diagram for Gauging Stations

The water level correlation formula for the flood forecasting at Blumenau was developed by the FURB/ CEOPS in 1990's as follows.

$$Y(t) = 1.98063 \times Y(t-1) - 0.98506 \times Y(t-2) + 0.009200 \times u_1(t-4) - 0.08732 \times u_1(t-5) + 0.01806 \times u_2(t-4) - 0.01411 \times u_2(t-5) + 0.03083 \dots (1)$$

where,

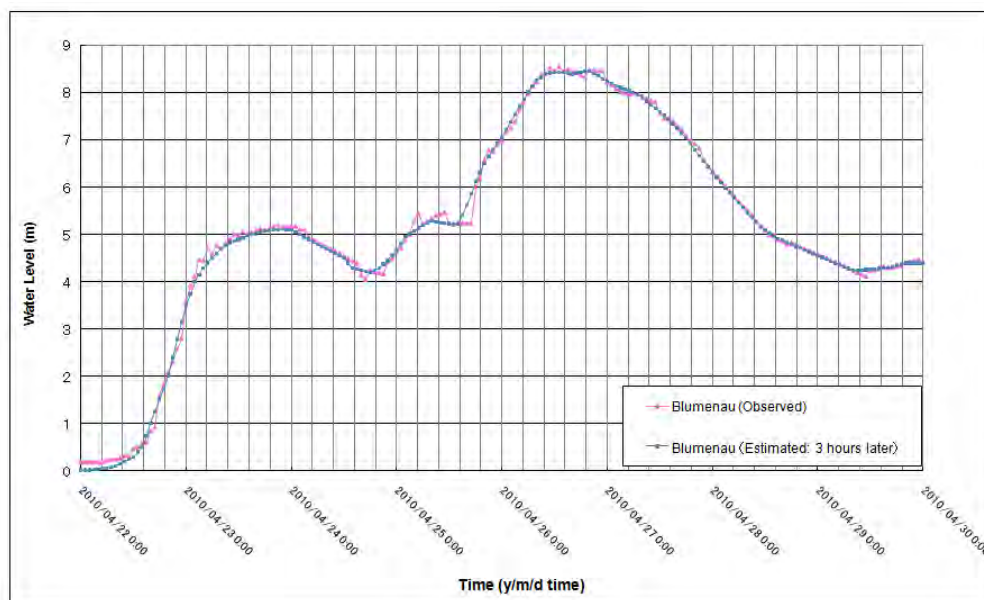
- $Y(t)$: Forecasted water level at time of (t) hour at Blumenau station
- $y(t-1)$: Water level at time of (t-1) hour at Blumenau station
- $y(t-2)$: Water level at time of (t-2) hour at Blumenau station
- $u_1(t-4)$: Water level at time of (t-4) hour at Apiuna station
- $u_1(t-5)$: Water level at time of (t-5) hour at Apiuna station
- $u_2(t-4)$: Water level at time of (t-4) hour at Timbo station
- $u_2(t-5)$: Water level at time of (t-5) hour at Timbo station

The evacuation manual of Blumenau city says that the evacuation shall be announced 3 hours before the flood in consideration of priority people to be protected such as aged people, handicapped people, children and tourists and so on.

The required water level at Blumenau for calculating of forecasted flood water level using the proposed formula is the 1 hour before and 2 hours before the flood therefore, the following steps shall be conducted to compute the forecasted water level after 3 hours from present.

- i) To forecast water level after 1 hour at Blumenau using present and 1 hour before water level at Blumenau
- ii) To forecast water level after 2 hours at Blumenau using forecasted water level after 1 hour and present water level at Blumenau
- iii) To forecast water level after 3 hours at Blumenau using forecasted water level after 1 hour and after 2 hours at Blumenau

The formula was developed approximately 20 years ago. This verification shall be conducted using the flood data in April 2010. The Figure 6.2.2 is shown the comparison between the actual flood water level at Blumenau and the forecasted flood water level (after 3 hours at Blumenau) computed by the proposed formula. The forecasted water level is quite similar to the actual one.



Source: JICA Study Team

Figure 6.2.2 Comparison between Actual and Water Level Forecasted by Present Formula at Blumenau

In addition to above verification, new multiple correlation formula is created using water level at Blumenau, Apiuna and Timbo as described Table 6.2.1 and the accuracy of forecasted water level used by the new multiple correlation formula shall be confirmed with the actual.

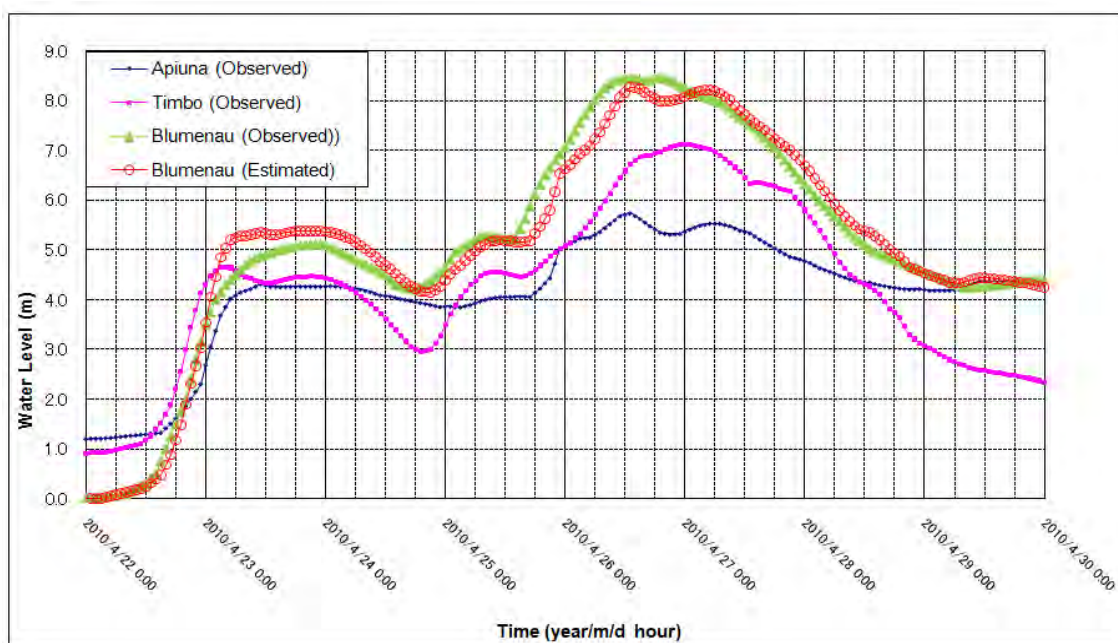
Table 6.2.1 Summary of Forecasting Formula by Multiple Correlation at Blumenau

Method	Gauging Sta.1	Gauging Sta.2	Coefficient of Correlation	Forecasting Formula
Multiple Correlation	Using 6 hours before actual water level at Apiuna considered arrival time	Using 3 hours before actual water level at Timbo considered arrival time	0.991	$Y = 1.1012259 * X_1 + 0.5622697 * X_2 - 1.830675 \dots\dots\dots (2)$

Source: JICA Study Team

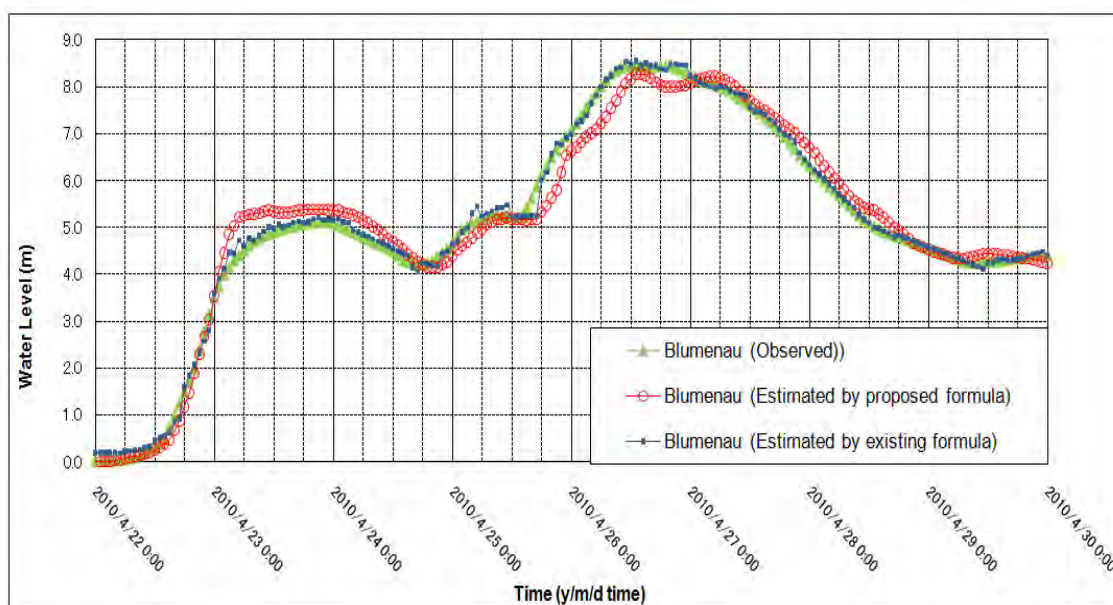
The forecasting formula by the multiple correlation among Blumenau, Apiuna and Timbo using the flood in April 2010 is quite accurate as shown in Figure 6.2.3 and the correlation coefficient is R=0.991 but not as highly accurate as the present forecasting formula (see Figure 6.2.4).

Therefore the present forecasting formula at Blumenau is still maintaining accuracy and even now it is applicable to use the present forecasting formula for forecasting flood water level at Blumenau. In future, whenever the flood comes the formula should be checked and updated if necessary.



Source: JICA Study Team

Figure 6.2.3 Comparison between Actual and Water Level Forecasted by Multiple Correlation Formula at Blumenau



Source: JICA Study Team

Figure 6.2.4 Comparison among Actual, Present Formula and Multiple Correlation Formula

6.2.2 Verification of Existing Flood Forecasting Formula at Rio do Sul

The present formula for forecasting flood water level at Rio do Sul was developed by Defesa Civil in Rio do Sul city. The formula was developed by the rainfall correlation method using the rainfall at Rio do Sul (C.A.:5,042 km²), Oeste Dam (C.A.: 1,042 km², 81km upstream of Rio do Sul) and Sul Dam (C.A.: 1,273km², 43km upstream of Rio do Sul). The formula was developed in a trial stage therefore presently the flood/ evacuation warning shall be implemented without using the forecasted water level computed by this formula.

- i. The daily average discharge shall be computed by the daily average water level using H – Q Curve at Rio do sul. The water level at Rio do Sul is ocularly observed at 7a.m. and 5 p.m. daily and the observation of flood water level is conducted hourly. The daily average water level means the average of 2 times of water level for ordinary days and maximum 24 times of water level for during the flood.

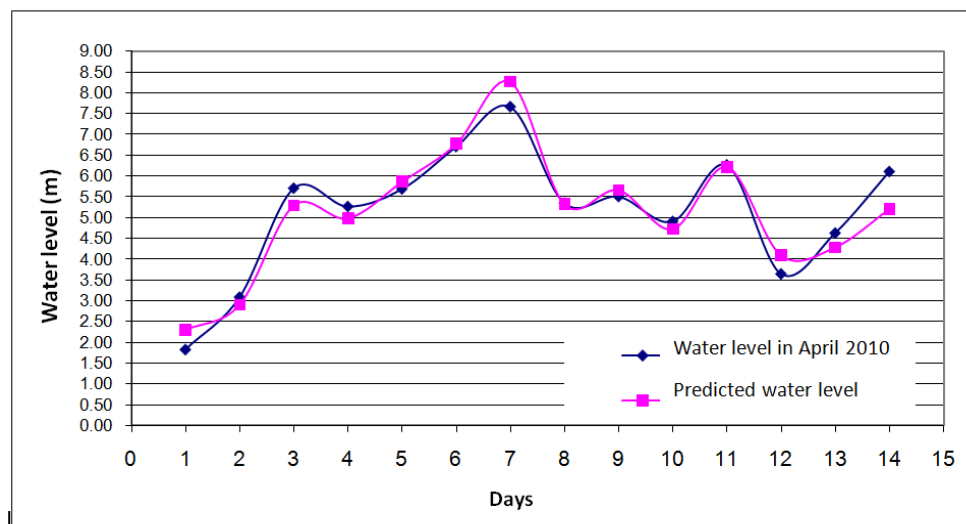
$$Q = 44.7757 (H - 0.235)^{1.48789} \dots\dots\dots(3)$$

- ii. The fluctuation discharge (ΔQ) shall be computed by daily rainfall data at aforementioned 3 locations using the following formula. The fluctuation discharge (ΔQ) means the different discharge volume between that day and next day.

$$Q = 6.07 + 1.66 * (\text{Rainfall at Rio do Sul}) + 2.51 * (\text{Rainfall at Sul Dam}) \\ + 0.45 * (\text{Rainfall at Oeste Dam}) \dots\dots\dots(4)$$

- iii. The daily average discharge for next day (Q2) shal discharge (ΔQ) to the daily average discharge for that day.I be computed to add the fluctuation
- iv. The daily average water level for the next day shall be computed using aforementioned H-Q Curve formula (3).

The forecasted daily average flood water level at Rio do sul was computed by using above method regarding the flood on April 2010 and the comparison between the actual daily average flood water level and forecasted daily average flood water level is shown in Figure 6.3.5. The forecasted daily average water level is 30 cm in difference from the actual and it is quite accurate.



Source: Rio do Sul, Defesa Civil

Figure 6.2.5 Comparison between Actual Daily Average Water Level and Forecasted Daily Average Water Level at Rio do Sul

However:

- the forecasting method is only applicable for daily average but not allowed to compute hourly base. Therefore the forecasting method is not appropriate to utilize for the warning system. It can be used only for the warning announcement for the next day.
- The definition of the daily average water level is not clear for the ordinary day and the flood time. In case of the flood time, the daily average water level could not be computed until the end of day (12pm) therefore the water level for the next day could not be forecasted until midnight. In this case the warning for the next day maybe difficult due to preparation of the warning after midnight.
- DEINFRA as dam operator has no data of discharge from 2 dams and the information of discharge is not transmitted to downstream cities such as Rio do Sul, Ituporanga and Taio City.

Due to those above mentioned matters, the following comments are well considered for the future.

- In future, the correlation method should be applied for the flood forecasting at Rio do Sul as a ordinary method and it must be hourly forecasting.
- However Rio do Sul has 2 flood control dams in upstream. The coefficient of correlation among 2 locations is low therefore the flood forecasting modeling is needed to be developed by the runoff analysis including the mechanism of control gates at dams.
- In case of the modeling of the flow-runoff analysis, in addition to the existing rainfall gauging stations, the system for transmitting data of dam discharge including the gate control status to the city/ provincial Defesa Civil by the DEINFRA as the dam operator must be set up and implemented essentially.

6.2.3 Flood Forecasting System at Itajai City

The Itajai City has very important role for the economy in the Itajai River Basin and the flood forecasting system should be organized as same as Rio do Sul and Blumenau. However the Itajai City is located at the estuary and the city is seriously affected by the tide and influenced by the tributary of Mirim River. Therefore the forecasting of flood water level at Itajai city is

very complicated and difficult.

The Defesa Civil at Itajai City has already installed new 8 water level gauges around the city in February 2011 and they are planning to set up new system for the flood warning and evacuation announcement but they has presently hard time to set up the flood forecasting system since the information in upstream such as Blumenau and Brusque is not transmitted to Itajai City.

Other hand, the Defesa Civil, SDS and EPAGRI in SC Province are planning to develop the flood forecasting modeling for the flow-runoff analysis and inundation analysis but it needs more time to get accurate forecasting system using sufficient data collected by the proposed gauging stations under this FFWS. However the development of the flood forecasting modeling should be continued. Meantime the flood warning and evacuation announcement should be implemented by the SC Province due to the flood water level of upstream such as Blumenau and Brusque.

- There are no previous data for the flood water level at Itajai City at all. The inundation at Itajai City must be forecasted from the upstream flood water level at Blumenau and Brusque after researching previous flood water level at Blumenau and Brusque in relation to previous inundation record of Itajai City.
- In next study, the flood forecasting method at Itajai City should be prepared after analysis of relation of flood water level at Itajai City and upstream, relation of Itajai City inundation and upstream flood water level, analysis of flood arrival time using data from the water level gauges newly installed by the Itajai City, water level gauges at Gaspar and Ilhota proposed under this FFWS in addition to the existing gauges.

6.3 Cost Estimate for Strengthening FFWS

The cost estimation for strengthening FFWS is shown as follows.

- Equipments cost including installation
- System development cost including consultant services

The summary of new gauging station is shown in Table 6.4.1. as follows.

Table 6.3.1 Quantity and Location of New Gauging Stations

Station		Rainfall	Water Level	CCTV	Warning Tower	Warning Siren
1	Rio do Sul			1	3	3
2	Blumenaur			1	3	3
3	Itajai			1	3	3
4	Vidal Ramos	1	1			3
5	Trombudo	1	1			3
6	Rio dos Cedros	1	1			3
7	Benedito Novo	1	1			3
8	Gaspar	1	1			3
9	Ilhota	1	1			3
10	Mirim Doce	1	1			3
11	Salete	1	1			3
12	Pouso Redondo	1	1			3
13	Agua Clara	1	1			3
14	Gurabiruba	1	1			3
15	Sul Dam	1	1			3
16	Oeste Dam	1	1			3
17	Pinhal Dam	1	1	1		3
18	Rio Bonito Dam	1	1	1		3
19	Luiz Alves	1	1			3
Total		16	16	5	9	57

Source: JICA Study Team

In addition to above, the Master Station at the Defesa Civil at Florianopolis City shall be established as described Section 8.5.1, Chapter-8 and the three (3) monitoring Centers shall be established at the Defesa Civil at Itajai City, Blumenau City and Rio do Sul City.

Table 6.3.2 Specification of Equipments

Item	Specification	Nos.
Telemetry rainfall gauge	Radar type OTT/RLS model	16
Telemetry water level gauge	Radar type OTT/RLS model	16
Software	Automatic E-mail system	16
Solar panel/battery	Polycrystalline silicon type 12V	16
Data transmission (GPRS)	For data transmission 2.0Mbyte	16
CCTV	In-line transmission CCD	5
Data transmission (GPRS)	For CCTV 2.0Gbyte	5
Database	Memory capacity for 20 years record	5
Monitoring panel	52 inches display LDC	5
Electric bulletin board (warning tower)	5.0 m width and 3.0 m height Rio do Sul (3), Blumenau (3), Itajai (3)	9
Alarm (siren)	Large disaster warning siren, for external moisture	57

Source: JICA Study Team

The cost estimate for new gauging stations including the Master Station and Monitoring Centers is shown in Table 6.4.3.

Table 6.3.3 Cost Estimate for Proposed Gauging Stations

Item	Nos.	Unit Price (R\$)	Amount (R\$)
Telemetry rainfall gauge	16	5,300	84,800
Telemetry water level gauge	16	6,800	108,800
Software	16	-	-
Solar panel/battery	16	17,000	272,000
Data transmission (GPRS)	16	20,000	320,000
CCTV	5	26,500	128,000
Data transmission (GPRS)	5	20,000	100,000
Database	5	120,000	600,000
Monitoring panel	5	8,000	40,000
Electric bulletin board (warning tower)	9	30,000	270,000
Alarm (siren)	57	2,000	114,000
Monitor station	3	80,000	240,000
Central station	1	257,000	257,000
Total			2,534,600

Note: The cost for development of programs regarding the telemeter system is not included in the above cost.

Source: JICA Study Team

The unit price of equipments and establishment of center including system development is shown in the Supporting Report D. The river register book is needed to prepare for total river management together with the proposed gauging stations above. The river register book must include total 350 cross section survey (1.0 km interval) along Itajai Main River and major tributaries, cross section survey for existing water level gauges and km piles (KP) along the river. The work for river register book shall also include the development of modeling for the flood runoff analysis.

The purposes for the consultant services regarding the system development are as follows.

- i) Tendering for procurement of equipments
- ii) Training for concerned organizations
- iii) Development for flood forecasting modeling and simulation modeling
- iv) Establishment for H-Q curves for all water level gauging stations including existing and proposed stations
- v) Study for preparation of operation system for Bonito and Pinhal Dams

- vi) Study for preparation of operation system for Oeste and Sul Dams

The cost for the consultant services for system development is shown in Table 6.4.4.

Table 6.3.4 Cost for Consultant Services for System Development

Item	M/M	Unit Price (R\$)	Amount (R\$)
Project Manager	10	60,000	600,000
Hydrologist	8	50,000	400,000
River Engineer	8	50,000	400,000
Program Engineer	4	50,000	200,000
Telecommunication Engineer	5	50,000	300,000
System Engineer	5	50,000	300,000
Network Engineer	5	50,000	300,000
Database Engineer	5	50,000	300,000
Supporting Staff	10	20,000	200,000
Total	-	-	3,000,000

Source: JICA Study Team

The direct cost for the propose FFWS is shown in Table 6.3.5.

Table 6.3.5 Direct Cost for Strengthening Existing FFWS

Item	Amount (R\$)
1. Equipment cost	2,534,600
2. River survey for a river inventory book	1,500,000
3. System development	3,000,000
Total	7,034,600

Source: JICA Study Team

CHAPTER 7 FEASIBILITY STUDY OF STRUCTURAL MEASURE FOR LANDSLIDE

7.1 General

The 13 priority sites (potential annual loss is more than R\$500 thousand) are selected for structural measures. The safety target of the structural measure is to ensure full functionality of the infrastructure and/or buildings/lands against heavy rain of 60 years return period, or heavy rain level of in November 2008 at Blumenau Municipality (hereinafter referred to as '60 years heavy rain'). All of the priority sites are road slopes, and the structural measures will be planned to ensure full width road traffic against 60 years heavy rain.

In the master plan, safety target is set to ensure half width road traffic against 60 years heavy rain. In this feasibility study, safety target is changed to ensure full width road traffic against 60 years heavy rain, because that high possibility of human lives lost is recognized on 13 priority sites by new finding of the field survey and comprehensible consideration as summarized in follows.

The partial width road closure is expected even structural measures have been conducted to ensure half width road traffic against 60 years heavy rain. In that case, the landform characteristics indicate that rapid slope collapse which directly attack road users, or tumble down of road users due to sudden road foundation failure.

Annual average daily traffic (AADT) of the priority 13 sites is relatively higher and from 1,800 to 43,000 vehicles per day. The high traffic may increase possibility of direct hit by disasters; even they are partial width road closure.

Especially, 7 sites are Aregisso Vermelho-Anarelo (red-yellow soils) which has the character of remarkable strengths deterioration by water contains. The shallow slide deformations were recognized on sod facing cut slopes on Aregisso Vermelho-Anarelo by the inspection in April 2011. The deformations had been progressive by the comparison with the inspection in May 2010; even the slopes had not suffered by 60 years heavy rains. The new finding shows that cutting slopes of 7 meter height or more on Aregisso Vermelho-Anarelo have a high possibility of collapse by a 60 year heavy rain, because they are slightly deformed even with sod facing without 60 year heavy rains. In the master plan stage, reinforced earth of cut slope is planned on slopes on 15 meter height or more, because these slopes can not secure the half width road traffic when they are collapsed. In the feasibility study, reinforced earth on cut slope is adopted on more widely on cut slopes of 7 meter or more to avoid human lives loss and to secure whole width road traffic for 60 year heavy rains.

Type for measures will be selected by learning from existing measures of similar condition slopes, which have not been occurred disaster even under 60 years heavy rain. It is also referred that technical norm in Brazil, NORMA BRASILEIRA ABNT (Associação Brasileira de Normas Técnicas), NBR (Número de referência) 11682, Estabilidade Encostas (Slope Stabilization).

The road drainage will be planned by using rainfall intensity- duration curve of 10 years return period, according to the practices of DEINFRA.

Following three methods have not utilized in Itajai River basin. It means that they have not been tried of 60 years heavy rain. In referring experience of similar slopes in Japan, they are also selected as alternative methods for this feasibility study..

Lightweight embankment of expanded polystyrene (EPS)

Reinforced earth of polypropylene (PP) fiber/cement/sand mixture

Connecting concrete blocks revetment which enable covering soil and vegetation

Landslides cause sediment discharge also, and it cause negative influence of flood, flash flood, further landslide process, and infrastructure function. Therefore vegetation and drainage ditch

will be utilized to protect erosion. In no risk place of falling trees, the trees will be planted. The tree plantation will contribute to the carbon fixation and the improvement of global environment, also.

7.2 Landslide Type and Selection of Type of Structural Measures

7.2.1 Classification of Landslide Type

Appropriate structural measures are different by type of landslide movement and landslide location from preservation object generally. In this feasibility study, types of landslide are as Table 7.2 .1 for the selection of the appropriate structural measures.

Table 7.2.1 Type of Landslide

Landslide location from preservation object	Type of landslide movement
Mountainside slope	Collapse
Vallyside slope	
River bank slope	
-	Slide
-	Flow

Source: JICA Survey Team

The selected 13 priority sites and types of landslide are summarized in Table 7.2.2.

Table 7.2.2 Selected 13 Priority Sites and Type of Landslide

No. of priority order	Site	Municipality	Management	Potential annual loss mil R\$/year	Type of landslide
1	SC 302 Taio-Passo Manso-5	Taio	State	1,255	Slide
2	SC470 Gaspar River Bank	Gaspar	State	1,095	River bank collapse
3	Blumenau -Av Beira Rio	Blumenau	Municipality	1,021	River bank collapse
4	SC418 Blumenau - Pomerode	Pomerode	State	989	Slide
5	SC474 Blumenau-Massaranduba 2	Blumenau	State	907	Mountainside collapse
6	Gaspar - Luiz Alves, Gaspar 9	Gaspar	Municipality	774	Slide, Mountainside, and valley side collapse
7	Gaspar - Luiz Alves, Luiz Alves 6	Luiz Alves	Municipality	700	Mountainside collapse
8	SC470 Gaspar Bypass	Gaspar	State	689	Mountainside collapse
9	SC477 Benedito Novo - Doutor Pedrinho 1	Benedito Novo	State	680	Slide
10	SC418 Pomerode-Jaragua do Sul 1	Pomerode	State	651	Vallyside collapse
11	Gaspar - Luiz Alves, Luiz Alves 4	Luiz Alves	Municipality	629	Mountainside collapse
12	SC474 Blumenau - Massaranduba 1	Blumenau	State	601	Mountainside collapse
13	SC 302 Taio - Passo Manso 4	Taio	State	526	Mountainside collapse

Source: JICA Survey Team

7.2.2 Selection of Measure against Mountainside Collapse

The selection criteria of measure structural type's alternatives against mountainside collapse are formulated by the policy described in section 7.1.1 and shown in Table 7.2.3. The vegetation works, and open ditch are included in basic measures to prevent sediment discharge.

There are many existing gabion retaining walls on slope foots with slope vegetation in the Itajai river basin. It is enough against 60 years heavy rain for the slope less than 7 m height. But in case of slope height is more than 7m, some slopes occurs deformation as shown in following photo.



Slope deformation in cut slopes which higher than 7 m on SC 474 Blumenau - Massaranduba road in Blumenau Municipality.

Source: JICA Survey Team

Table 7.2.3 Structural Measures against Mountainside Collapse

Slope condition		Typical measure alternatives	Common items
Stable cutting gradient is Not secured		Rock bolts, anchor works.	Open ditch, vegetation
There is rock falls probability		Removal of unstable rock, foot protection, rock protection fence, rock catch/cover net.	
Stable cutting gradient for deep collapse is secured	Slope height is more than 7 m.	Cutting of unstable portion, slope reinforcement works.	
	Slope height is less than 7 m	Cutting of unstable portion, vegetation net, and gabion on slope foot.	

Source: JICA Survey Team

Structural measures types are selected against mountainside collapse as Table 7.2.4. To prevent erosion or sediment discharge due to rainfall or springs, open ditch and vegetation are planed for all selected sites.

Table 7.2.4 Selected Measures for Mountainside Collapse

No. of priority order	Site	Height Gradient	Soil or rock type	Spring recognized	Selected structural measure
5	SC474 Blumenau-Massaranduba 2	15 m height 40 degree	Weathered rock	In rainfall time	1. Cutting of unstable portion
6	Gaspar - Luiz Alves, Gaspar 9	15 m height 45 degree	Clay, sand, or weathered rock		2. Open ditch
7	Gaspar - Luiz Alves, Luiz Alves 6	10-20 m 60 degree	Clay, sand, or weathered rock		3. Slope reinforcement works
8	SC470 Gaspar Bypass	20 m 50 degree	Weathered rock		4. Vegetation
11	Gaspar - Luiz Alves, Luiz Alves 4	15 m 25 degree	Clay, sand, or weathered rock		
12	SC474 Blumenau-Massaranduba 1	30 m 50 degree	Weathered rock		
13	SC 302 Taio-Passo Manso 4	20 m 50 degree			

Source: JICA Survey Team

Comparison of alternatives of slope reinforcement measure for 1,000 m² is carried out and shown in Table 7.1.4. Reinforced earth method of PP fiber/ cement/sand is recommendable, because it is advantage of all evaluation items of the cost, construction period, and landscape.

- Crib works (shotcrete crib)
- Crib works (cast-in-place concrete crib)
- Reinforced earth of PP fiber/cement/sand mixture

Table 7.2.5 Comparison of Alternatives of Slope Reinforcement Measure

	Shotcrete crib works	Cast-in-place concrete crib works	Reinforced earth of PP fiber/cement/sand mixture
Example photo			
Constriction date estimation date estimation for 1000 m ²	Sub-work items day/1000 m ²	Sub-work items	Sub-work items day/1000 m ²
	Cleaning slope 5	Cleaning slope	Cleaning slope 5
	Wire mesh 8	Crib works including curing term	Anchor bar 40
	Crib works 25	Vegetation	Drainage
	Vegetation 5		Reinforced earth of PP 5
	Total 43	Total	Vegetation 50
			Total
Unit cost,	Sub-work items R\$/m ²	Sub-work items R\$/m ²	Sub-work items R\$/m ²
	Cleaning slope 15	Cleaning slope 15	Cleaning slope 15
	Wire mesh 45	Crib works 340	Anchor bar 50
	Crib works 300	Vegetation 65	Drainage 35
	Vegetation 65		Reinforced earth of PP 235
	Total 425	Total 420	Vegetation 75
			Total 410
Evaluation	Not recommendable - 2 nd long construction period - Highest construction cost - Not good landscape	Not recommendable - Longest construction period - 2 nd low cost Construction - Not good landscape	Recommendable alternative - Shortest construction period - Lowest construction cost - Good landscape

Source: JICA Survey Team

7.2.3 Selection of Measure against Valley Side Slope Collapse

The selection criteria of measures alternatives against valley side slope collapse are formulated by the policy described in section 7.1.1 and shown in Table 7.2.5. The vegetation works, and open ditch is included in basic measures to prevent sediment discharge.

Table 7.2.6 Structural Measures against Valley Side Collapse

Slope condition			Typical measure alternatives	Common item
Height (H) of collapse H>10	Height (H) and width (W) of collapse H/W > 0.5		Pilling, or large block placing	Tree planting Open ditch
	Height (H) and width (W) of collapse H/W ≤ 0.5		Gully filling by gabion and longitudinal drainage	
Height (H) of collapse H ≤ 10	Height (H) and width (W) of collapse H/W > 0.5	Embankment on slope foot is Possible	Embankment	
		Embankment on slope foot is Impossible	Pilling, or large size block placing	
	Height (H) and width (W) of collapse H/W ≤ 0.5		Gully filling by gabion and longitudinal drainage	

Source: JICA Survey Team

Table 7.2.7 Selected Measures for Valley Side Collapse

No. of priority order	Site	Height of collapse	Width of collapse	Embankment possibility	Selected Measure
6	Gaspar - Luiz Alves, Gaspar 9	30m	3m	Impossible	Gully filling by gabion and longitudinal drainage, tree planting
10	SC418 Pomerode – Jaragua do Sul 1	8m	30m	Possible	Embankment, open ditch, tree planting

Source: JICA Survey Team

7.2.4 Selection of Measure against River Bank Collapse

Selections of measures for two river bank slope collapse (priority No.2 SC 470 Gaspar River Bank, priority No.3 Blumenau - AV. Pres Casrelo Branco) are conducted by considering river flow rate and advantage for environment preservation.

The flow rates are calculated by river cross section at the sites using height - quantities relation of river discharge at studied sites.

Table 7.2.8 Height - Quantities Relation of River Discharge at Studied Sites

Discharge (m ³ /s)	Priority No.2 SC 470 Gaspar River Bank	Priority No.3 Blumenau AV. Beira Rio	Remark
500	1.98	2.41	
1,000	3.01	3.94	
1,500	4.13	5.37	
2,000	5.28	6.71	
2,500	6.29	7.88	
3,000	7.25	8.92	
3,500	8.27	9.96	
3,700	8.58	10.30	Discharge return period 10 year
4,000	9.04	10.81	
5,000	10.44	12.36	
5,500	11.09	13.06	Discharge return period 50 year
6,000	11.74	13.77	

Source: JICA Survey Team

Flow rate is calculated as shown in Table 7.2.9. Compensating rate of both sites is adopted 1.0, because Priority No.2 SC 470 Gaspar site is straight river course, and Priority No.3 Blumenau AV. Pres Casrelo Branco is fixed bed of solid rock and the radius of the river is about 2km.

Table 7.2.9 Design Flow Rate

Site	Return Period or Max value	Design discharge (m ³ /s)	Section al area (m ²)	Flow rate (m/s)	Straight or Incurve	Bed condition	Compensatin g rate	Design flow rate (m/s)
Gaspar	50	5,500	3,543	1.55	Straight	Fixed	1.0	1.55
	Max	5,609	3,995	1.40	Straight	Fixed	1.0	1.40
Blumenau	50	5,500	2,069	2.65	Curve	Fixed	1.0	2.65
	Max	6,008	2,182	2.75	Curve	Fixed	1.0	2.75

Source: JICA Survey Team

Experimentally applicable condition of revetment types for slope conditions shown in Table 7.2.10.

For priority No.2 SC 470 Gaspar River Bank, gabion revetment is applicable as shown in Table 7.2.11.

For priority No.3 Blumenau AV. Pres Casrelo Branco, revetment of connecting concrete blocks with cover soil and vegetation is applicable as shown in Table 7.2.12.

Table 7.2.10 Applicable Condition of River Revetment Types

River Revetment Type		Experimentally applicable condition						The other condition
		Design Flow Rate (m/sec)						
		2	3	4	5	6	7	
Vegetation	Sodding							Area for higher than ordinary water level
Sheet	Geotextile							Without area for gravels/cobbles sediments. Without water impact part.
	Block matt							
Wood material	Log crib works							Without area for gravels/cobbles sediment. Area where lower than ordinary ground level of area protected by levee
	Brushwood crib works							
	Woodpile fence							
Stone material	Dry stone pitching (without mortar)							In case of stone material is available near the site. Area where lower than ordinary ground level of area protected by levee
	Wet stone pitching (with mortar)							
Gabion	Wirer-cylinder							Without area for gravels/cobbles sediment. Area where lower than ordinary ground level of area protected by levee
	Flat gabion placing							
Concert material	Connecting concrete blocks							It is applicable at area of gravels/cobbles sediment
	Concert block pitching							

Legend

Applicable range

Applicable, but more low cost alternative is applicable.

Source: JICA Survey Team referring web-page of Ministry of Land Transportation and Infrastructure ,Japan

Table 7.2.11 Selection Result for Priority No.2 SC 470 Gaspar River Bank

Type of Revetment		Adaptabilitas
Vegetation	Sodding	NOT applicable.
Sheet	Geotextile	The site is broken portion by 60 year heavy rain. Local rapid flow rate might be occurred.
	Block matt	
Wood material	Log crib works	NOT applicable. Wood materials will be deteriorated in 10 years.
	Brushwood crib works	
	Woodpile fence	
Stone material t	Dry stone pitching (without mortar)	NOT applicable. It is difficult to stable cover soil as vegetation base.
	Wet stone pitching (with mortar)	
Gabion	Wirer-cylinder	Applicable. It is good landscape harmony with both side of stream by using cover soil.
	Flat gabion placing	
Concrete	Connecting concrete blocks	Applicable and Not Advantage in cost.
	Concert block pitching	NOT applicable. It is require the special type block material for stable soil covering as vegetation base

Source: JICA Survey Team

Table 7.2.12 Selection Result for Priority No.3 Blumenau AV. Pres Casrelo Branco

Type of Revetment		Adaptabilitas
Vegetation	Sodding	NOT applicable. It is NOT stable against design flow rate.
Sheet	Geotextile	NOT applicable.
	Block matt	The site is beside the bridge pier and possibility of rapid flow rate.
Wood material	Log crib works	NOT applicable. Wood materials will be deteriorated in 10 years.
	Brushwood crib works	
	Woodpile fence	
Stone material	Dry stone pitching (without mortar)	NOT applicable. It is difficult that stable cover soil placing as vegetation base.
	Wet stone pitching (with mortar)	
Gabion	Wirer-cylinder	NOT applicable

	Flat gabion placing	It is not harmony with continuous landscape with upstream and down stream. The landscape of the site is important for Blumenau Municipality.
Concrete	Connecting concrete blocks	Applicable. It shall be adopted the type of connecting concrete block revetment which available soil as vegetation base.
	Concert block pitching	NOT applicable. It is not available stable soil covering as vegetation base

Source: JICA Survey Team

Table 7.2.13 Selected Measures for Valley Side Collapse

No. of priority order	Site	Height of slope	Average slope gradient Horizontal: Vertical	Design flow rate (m/sec)	Selected Measure
2	No.2 SC 470 Gaspar River Bank	30m	1: 0.7 35 degree	1.6	Gabion revetment, cover soil, vegetation
3	No.3 Blumenau AV. Pres Castelo Branco	8m	1:0.6 31 degree	2.8	Connecting concrete blocks revetment, cover soil, vegetation

Source: JICA Survey Team

7.2.5 Selection of Measures against Slide

(1) Factor of Safety of Sliding

Stability analysis is conducted for determination of the scale and quantity of structural measure to maintain the stability of the sliding slope by ensuring the design factor of safety.

The Swedish slice method is used for stability analysis of a landslide slope, as follows:

$$F_s = \frac{(\sum N - \sum U) \times \tan \phi + C \times \sum L}{\sum T}$$

Where,

N(kN/m) = Normal force along sliding surface by gravity of slice, $N = W \cos \alpha$

T(kN/m) = Tangential force along sliding surface by gravity of the slice, $T = W \sin \alpha$

α (°) = Angle of the base of the slice to the horizontal

U(kN/m) = Uplift due to pore pressure acting on sliding surface of the slice

L (m) = Length of sliding surface acting on the slice

C(kN/m²) = Cohesion of sliding surface

ϕ (°) = Internal friction angle of sliding surface

Table 7.2.14 Determination of Initial Factor of Safety (IFS)

Initial factor of safety	Movement conditions
IFS = 0.95	• A large number of obvious potential slide topography such as scarps, bulges, stepped land, ponds and swamps; and • Many visible ongoing and active movements of cracks, subsidence, upheaval, toe erosion, or small toe collapse as well as springs.
IFS = 0.98	• Obvious potential slide topography such as bulges, stepped land, ponds and swamps, but • Few or small ongoing movements of cracks, subsidence, upheaval, or small toe collapse.
IFS = 1.00	• Potential slide area is at rest, and • Cracks, subsidence, upheaval, or small toe collapse are visible, but not progressing.

Source: Modification from MANUAL FOR RIVER WORKS IN JAPAN, Published by River Bureau, Ministry of Construction Japan, November 1997

The design factor of safety (DFS) is the target value for enhancing the slope stability by structural measures as shown in Table 7.2.15.

Table 7.2.15 Determination of Design Factor of Safety (DFS)

Design factor of safety	Condition
DFS = 1.10 to 1.20	- Sudden and severe movement is expected; and - Slide prone cause significant damage to, houses, buildings infrastructures, and/or human lives.
DFS = 1.05 to 1.10	- A slide have little effect on houses, buildings or infrastructures; or - The proposed prevention works are temporary countermeasures.

Source: Modification from MANUAL FOR RIVER WORKS IN JAPAN, Published by River Bureau, Ministry of Construction Japan, November 1997.

The design factor of safety indicates multiplication ratio to the initial factor of safety IFS after completion of structural measures.

The slide slopes of this feasibility study, and initial/target factor of safety are determined in accordance with Table 7.2.14 and Table 7.2.15, and shown in Table 7.2.16.

Table 7.2.16 Object Slopes against Slide and Initial/Target Factor of Safety

Priority No.	Site	Initial factor of safety (IFS)	Design factor of safety (DFS)
1	SC 302 Taio-Passo Manso-5	1.00	1.15
4	SC418 Blumenau – Pomerode	1.00	1.15
6	Gaspar - Luiz Alves, Gaspar 9	1.00	1.15
9	SC477 Benedito Novo - Doutor Pedrinho 1	1.00	1.15

Source: JICA Survey Team

(2) Selection of Structural Measure Types

Table 7.2.17 shows the general structural measures for slides. The structural measure types are selected by flow as shown in Figure 7.2.1.

The selected structural measures for 4 slides sites are shown in Table 7.2.18.

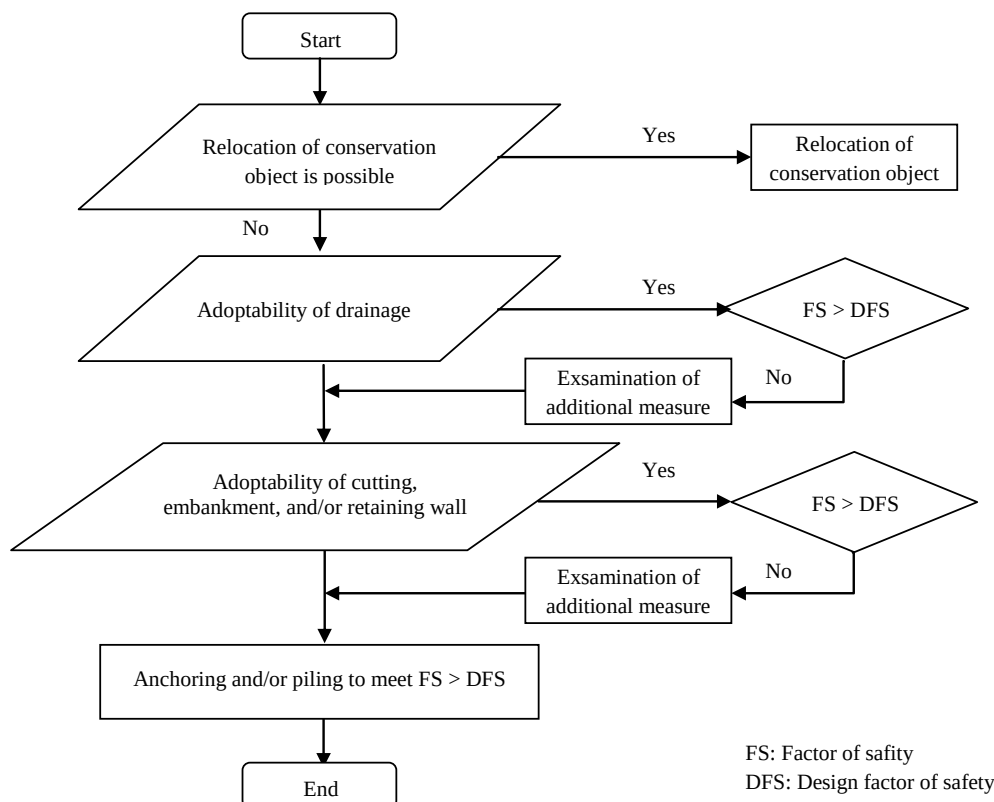
The effects of groundwater level lowering by installation of drainage are set experimentally as shown in Table 7.2.19.

For the site of the priority No. 9 SC477 Benedito Novo - Doutor Pedrinho 1, groundwater drainage is not appropriate; because groundwater table is initially low. Light weight embankment by EPS (Expanded polystyrene) is appropriate for the site condition of deep foundation rock and low groundwater.

Table 7.2.17 General Structural Measures for Slides

Classification	Type of Structural Measure
1. Drainage	Surface Drainage
	Open ditch
	Closed conduit with open ditch
	Underground Drainage
	Horizontal drainage drilling
2. Cutting and Embankment	Drainage wells
	Drainage tunnels
	Cutting of slide head
	Embankment of slide foot
3. Retaining wall	Light weight embankment of slide head
	Gabion walls
4. Anchoring	Retaining walls
	Rock bolts
5. Piling	Ground anchors
	Steel pipe piles
	Shaft work

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.2.1 Flowchart of Selection of Structural Measures for Slide

Table 7.2.18 List of Structural Measures and Result of Stability Analysis

No. of priority order	Site	IFS: Initial factor of Safety	DFS: Design factor of safety	Safety factor after groundwater drainage or light weight embankment	Measure
1	SC 302 Taio-Passo Manso-5	1.00	1.15	1.14 by 1.0 m lowering of groundwater table. 1.20 by 1.5 m lowering of groundwater table.	Horizontal drainage drilling Gabion retaining wall
4	SC418 Blumenau - Pomerode	1.00	1.15	1.15 by 0.5 m lowering of groundwater table.	Closed conduit with open ditch, Gabion retaining wall
6	Gaspar - Luiz Alves, Gaspar 9	1.00	1.15	1.150 by 1.0 m lowering of groundwater table.	Horizontal drainage drilling Gabion retaining wall
9	SC477 Benedito Novo - Doutor Pedrinho 1	1.00	1.15	1.15 by lightweight embankment.	Lightweight embankment

Source: JICA Survey Team

Table 7.1.19 Effects of Groundwater Level Lowering by Installation of Drainage

Type of Work	Lowering of groundwater table
Closed conduit with open ditch	-0.5m
Horizontal drainage drilling	From -1.0 to -1.5m

Source: JICA Survey Team

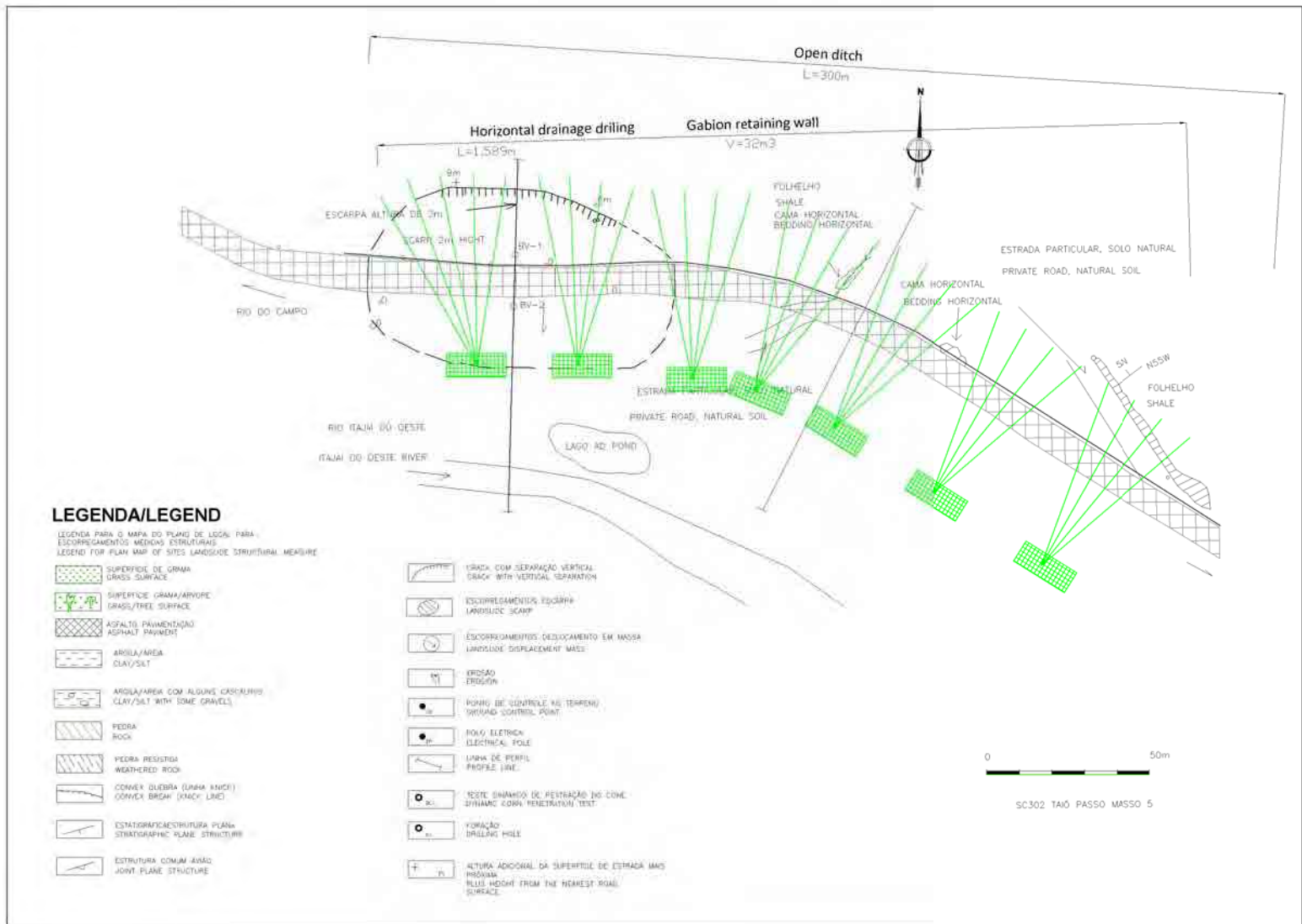
7.3 Feasibility Design on Structural Measures for the Selected Site

The work quantities of structural measures are summarized in Table 7.3.1. Layout of the structural measures of priority No.1 Taio-Passo Manso is shown in Figure 7.3.1 and 7.3.2.

Table 7.3.1 Work Quantities of Structural Measures

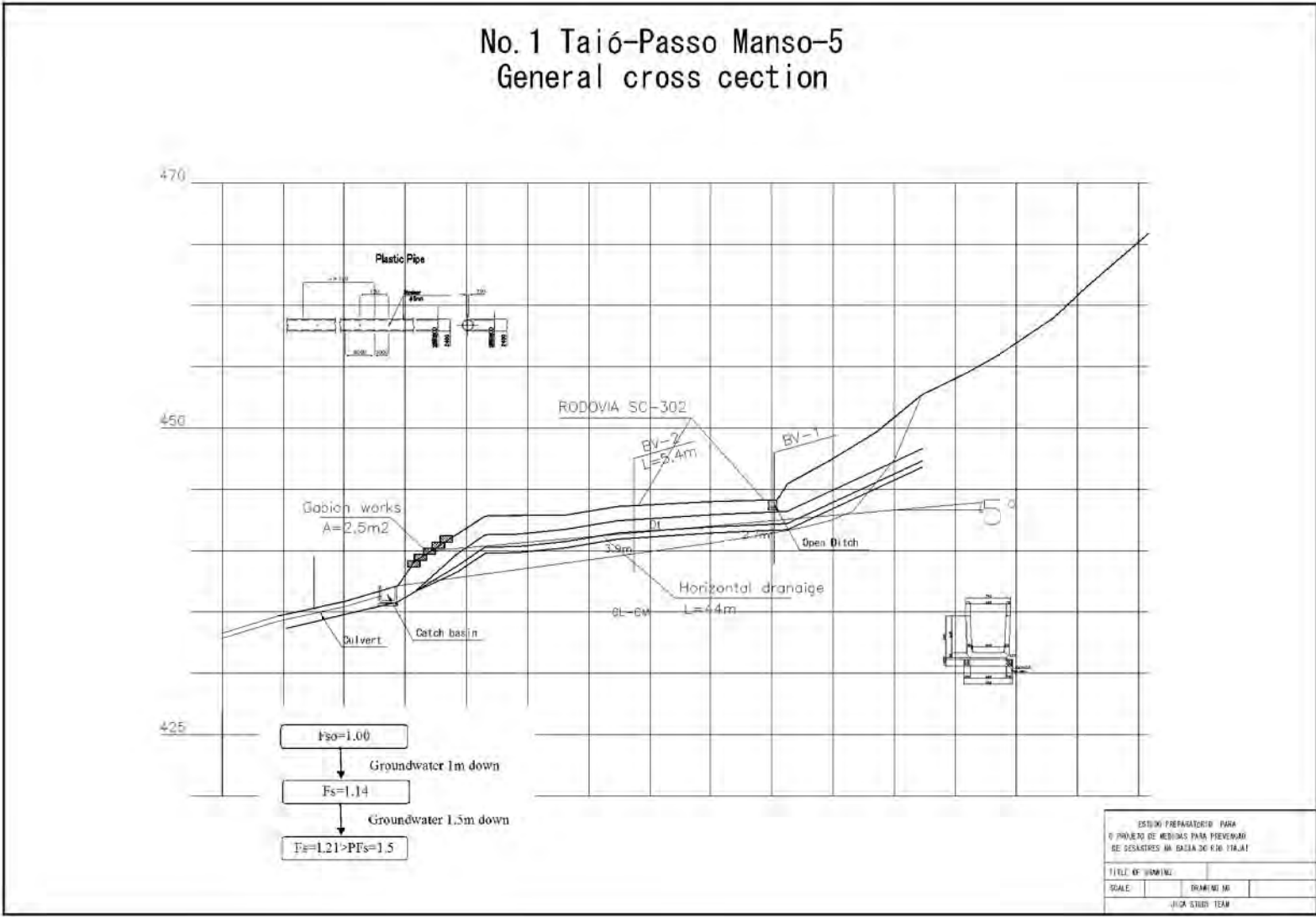
No. of priority order	Site name	Type of countermeasure	Unit	Quantities
1	SC 302 Taio-Passo Manso-5	Horizontal Drainage drilling	m	1,589
		Gabion retaining wall	m ³	32
		Open ditch	m	300
		Land acquisition (rural area)	m ²	7,000
2	SC470 Gaspar River Bank	Cutting, excavation	m ³	16,660
		Embankment	m ³	16,660
		Pavement	m ²	700
		Gabion retaining wall	m ³	2,000
		Nursery planting	m ²	3,400
		Concrete culvert pipe placing	M	27
3	Blumenau – Av Pres Castelo Branco	Sheet pile	m ²	598
		Connecting concrete block	m ²	4,852
		Geotextile	m ²	4,852
		Cutting	m ³	150
		Sodding	m ²	4,852
4	SC418 Blumenau – Pomerode	Closed conduit with open ditch	m	373
		Gabion retaining wall	m ³	238
		Open ditch	m	95
		Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m ²	3,112
5	SC474 Blumenau-Massara nduba 2	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m ²	6,986
6	Gaspar - Luiz Alves, Gaspar 9	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m ²	5,560
		Gabion open ditch	m ³	572
		Waterproof sheet	m ²	312
		Open ditch	m	282
		Horizontal Drainage drilling	m	160
		Gabion retaining wall	m ³	100
		Nursery planting	m ²	14,952
		Land acquisition (rural area)	m ²	14,629
7	Gaspar - Luiz Alves, Luiz Alves 6	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m ²	2,662
		Open ditch	m	240
8	SC470 Gaspar Bypass	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m ²	5,151
		Open ditch	m	182
9	SC477 Benedito Novo - Doutor Pedrinho 1	Lightweight embankment by EPS(Expanded polystyrene)	m ³	1,930
		Cutting, excavation	m ³	1,930
		Open ditch	m	234
		Pavement	m ²	863
		Temporary Scaffold	m ³	450
		Land acquisition (rural)	m ²	500
10	SC418 Pomerode – Jaragua do Sul 1	Gabion retaining wall	m ³	764
		Embankment	m ³	10,216
		Nursery planting	m ²	5,930
		Pavement	m ²	404
		Open ditch	m	340
		Land acquisition (rural)	m ²	6,713
11	Gaspar - Luiz Alves, Luiz Alves 4	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m ²	6,930
		Open ditch	m	260
12	SC474 Blumenau-Massara nduba 1	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m ²	967
13	SC 302 Taio-Passo Manso 4	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m ²	2,182
		Open ditch	m	82

Source: JICA Survey Team



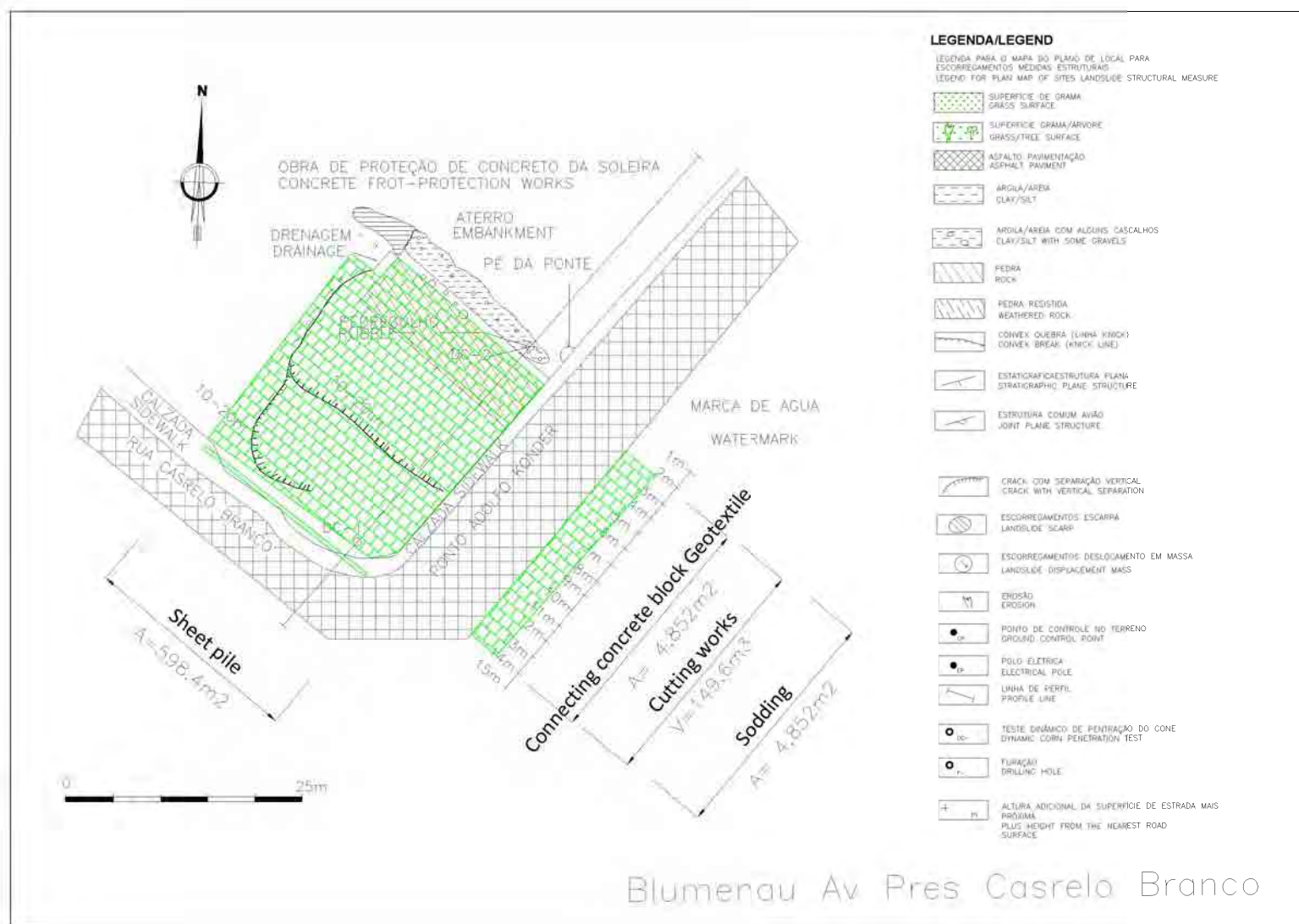
Source: JICA Survey

Figure 7.3.1 Plan Layout of Structural Measure for Priority No.1 Landslide SC 302 Taio-Passo Manso-5



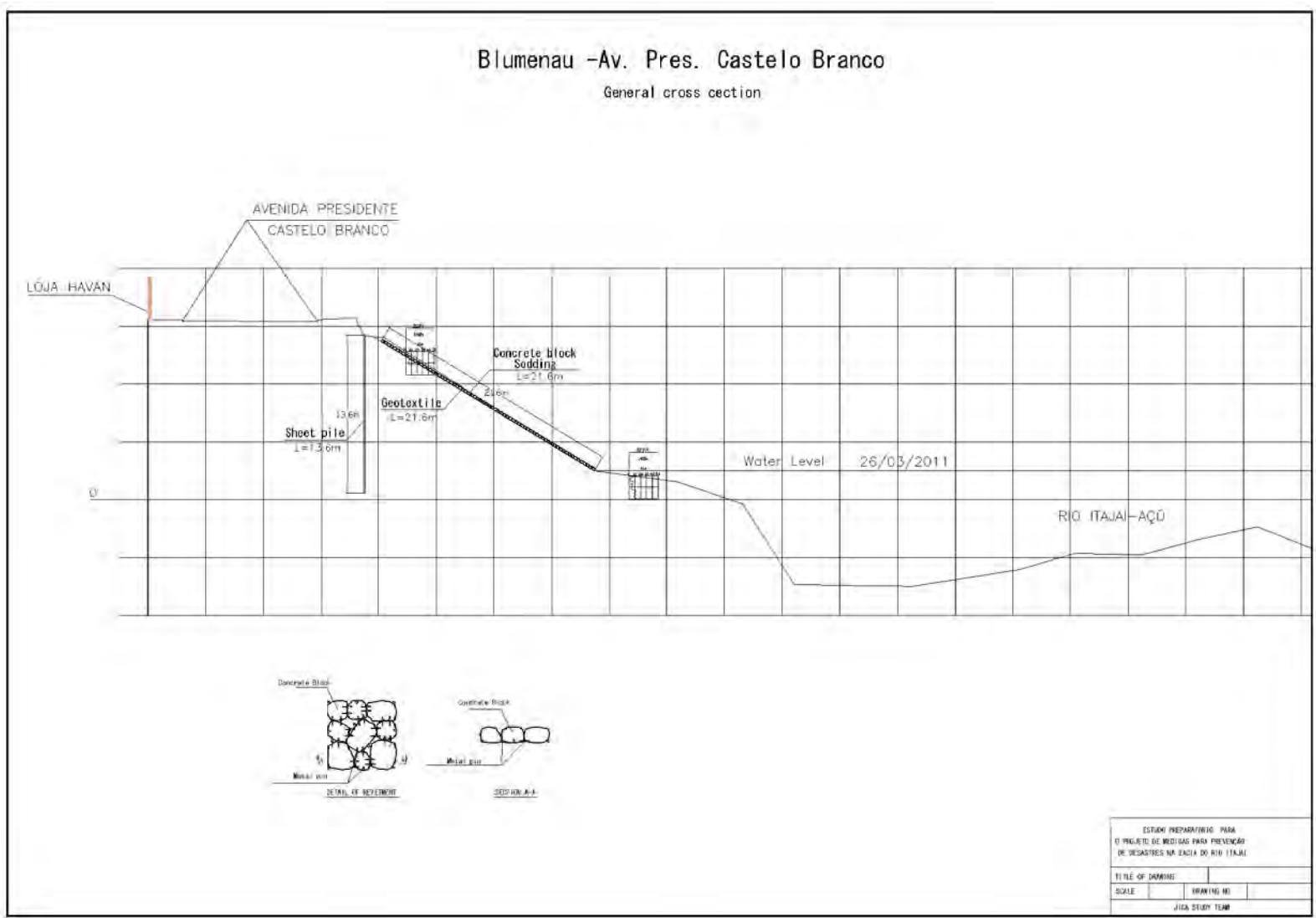
Source: JICA

Figure 7.3.2 Profile Layout of Structural Measure for Priority No.1 Landslide SC 302 Taio-Passo Manso-5



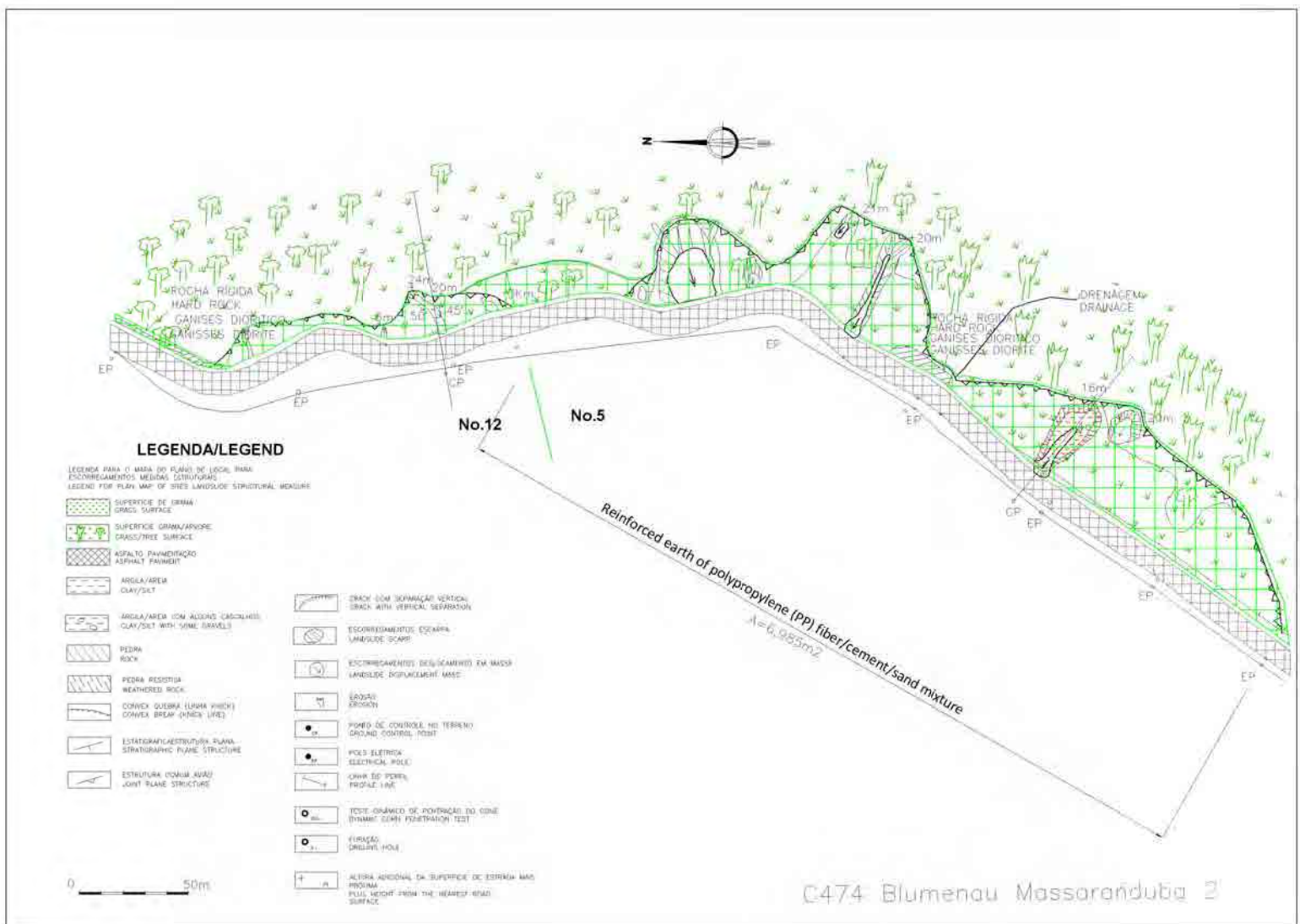
Source: JICA Survey

Figure 7.3.3 Plan Layout of Structural Measure for Priority No.3 Blumenau –Av Pres Casrela Branco



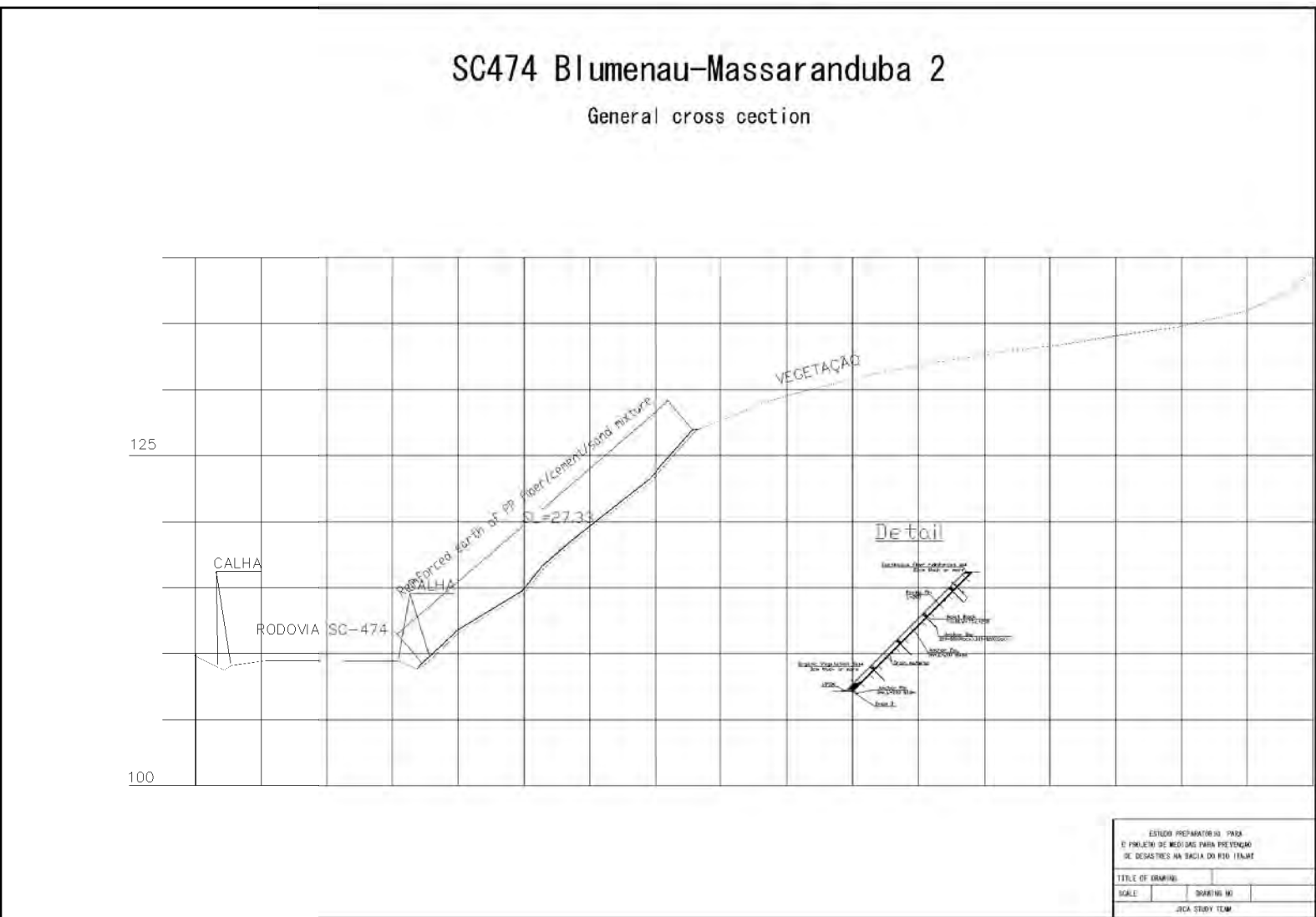
Source: JICA

Figure 7.3.4 Profile Layout of Structural Measure for Priority No.3 Blumenau -Av Pres Casrelo Branco



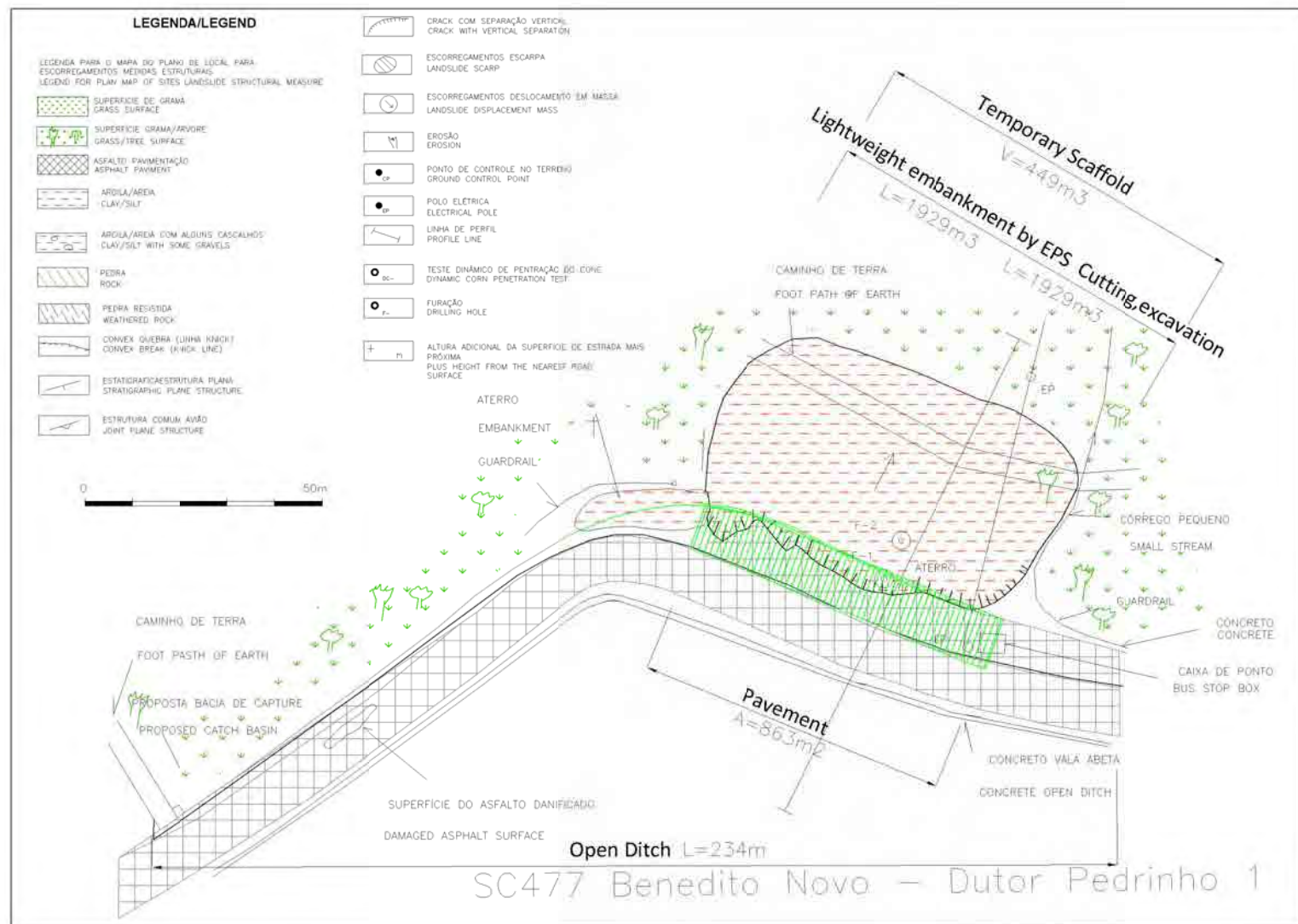
Source: JICA Survey

Figure 7.3.5 Plan Layout of Structural Measure for Priority No.5 SC474 Blumenau-Massaranduba 2



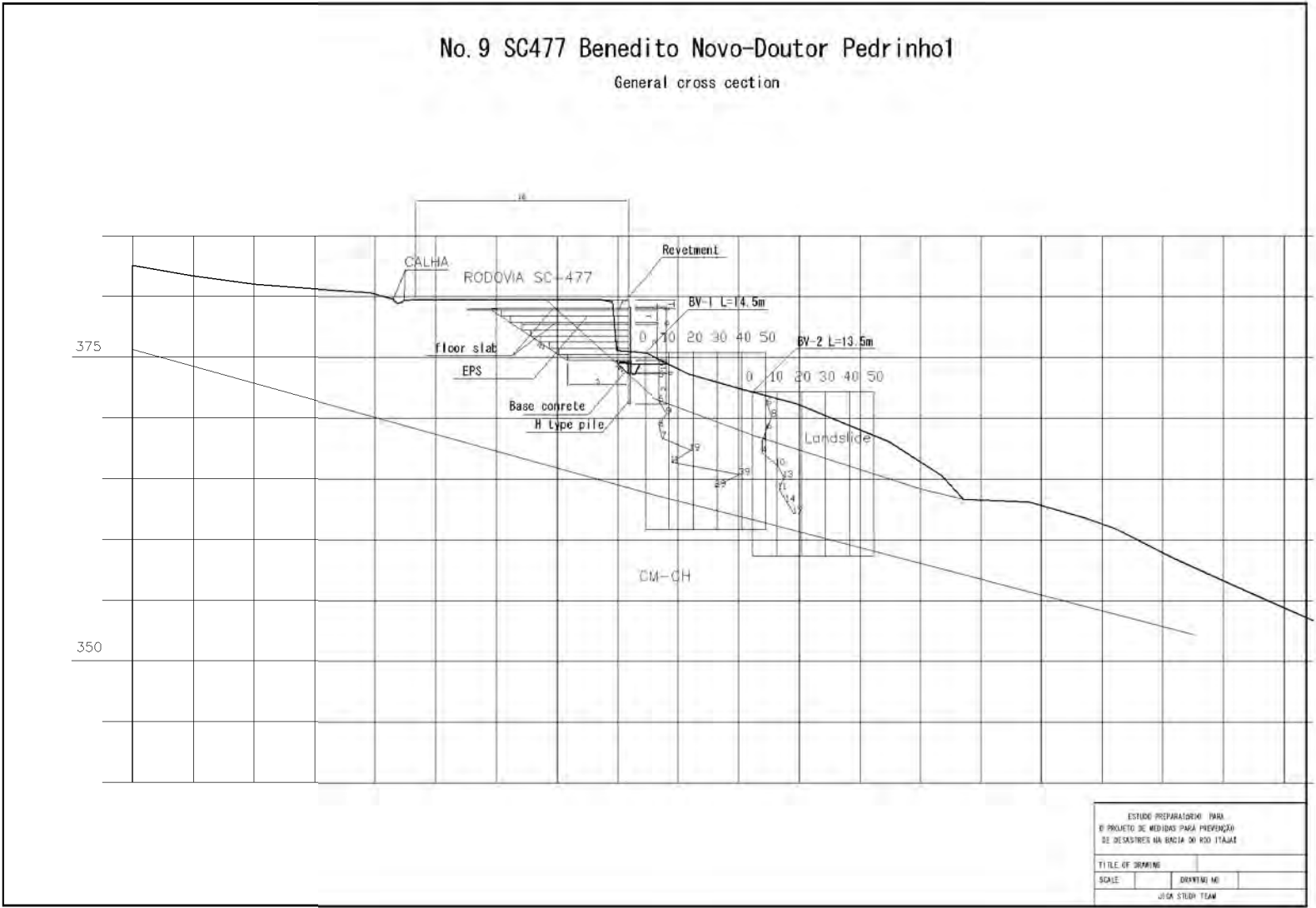
Source: JICA Survey

Figure 7.3.6 Profile Layout of Structural Measure for Priority No.5 SC474 Blumenau-Massaranduba 2



Source: JICA Survey

Figure 7.3.7 Plan Layout of Structural Measure for Priority No.9 SC477 Benedito Novo - Dutor Pedrinho 1



Source: JICA

Figure 7.3.8 Profile Layout of Structural Measure for Priority No.9 SC477 Benedito Novo - Doutor Pedrinho 1

CHAPTER 8 FEASIBILITY STUDY OF EARLY WARNING SYSTEM FOR LANDSLIDE AND FLASH FLOOD

8.1 General

The effectiveness and sustainability of the early warning system for landslide/flash flood are studied regarding following items.

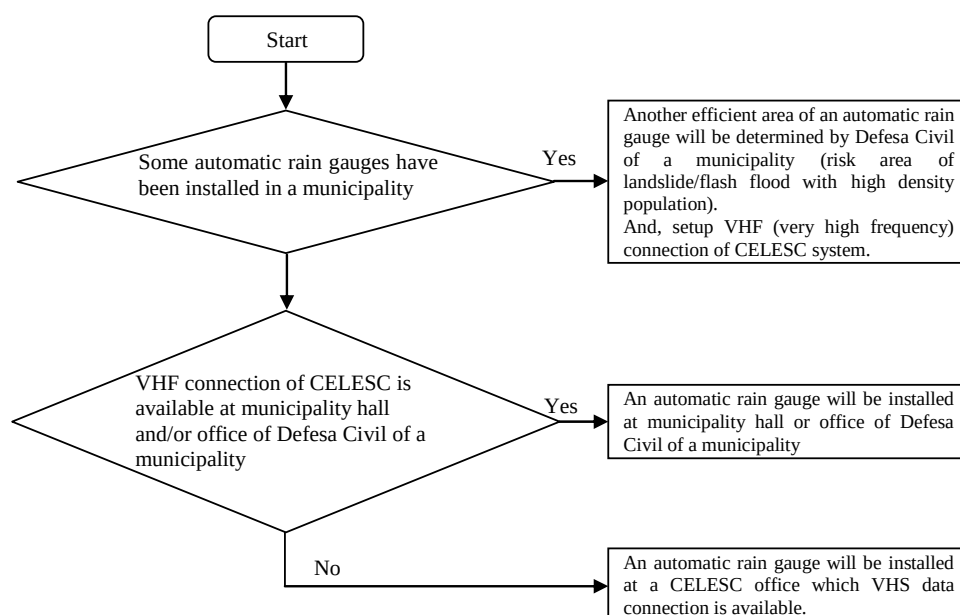
- Rainfall monitoring and data communication/repository
- Criteria of rainfall index for attention/alert
- Management of information, calculation of rainfall index, issue/announce of attention/alert
- Evacuation order and disaster education
- Road traffic regulation for risk avoidance

8.2 Rainfall Monitoring, Data Communication, and Repository

An automatic rain gauge will be installed in each municipality (293 municipalities in Santa Catarina State) for the early warning purpose.

Defesa Civil-SC is a responsible organization for establishment and maintenance of automatic rain gauges and equipments for data communication/repository. EPAGRI/CIRAM and each municipality are implementation organization for the rainfall monitoring, data communication and repository.

Location of automatic rain gauge will be determined by following procedure. Redundant data communication will be established by both of VHS (very high frequency connection) of CELESC system and GPRS (general packet radio services) to secure information communication even under stormy condition.



Source: JICA Survey Team

Figure 8.2.1 Flowchart to Determination Location of Automatic Rain Gauges

8.3 Criteria of Rainfall Index for Attention/Alarm

Criteria of rainfall index for attention/alert will be set by Defesa Civil-SC by support of EPAGRI/CIRAM.

It is not available landslide/flash flood database with exact time and location of occurrence. The rainfall monitoring stations are sparse, so locations of landslide/flash flood are mostly more than 10 km distance.

Therefore the appropriate criteria setting by the following indexes are not possible so far, it shall be conducted when exact disaster database is furnished.

Accuracy on prediction of disaster occurrence:

$$\text{Correct_Prediction_Index} = \frac{\text{Number_of_disasters_over_the_warning_criterion_value}}{\text{Total_number_of_disasters}} (\%)$$

Efficiency on prediction of disaster occurrence:

$$\text{Efficiency Index} = \frac{\text{Total hours for early warning}}{\text{Number of disasters over the warning criterion value}} (\text{Hours} / \text{Numbers of disasters})$$

The soil water index (SWI) is used for landslide early warning criteria in Japan as described in the section 9.2.3 of Main Report Part 1 Master Plan.

The Japan methodological agency analyzed that 93 % of fatality due to landslide was caused by most big SWI in past 10 years. The analysis was conducted by 53 thousand landslides data from 2001 to 2009. In case of the storm in November 2011 in the Itajai River basin, the fatalities were occurred only in area of SWI was more than 20 years return period. Therefore, the SWI of 10 years return period is appropriate for alert criteria as the initial setting.

The rainfall index criteria for attention are appropriate to be set once a year level. The purpose of the attention is preparation for alert level storm, reorganization of the warning system by inhabitants, checking of functions of the warning system, and training opportunity for risk avoidance activities.

8.4 Management of Information, Calculation of Rainfall Index, Issue/Announce of Attention/Alarm

Defesa Civil-SC is responsible organization for management of information, calculation of rainfall index, issue of attention/alarm.

The attention and alert are issued by Defesa Civil-SC formally. Because, the early information for the public is important, Defesa Civil-SC delegates EPAGRI/CIRAM the announcement of the rainfall level of attention/warning by web-page and/or mass media, as a part of routine or emergency weather report. The computer system of the early warning shall be included the function of automatic sending electronic mail to Defesa Civil-SC, mayor/defesa civil staff of each municipality, and EPAGRI/CIRAM staffs in charge.

8.5 Evacuation Order and Disaster Education

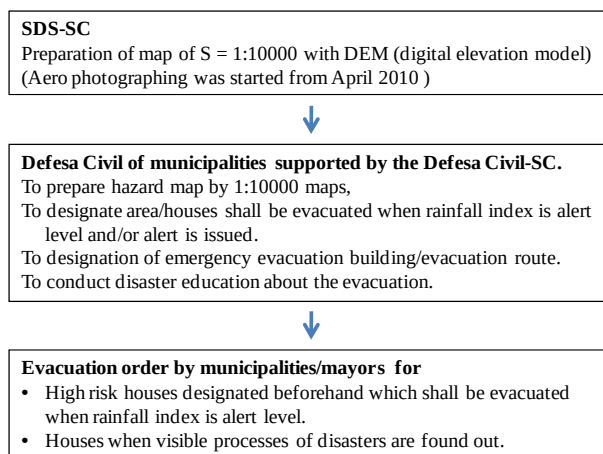
Municipalities/mayors are responsible official for evacuation order. Evacuation will be ordered for risk houses designated which shall be evacuated when rainfall index is alert level. The evacuation will be also ordered if visible processes of disasters are found out.

The Defesa Civil of municipalities will prepare the detailed hazard map (S=1:10000), and will designate the risk areas/houses, emergency evacuation building such as schools and/or churches, evacuation route. The disaster education about the evacuation will be also conducted. Santa Catarina State shall clarify the responsibility of the municipalities/mayors about evacuation order in a law.

The capacity of a municipality is not enough for the evacuation order generally. The Defesa Civil-SC shall coordinate the support of the municipalities, using human resources of universities, engineer of public/private, and/or international technical assistance. The early

warning system shall be started as soon as possible. And then, the risk areas/houses which shall be evacuated would be designated one by one by the maximum effort of municipalities to make mature the early warning system.

The summary of evacuation order and disaster education is shown in Figure 8.5.1.



Source: JICA Survey Team

Figure 8.5.1 Evacuation Order and Disaster Education

8.6 Road Traffic Regulation for Risk Avoidance

The structural measures for landslide will be conducted from high risk (big potential annual loss) slopes. But, there are many landslide/flash flood prone road sections mostly on low traffic volume mountainous road. The potential annual losses of road slopes on low traffic volume are generally not high and not prioritized even they are disaster-prone. Therefore it is required that the road traffic regulation for risk avoidance on disaster prone road segments.

Traffic regulation will be ordered to disaster prone road section designated when rainfall index is alert level. The traffic regulation will be ordered when disaster process associate with landslide/flash flood is found out. The disaster prone road sections would be designated one by one by the maximum effort to make mature the early warning system. After the completion of the structural measures, the designations of disaster prone road sections for early warning will be removed.

Municipality is responsible for municipality roads; DEINFRA is responsible for state roads for the road traffic regulation for risk avoidance. The capacity of a municipality is not enough for the traffic regulation order generally. The Defesa Civil-SC shall coordinate the support of the municipalities, using human resources of universities, engineer of public/private, and/or international technical assistance.

CHAPTER 9 ENVIRONMENTAL AND SOCIAL CONSIDERATION

9.1 Environmental and Social Consideration of Selected Projects

9.1.1 Introduction

The JICA Survey Team has held a series of meetings and public consultations with the relevant stakeholders in accordance with the JICA's Guidelines on Social and Environmental Consideration (2010) in the course of the master plan study. Comments and suggestions given by the stakeholders in the meetings were fully reviewed and examined in the preparation of the master plan. As a result, the JICA Survey Team adopted the disaster-prevention measures against the 50-year flood as the main framework of the master plan.

As described in Chapter 16 of this master plan, the Survey Team proposed the implementation of the master plan in a stage-wise implementation since the implementation of the entire disaster-prevention measures against the 50-year flood would require an enormous amount of money and take a long period of time until its completion.

To this end, the Survey Team evaluated and examined all the measures proposed in the master plan for prioritization. Among others, the Team put emphasis on whether or not a consensus on the implementation of the proposed measure among the stakeholders is easy to get in the evaluation, as the meetings with the stakeholders in the master plan study revealed that it would be difficult for them to accept the construction of a diversion channel for floodway and dykes along the river due to the likely impacts on the surrounding ecosystems and other natural environment. In fact, the Survey Team expected that the consensus building on the construction of those measures would not be easy and require a long-term process. As a result of the evaluation, the disaster-prevention measures against the 10-year flood were determined as the priority projects in the first phase.

The environmental and social considerations in this study were carried out with the following limitations:

- i) No interview survey on socio-economic conditions, such as land ownership, family structure, and household income, was made in the areas where the land acquisition might be required, as the information of the projects were not able to open during the study due to the uncertainty about the commencement of the projects. In fact, the study team did not disclose as much information as explained in the public hearings at the end of the master plan study.
- ii) The topographic maps on a scale of 1:10,000 were not available when the feasibility study was made although they were supposed to be ready to use during the study. Alternatively, the topographic map of 1:50,000 and the results of a topographic survey of river conducted in the feasibility study were used for the detailed study and designing. In addition to them, the topographic maps of Itajai City on a scale of 1:2,000 was available and also used for the study on the urbanized areas of Itajai City.

The feasibility study revealed that the existing roads of Itajai Mirim River was sufficiently high and not necessarily heightened as a disaster-prevention measure. Hence, the Survey Team judged that no resettlement or extensive land acquisition except the areas to be affected by the heightening of Oeste Dam would take place.

This chapter describes: i) the results of a review of the initial environmental examination (IEE) made in the master plan; ii) the draft terms of reference for an environmental impact study (EIA) that would be needed for implementation of the priority projects; iii) the results of environmental and social considerations of the priority projects; and iv) the environment-related legislation and necessary steps and surveys for acquisition of an environmental license in Brazil.

9.1.2 Review of Initial Environment Examination (IEE) in M/P Study

(1) Requirement for Environmental License

Since the catchment of Itajai river is located within the territory of SC state, FATMA in SC state is the responsible institution for examining environmental study reports and issuing an environmental license for the project. Therefore, the information on the environmental impact studies, especially crucial points in environmental and social assessments, were collected at FATMA in the study.

In SC state, an environmental assessment report to be submitted to FATMA varies with the extent of expected environmental impact. A proponent of a project shall submit one of the following reports based on the size, type and location of a project as described in Chapter 7 of the master plan study.

- Environmental Impact Assessment (EIA; Estudo de Impacto Ambiental)
- Simplified Environmental Study (EAS; Estudo Ambiental Simplificado)
- Previous Environmental Report (RAP; Relatório Ambiental Prévio)

As this project targets all the water sources in the whole catchment of Itajai river, FATMA is, therefore, obligated to submit an EIA report for a “macrodrainagem¹” project, which covers all the components proposed as the priority projects in the first phase.

(2) Review of IEE

The Survey Team reviewed the initial environmental examination (IEE) made in the master plan study using the maps and data additionally collected in the feasibility study. The focus of the review was put on the components proposed as the priority projects in the first phase. The following sections describe the results of the review and Table 9.1.1 shows the revised environmental screening and scoping of the priority projects in the first phase.

a. Water Storage in Paddy Fields

The environmental and social impacts caused by this component are expected to be negligible, as the component does not require any large-scale engineering work. The component will be implemented by CRAVIL when the topographic maps of 1/10,000 are completed and the implementable areas are determined. Having determined the target areas using the topographic maps, CRAVIL shall prepare an implementation plan and take the necessary procedures for the registration of the target areas as Legal Reserve (RL) areas according to the Forestry Law.

b. Heightening of Sul and Oeste Dams

The lands used for heightening Sul and Oeste dams and those that might be inundated in the operation phase were considered as the areas affected by this component. In the feasibility study, the progress of the land acquisition made by the Government of SC state and the proposed designs of the dams, which were not available in the master plan study, were able to be collected and, therefore, fully reviewed and analyzed to identify and determine the

¹ It is used as the term standing for the project including “integrated flood control” and “basin management”, although its literal meaning is “large-scale drainage.”

potentially-affected areas. As detailed in the following sections, the assessment revealed that all the areas to be affected by the heightening of Sul dam and those up to the height of the existing spill way of Oeste dam had already been acquired, although the results of the IEE in the master plan study indicated that land acquisition and involuntary resettlement might be the possible impacts caused by the heightening of both dams.

Figure 9.1.1 shows the potential water level of the dams with and without heightening of dam crests and the progress of the land acquisition that the Government of SC state has made so far.

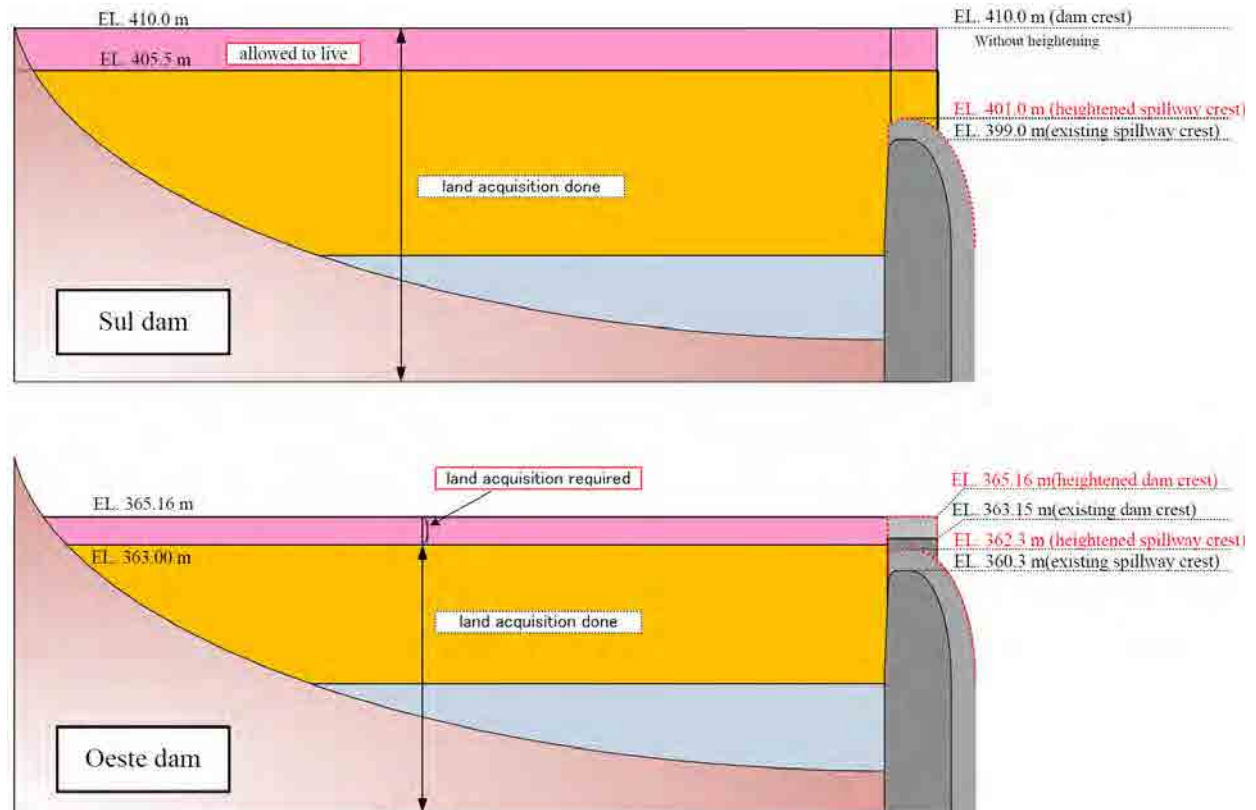


Figure 9.1.1 The Change of Altitude with Heightening and Existing Land Tenure

The heights of spillway of Sul dam will be heightened from 399.0 m to 401 m, but the dam crest will not be heightened. As the Government of SC has already acquired the potential inundation areas up to EL. 410.0 m, no further land acquisition will be required for this component. However, DNOS (former federal government who constructed Sul and Oeste Dam) has made an agreement with COOPERBASUL on the use of the lands extended from EL. 405.0 m to EL. 410.0 m elevation, which have been rarely inundated. As the agreement does not include a compensation clause on any damages caused by inundation, DNOS shall review and revise the current agreement with COOPERBASUL so as to ensure that COOPERBASUL could get compensation when such areas are inundated.

The dam and spillway crests of Oeste Dam will be heightened by 2 m, and therefore the heights of both crests will be EL. 365.16 m and EL. 362.3 m, respectively. Although Deinfra of SC state has already acquired the potential inundation areas up to 363.0 m, there is still a need to acquire the rest of the potential areas up to the height of the planned dam crest (EL. 365.16 m). In other word, the heightening of Oeste Dam is expected to affect households/communities residing in the potential inundation areas from 363.0 m to 365.16 m elevation.

An inventory of existing buildings (houses and barns) in the potential inundation areas of Oeste Dam was also carried out to assess the compensation cost for households who might be affected

by heightening its dam crest. The results of the simplified inventory are described in Section 9.2.1.

Besides, the heightening of Oeste dam might cause the adverse impact on the river environment (e.g., water quality, river bed, and riverine flora and fauna) since the engineering works will be done on the main body of the dam and need to divert the main stream of the Oeste river during the period of its construction works. On the other hand, no adverse impact on the river environment is predicted by the heightening of Sul dam, as the engineering works for Sul dam is to heighten the spillway by two meter and do not require any works on the mainstream of the river.

c. Utilization of CELESC' s Hydro-Electric Dams for Flood Control (Introduction of Pre-release method)

This is the measure taken by CELESC, which is the operation of Rio Bonito and Pinhal Dams in Rio dos cedros river, to mitigate the flood risk by the pre-lease of storage water in the dams when having a flood warning. An alert system needs to be installed to alarm households living in the downstream areas of both dams to cope with a potential flood risk after discharging the storage water from the dams. More details about the pre-release along with an early warning system are described in Chapters 4 and 6 in Part II of this report.

d. Installation of Floodgates in Intajai Mirim River

This measure aims to install two floodgates and one back water dyke in the old river canal of Itajai Mirim river as described in Chapter 5 in Part II of this report.

The places of the floodgates are located in the residential area, the construction work for the floodgates might cause a vibration and/or noise or increase trafic. The construction work might also cause turbid water in the river. However, these impacts would be negligible if the necessary mitigation measures for these impacts are to be taken by the contracotr in the construction phase. On the other hand, there is no impact predicted in the operation phase as long as the floodgates are operated properly.

As described in Chapter 5 in part II of this report, driving sheet pile walls on the right bank was proposed to secure the safety of households living by the river in addition to the floodgates, as such areas on the right bank are subject to flood damage especaiily by high tide and back water. The construction work associated with driving sheet pile walls is exected to generate noise and vibration in the surrounding areas, the contractor should arrange and allocate temporary accommodations for households living in such affected areas in advance.

e. Structural Measure for Landslide

This measure is to apply slope protection measures to the slopes along the national roads to prevent landslides/slope failures. As the construction work will cause the traffic hindrance by parking a large truck in the road or blocking off one of the lanes, the contractor needs to take safety measures, such as traffic control, during the construction.

f. Development of Flood Forecasting and Warning System (FFWS)

Since this measure does not include any structural works, no environmental impact is predicted in the construction phase. Furthermore, the system will not change the lifestyle or any socio-economic conditions of households living in the area but help them protect their lives from flood damage. Consequently, no social impact is predicted by the introduction of the flood forecasting and warning system (FFWS). It is however important to ensure that such a system can disseminate the information up to the vulnerable groups and to conduct an

emergency drill with the participation of those groups using the system, so as to minimize the risk of a flood.

g. Development of Landslide and Flush Flood Warning System

Likewise, this measure is not predicted to cause any environmental or social impact in both construction and operation phases since the measure does not include any structural work or cause any socio-economic change. As in the case of FFWS described above, what would be requisite for ensuring the effectiveness of the system are to disseminate the information to the vulnerable groups using the system and conduct sufficient emergency drills along with the system, so that the group could react properly when having a warning by the system.

Table 9.1.1 IEE Results of Selected Components

Flood Probability	Construction Phase	Socio-economic Impacts																				Pollution				Natural Environment									
	SOCIOECONOMIC IMPACTS, POLLUTION AND NATURAL ENVIRONMENT	Landscape	Global Issues: Greenhouse gas	Coastal area	Fauna and flora	Groundwater	Solid waste	Bottom sedimentation	Topography and geology	Offensive odor	Land subsidence	Noise and vibration	Soil contamination	Air pollution	Water pollution	Impacts of regional infrastructure (Transmission line, roads, bridges, etc.)	Impacts of land / buildings	Involuntary resettlement	Impact in downstream area	Impact of agriculture	Change of income, life condition	Traffic /interference of traffic during construction	Public health	Sanitation	Cultural heritages	Indigenous /traditional people	Water use	Effects /prejudice of low income people	Benefit to urban area vs. prejudice of rural area	Regional conflicts	Land use and occupation	Economic and Productive activities	Land acquisition	Expectation in local and regional people / Mobilization of NGO	
	PROPOSED MEASURES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin Storage Measures	Rain water storage in rice field	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Heightening of Oeste Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Heightening of Sul Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
River Improvement Measure	Preliminary discharge of CELESC hydro-electric dams	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Flood gate control installation in Itajai Mirim	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
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Others	Measures for landslide disaster	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Flood Forecasting and Warning System (FFWD)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
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Flood Probability	Construction Phase	Socio-economic Impacts																				Pollution				Natural Environment									
	SOCIOECONOMIC IMPACTS, POLLUTION AND NATURAL ENVIRONMENT	Landscape	Global Issues: Greenhouse gas	Coastal area	Fauna and flora	Groundwater	Solid waste	Bottom sedimentation	Topography and geology	Offensive odor	Land subsidence	Noise and vibration	Soil contamination	Air pollution	Water pollution	Impacts of regional infrastructure (Transmission line, roads, bridges, etc.)	Impacts of land / buildings	Involuntary resettlement	Impact in downstream area	Impact of agriculture	Change of income, life condition	Traffic /interference of traffic during construction	Public health	Sanitation	Cultural heritages	Indigenous /traditional people	Water use	Effects /prejudice of low income people	Benefit to urban areas vs. prejudice of rural area	Regional conflicts	Land use and occupation	Economic and Productive activities	Land acquisition	Expectation in local and regional people / Mobilization of NGO	
	PROPOSED MEASURES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin Storage Measures	Rain water storage in rice field	-	-	-	B+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Heightening of Oeste Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Heightening of Sul Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	
River Improvement Measure	Preliminary discharge of CELESC hydro-electric dams	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Flood gate control installation in Itajai Mirim	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
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Others	Measures for landslide disaster	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Flood Forecasting and Warning System (FFWD)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
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Note: A+: Big positive impact, A-: Big negative impact, B+: Medium positive impact, B-: Medium negative impact, C: Impact of measure is unknown, -: No impact .

Note: A+: Big positive impact, A-: Big negative impact, B+: Medium positive impact, B-: Medium negative impact, C: Impact of measure is unknown, -: No impact. .

9.1.3 Draft Outlines of TOR for EIA/RIMA Study

(1) Draft Contents of EIA required for the Environmental License

A draft TOR for EIA study on the flood management project in the Itajai river basin was prepared and shown as attached to this report. In the preparation of the draft TOR, the JICA Survey Team collected the existing TORs for the past EIA studies kept in FATMA in SC state. Although there was no EIA study made for a flood management or landslide disaster management project in SC state, those used for a basin management project in Minas Gerais state and an integrated port development project in SC state were referred for preparation of the draft TOR. The outlines of the draft TOR are shown below.

(2) Schedule of an EIA Study and Estimated Cost for the Study

An environmental impact assessment study is to be carried out by a consulting firm or consultants registered in the state. In general, an EIA study to be contracted out to a consulting firm/consultants encompasses: i) the preparation and finalization of TOR for the study; ii) the conduct of the study; iii) the preparation of environmental reports (RIMA report and report for public disclosure); and iv) the arrangement and organization of public audience. Hence, the TOR for an EIA study is to be first drafted by a consulting firm/consultants after it is officially selected. The draft TOR is to be reviewed, examined and approved by FATMA in the state within 45 - 60 days after its submission. An EIA Study shall be carried out in accordance with the approved TOR.

A tentative works schedule of an EIA study and estimated cost for the study are shown in Tables 9.1.2 and 9.1.3, respectively.

Table 9.1.2 Tentative Schedule of EIA/RIMA Study

Items	Months											
	1	2	3	4	5	6	7	8	9	10	(11*)	12
Preparation of TOR	○	○										
EIA Study		○	○	○	○	○	○	○	○			
Preparation of RIMA										○		
Public consultations												○

Note* : The duration from the preparation of RIMA to the public consultations varies with the environmental examination institutions in the respective states

Source : JICA Study Team

Table 9.1.3 Estimated Cost for EIA Study

Unit: R\$

Item	Unit Cost	Unit	Quantity	Contingency (20%)	Total
Preparation of TOR	6,880	MM	2	3,430	17,150
EIA Study	57,168	MM	3	114,336	571,680
Preparation of RIMA	36,587	L.S.	1	9,147	45,734
Public consultations	26,676.0	MM	1	6,644	33,220
Total					667,785

Source : ECSA, Engenharia Socioambiental S/S

9.2 Necessary Land Acquisition and Resettlement in Priority Projects

9.2.1 Results of Field Survey of Target Area for Dam Heightening

(1) Introduction

Oeste and Sul dams, which respectively are located in Taió city and Ituporanga city, are targeted for dam heightening. In the planning stage of the dam heightening, the state government as an implementing body shall acquire the areas, which will be potentially inundated or impounded by heightening dam crests of both dams, from land owners. Both dams are located in upper tributaries of Itajai River, Oeste dam in Itajaí do Oeste River and Sul dam in Itajaí do Sul River.

This section describes the results on the study on the potential social impacts caused by the dam heightening works and mitigation measures against potential impacts. Oeste and Sul dams both are flood control dams which usually have no strage water during the non-flooded period.

In Brazil, there are some existing Environmental Impact Assessment (EIA) studies for hydro-electric generation dam projects, while EIA for flood control dam² had not been made so far³.

The boundaries of the areas affected by the construction of Oeste and Sul dams were not ble to be determined due to lack of information, such as their design and completion drawings, as the construction works and resettlement was implemented more than 30 years ago. Accordingly, there had been no major complains made by the surrounding communities about land acquisition and dam operations of each dam site.

As described in Section 9.1.2, the heightening of dam is expected to affect the areas from the elevation of the existing dam crests to that of the heightened dam crests, especially for Oeste dam. In order to grasp the actual conditions of the affected area, the JICA Survey Team conducted a field survey composed of literature study and site reconnaissance as described below.

(2) Survey method

a) Literature study

During the literature study, the following information and data were obtained from Deinfra - SC, which is the responsible agency for operation and maintenance of Oeste and Sul dams.

- Base map of Sul Dam which shows the distribution and locations of areas to be acquired
- Engineering drawings of Sul Dam Body

² Since flood control dam does not form the inundation area, the dam storage area can be accessible by the communities during non-flooded period.

³ Environmental licensing system had not been established yet when Oeste and Sul dams were constructed.

- Base map of Oeste Dam which shows the distribution and locations of areas to be acquired
- Results of trial evaluation of land prices of the areas to be affected by heightening both dams
- Results of interviews to the responsible agency of dam operations and the agricultural unions

Deinfra – SC has limited data and information relevant to Oeste and Sul dams possibly due to the transfer of the responsibility for operation and maintenance of dams from DNOS to Deinfra - SC.

b) Site reconnaissance

Site reconnaissance survey in Oeste and Sul dams was conducted during April 15-17, and April 14-16, 2011, respectively with an aim to collect information required for development of a resettlement program with cost estimation. During the survey, the geographical data, such as latitude, longitude, and elevation of the houses and barns located in the affected area, were collected by using the receiver devices, TOPCOM GR-3 under Global Navigation Satellite System (GNSS).

(3) Results of the field survey

a) Current condition of the affected and surrounding areas of Sul Dam

As for the heightening of spillway of Sul Dam, which is one of the priority projects, the design flood water level was set as EL. 410.0m in consideration of the maximum water level of 10,000-year flood and freeboard in accordance with the official design standards of Brazil⁴.

According to the design drawings of Sul dam and information obtained from key informants in Deinfra - SC, land acquisition had been already completed up to EL. 410.0 m when existing dam was constructed. Heightening the spillway would not require further land acquisition in principle. However, the satellite images covering the affected area indicated that some buildings, such as houses and barns, were located below EL. 410.0 m. Hence, the site reconnaissance survey was conducted. During the site reconnaissance, due consideration was given to keeping the residents in the affected area from having the project information.

The survey revealed that six (6) buildings, four (4) houses with kiosk and two (2) log cabins, were located at between EL. 401.276 m and EL. 409.314 m.

Furthermore, the survey identified the present land use classes in the potentially affected areas under Sul dam as follows:

- | | |
|---|--------|
| - Paddy field (class I): | 10.0 % |
| - Onion farm (class III and IV): | 25.0 % |
| - Slope area (class V): | 5.0% |
| - Grassland (class VI and VII): | 35.0% |
| - Permanent Preservation Area (APP) (class VIII): | 25.0 % |

Details of the land use classification are shown in Section 9.3.4.

b) Current condition of the affected and surrounding area of Oeste Dam

Likewise, the design flood water level of Oeste dam was set as 365.0 m in consideration of the the maximum water level of 1,000-year flood and freeboard in accordance with the official

⁴ Critérios de Projeto Civil de Usinas Hidroelétricas”, October, 2003

design standards of Brazil. Consequently, heightening the existing dam by 2 m was proposed by raising the dam crest from EL. 363.15 m to EL. 365.16 m. Although the land acquisition was completed up to EL. 363.0 m when the existing dam was constructed, the rough estimation based on the topographic maps of 1:50,000 revealed that the additional 67 ha of lands still need to be acquired.

The present land use in the affected areas are classified as follows:

- Agricultural farm (class III): 10.0 %
- Agricultural farm for short-term crops (class IV): 25.0%
- Perennial crops planted area (class V): 30.0%
- Grassland (class VI): 20.0%
- Steep grassland (class VII): 5.0%
- Permanent Preservation Area APP (class VIII): 10.0 %

The site reconnaissance survey further found that there were two (2) wooden houses, three (3) wooden sheds and one (1) brick house with barn in the potential affected areas between EL. 361.988 m and 354.979 m (See Supporting Report F).

9.2.2 Necessary Measures to be taken for Minimizing the Possible Impacts by the Dam-heightening of Sul Dam

As mentioned in 9.2.1 (3), land acquisition was completed up to EL. 410.0 m by DNOS for construction of the existing dam. In 1981, an agreement on land use concession for the area between EL. 405.5 m and 410.0 m was concluded by DNOS and COOPERBASUL, which was a cooperative organized by the surrounding communities, to allow the members of COOPERBASUL to use the said area for animal husbandry. The contents of the said contract are shown in Supporting Report F.

Currently, Deinfra - SC, which the responsibility for operation and maintenance of the dam was given from DNOS, follows the said contract signed by DNOS without any revision and allows the members of COOPERBASUL to use the area based on the contract.

To date, there have been no serious trouble with COOPERBASUL and Deinfra - SC, despite the fact that the water storage level had sometimes reached to the maximum water level.⁵ The heightening of dam, which would increase the possibility of inundation in the concession area, might cause a negative impact on the use of the area, although its possibility is least-likely.

It is therefore recommended that Deinfra - SC discuss the possible negative impact with COOPERBASUL to amend the current agreement on the use of land concession area on this occasion.

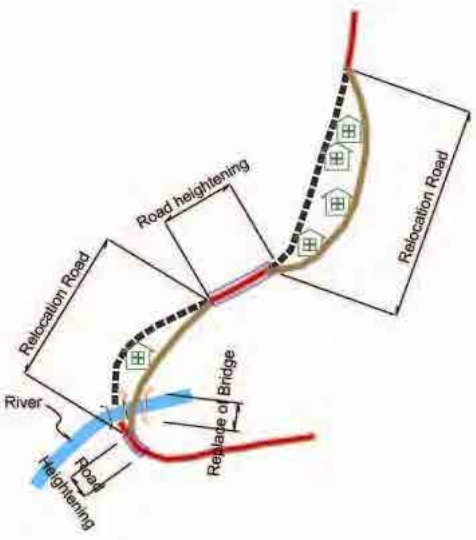
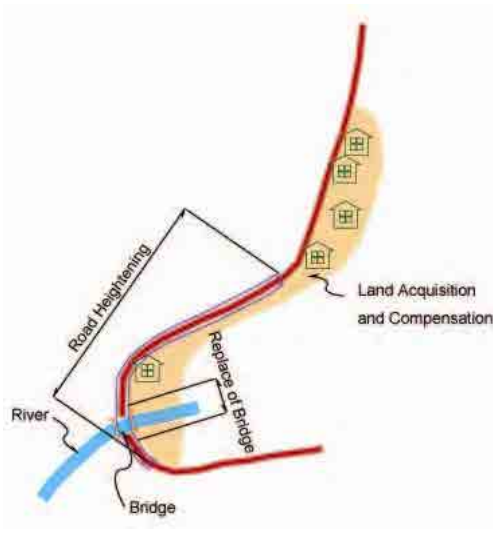
9.2.3 Mitigation Measures against the Possible Impacts Caused by the Heightening of Oeste Dam

As described in 9.2.1 (3), the heightening of Oeste Dam would require new land acquisition of 67 ha between EL. 363.0 m and EL. 365.16 m. The houses, sheds, some part of roads and bridges were located within the potential inundation areas as shown in Supporting Report F. With an aim to mitigate the possible negative impacts on the communities living in the possible inundation areas, JICA Survey Team proposes rerouting the existing roads and using them as dikes to protect the houses from being inundated.

⁵ Several overflows from the spillway of Sul dam were recorded by Deinfra-SC.

Table 9.2.1 shows the general features of two (2) alternative measures, one with road relocation and the other with resettlement of the communities, while Table 9.2.2 compares the estimated costs for both alternatives.

Table 9.2.1 General Features of Alternative Measures

	Alternative measure-1: with road relocation	Alternative measure-2: with resettlement
Chart		
General description	Some sections of roads and bridges shall be rerouted/relocated to protect existing buildings from being inundated by heightening the dam. Hence, the height of the rerouted roads and relocated bridges shall be higher than that of the heightened dam crest.	- The buildings located in the potential inundation areas shall be relocated. - Some sections of the roads and bridges, whose heights are lower than that of the heightened dam crest, shall be relocated
Merit	No resettlement of the communities	Less cost due to decrease of volume of construction works
Demerit	- Increase of construction cost due to road relocation - Reduction of inundation area due to installation of the road	Resettlement of houses/communities necessary
Project cost	R\$ 4,797,000 (100%)	R\$ 2,819,000 (58.8%)

Source: JICA survey team

Table 9.2.2 Cost Estimation

							(R\$)
			Alternative of Road relocation		Alternative of Compensation		Remarks
	unit	unit cost	quantity	amount	quantity	amount	
Replacement of Bridge	m2	3,000	160	480,000	80	240,000	
Relocation of Road	m	1,570	1,500	2,355,000	500	785,000	
Other works	%	30	---	851,000	---	308,000	Main works *30%
[1] Sub total (Construction cost)				3,686,000		1,333,000	
Land Acquisition	LS	966,000	1	966,000	1	966,000	
House Compensation	LS	326,000	---	---	1	326,000	3houses+3sheds
Price contingency for area delineation	%	15	---	145,000	---	194,000	
[2] Sub total (Land, Compensation)				1,111,000		1,486,000	
Total [1]+[2]				4,797,000		2,819,000	

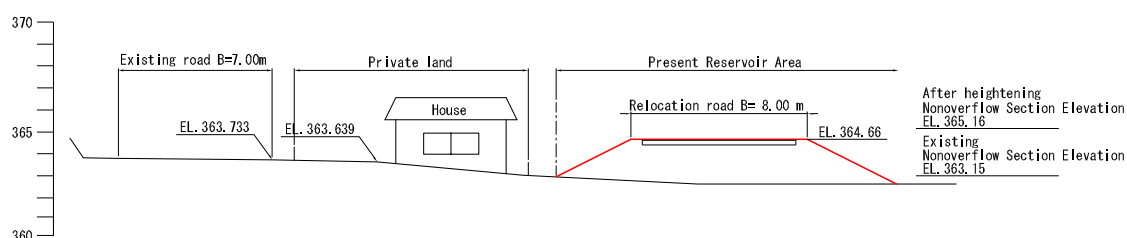
Source: JICA survey team

The cost breakdown for land acquisition and house compensation are also shown 9.2.3.

Table 9.2.3 Cost Breakdown for Land Acquisition and House Compensation

Land Acquisition	
7.0ha of Class III and 17.0ha of Class IV exploited with crops (R\$ 20,000.00/ha)	480,000.00
20.0ha of Class V of pasture (R\$ 15,000.00/ha)	300,000.00
13.0ha of Class VI and 3.0ha of Class VII with restrictions (R\$ 7,500.00/ha)	120,000.00
7.0ha of Class VIII of APP (R\$ 4,300.00/ha)	30,000.00
24.0ha permanent crops (R\$ 1,500.00/ha)	36,000.00
Total	966,000.00
House Compensation	
Masonry house (100.0m ²), masonry wall (240.0m), wooden shed (90.0m ²).	165,000.00
Wooden shed (72.0 m ²)	28,000.00
Wooden shed (60.0 m ²)	23,000.00
Wooden house (60.0 m ²)	30,000.00
Wooden shed (96.0 m ²)	36,000.00
Wooden house (90.0 m ²)	44,000.00
Total	326,000.00
Reserve +15%	194,000.00
GENERAL TOTAL	1,486,000.00

Source: JICA survey team



Source: JICA survey team

Figure 9.2.1 Typical Section of Relocation Road

Conclusion

In Brazil, compensation for properties affected by public works has been generally conducted in accordance with the relevant laws and regulations, while administrative proceedings have been often taken against the process of resettlement due to lack of the relevant legislation. In fact, there have been many troubles and complaints caused by insufficient and improper support/arrangement in resettlement, such as i) relocation to remote areas and ii) limited opportunities for employment in relocated areas, especially for professions that the resettled people used to engage in.

Although the cost for the alternative measure-1 with road rerouting is 1.7 times higher than that for the alternative measure-2 with resettlement as shown in Table 9.2.2, JICA Survey Team recommends alternative measure-1 as a more reasonable and justifiable plan in order to avoid and minimize future negative impacts in line with the basic principles of JICA Guidelines for Environmental and Social Considerations.

9.2.4 Process of Resettlement Under Oeste Dam and the Proposed Resettlement Program

(1) Introduction

While the JICA Study Team recommends the relocation of road, the state government might possibly select the alternative measure-2 since the number of target families to be relocated is limited. If so, the preparation and submission of necessary plans, such as resettlement plan and monitoring plan, will be required.

The following sections further describe the processes of resettlement and compensation.

(2) Resettlement process

a) Type of applicable compensation measures

The resettlement program aims to secure the livelihoods of the resettled families/people providing necessary support to restore their livelihoods but not to alter their cultural features.

According to the general process of resettlement in the country described in Section 9.3.3, JICA Survey Team proposes the following options as compensation measures for properties to be affected by the heightening of Oeste dam. Nevertheless, the amount of compensation for losses shall be valued in accordance with World Bank Operation Manual (OP) 4.12, Annex A- Involuntary Resettlement Instruments (WB OP 4.12, Annex A)⁶ as stipulated in JICA Guidelines for Environmental and Social Consideration (2010).

1) Compensation for assets

Value of existing buildings and lands shall be appraised to determine the amount to be paid in cash to the affected families in accordance with the process described in Section 9.3.3. In valuation, it is important to estimate the compensation in accordance with WB OP 4.12, Annex A as described above.

2) Individual resettlement (Commitment Letter, CC)

The target public is responsible for searching and selecting the land and other properties equivalent to those they originally owned. If the implementing body judges that the properties selected by the target public meets the criteria set in the agreement between the implementing body and the affected families, the implementing body shall purchase the selected properties.

3) Individual resettlement of special cases (CE)

In case the target public has some limitations/handicaps who need a special care or considerations in its families, special arrangements shall be made such as allocation of urban lots instead of rural ones (but the size of the lots should be lower than the affected one.).

b) Target public for resettlement

As for the heightening of Oeste dam, the following persons are expected to be the target public:

- the person who conducts economic activities in the affected area
- the person who lives in the affected area but has no legal property in the same
- the person who has his/her property/ies in the area remaining unused by heightening the dam
- the person who depends on the affected property/ies for his/her livelihood

⁶ Compensation for losses shall be valued by the replacement cost, which is defined below.

“For agricultural land, it is the pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes. For land in urban areas, it is the pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes. For houses and other structures, it is the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, plus the cost of any registration and transfer taxes. In determining the replacement cost, depreciation of the asset and the value of salvage materials are not taken into account, nor is the value of benefits to be derived from the project deducted from the valuation of an affected asset. Where domestic law does not meet the standard of compensation at full replacement cost, compensation under domestic law is supplemented by additional measures so as to meet the replacement cost standard.” (Source: World Bank OP 4.12, Annex-A)

c) Resettlement Process

1) Individual Resettlement

In the case of individual resettlement, the implementing body shall issue the Commitment Letter (CC) which shows the estimated cost of the affected properties so that the target public can have an idea on the amount of compensation.

Upon the issuance of CC, the target public shall search and select the properties, and inform the implementing body of the selected properties. The implementing body shall examine the appropriateness of the selected properties prior to the approval of its acquisition. Having validated the legitimacy and appropriateness of the properties, the implementing body will permit the acquisition/purchase of the property and sign on to the official document for purchase.

In the procedures of individual resettlement, the following points shall be considered.

- Size of lot acquired

The size of lot acquired will range from 3.0 ha to 17.0 ha depending on the family structure and its type based on CSE (See Section 9.3.3). In determination of the size of lot, due consideration shall be paid to the concept of “replacement cost” defined in WB OP 4.12 Annex-A.

- Buildings for acquisition

Likewise, the buildings in each lot shall be determined in consideration of the family structure and type of houses based on CSE (See Section 9.3.3). Likewise, WB OP 4.12 Annex-A shall be referred for estimation of compensation for losses.

- Option for the commitment letter

The target public can prepare its request in writing on the acquisition of properties. Once such a request is developed in writing, no revision is allowed.

- Technical assistance for recovery of livelihoods

The implementing body is responsible for provision of ad hoc technical and social assistance for the target public upon the acquisition of the new property/ies to restore its livelihoods.

- Mode of reimbursement

In case that the target public is non-owner of the affected area, reimbursement of the resettlement cost might be required. The implementing body and the target public will go into negotiations and determine whether or not the repayment is arranged. In case the repayment is required, the mode of reimbursement such as total or partial reimbursement, should also be discussed between the implementing body and the target public.

2) Special cases of individual resettlement (CE)

The special case of individual resettlement (CE) shall go through similar procedures and give similar considerations in the process of resettlement in principle. It is noted that the size of lot can be determined according to the features of the affected families.

The necessary considerations to be made in determining the size of lot are described below.

- Lots size for acquisition

Rural lots

Area remaining unused shall be preferably utilized for resettlement of the target public in the rural area.

The lower limit of the area of rural lots shall be eighteen (18) ha according to the Minimum Fraction of Parceling (FMP) as defined by the National Institute of Colonization and Agrarian Reform – INCRA.

Urban lots

The target public who selects urban area to reside shall have the right to acquire the minimum size of lot in accordance with the central and/or local government legislation.

- Mode of reimbursement

The target public, who is the owner, heir, or other claimants of the affected lands and properties, shall be exempted from any payments, except the transfer of the affected lands and properties to the implementing body as a payment.

If the value of the existing properties acquired exceeds the benefit which the target public can obtain from the resettlement, the balance shall be paid in cash to the target public.

9.3 Environmental Legislation, General Resettlement Program, and Monitoring Program in the Post-Resettlement in Brazil

9.3.1 Legislation relating to Compensation

The major legislation relating to environmental and social considerations in Brazil is presented in Section 7.2 in Part I of the master plan study.

The Constitution of the Federative Republic of Brazil in 1988 stipulates that any projects shall pay sufficient monetary compensation to people who own the areas affected by projects prior to its implementation. The same also stipulates that the compensation shall include the costs for the maintenance of the environmental quality, necessary environmental management works, and land acquisition for reforestation in permanent preservation areas (APP).

A proponent of a project shall have the legal responsibility for land acquisition for implementation of a project. In a dam construction project, the implementing body of the government shall be responsible for acquiring the construction sites following the proper process of land acquisition. In case the implementing body and the affected families/people can not reach an amicable agreement on land acquisition, the implementing body shall take the necessary legal measures for compulsory land acquisition.

In Brazil, various laws and regulations relating to land acquisition and compensations have been enacted and implemented since the first regulation was enacted in 1821. The applicable laws and regulations, which are currently effective, are shown below.

- Constitution of the Federative Republic of Brazil, as of 05/10/88;
- Decree-Law No. 3,365, as of June 21, 1941, and as amended, and complementarily the Code of Civil Procedures (CPC);
- Federal Law No. 4,132, as of September 10, 1962;
- Brazilian Association of Technical Standards (ABNT), as of 2004, for appraisal of rural properties (NBR 14,653-3), and of urban properties (NBR 14,653-2).

It is noteworthy that there is no legislation or regulation specifying the procedures for resettlement, although the regulations and guidelines on estimation of compensation and compulsory land acquisition are already in place. Therefore, in most of the projects in the past, the framework for resettlement needed to be determined through negotiations with the affected families/people.

The following sections highlight the relevant points of the existing legislation on land acquisition in Brazil.

(1) Constitution of the Federative Republic of Brazil, 05/10/1988

The Constitution of the Federative Republic of Brazil of 1988, which was enacted on May 10, 1988, brought important innovations to the conditions of land acquisition. Clause 14 of Article 5 in the Constitution is summarized below.

Article 5: Everyone is equal before the law, with no distinction of any nature. The law shall ensure to the Brazilian people and foreign residents in the Country the inviolability of the rights to life, to freedom, to equality, to safety and to property, under the following terms.

Clause XIV: The law shall define the procedure for land acquisition for need or public interest, through a fair and previous compensation in cash, except for the cases provided for in this Constitution.

(2) Federal Decree-Law No. 3,365 dated June 21, 1941.

The Federal Decree-law No. 3,365, as of June 21, 1941, provides for land acquisition for public-interest purposes. This Decree-Law specifies the rules and process of the land acquisition in Brazil and also referred to by the Code of Civil Procedures in Article 271. On January 29, 1999, this Decree-Law was partially amended by Law No. 9,785.

(3) Federal Law No. 4,132 dated September 10, 1962

This Federal Law defines the procedures for land acquisition for public-interest purposes. It was amended by Law 6,513 in December 20, 1977 (art. 31).

(4) Others

Federal Decree No. 24,643 of July 10, 1934, amended by Federal Decree No. 35,851 on July 16, 1954, defines so-called the Code of Waters in item “b” of Article 151 as shown below.

Article 151 item b: to acquire private buildings, and in pre-existing authorizations, the goods, including private waters upon which the concession is granted, and the rights which might be necessary, according to the law regulating land acquisition for public interest, being responsible for the resettlement and payment of compensations.

The Brazilian Association of Technical Standards (ABNT) in 2004 defines the standards for asset appraisal, such as general procedures in NBR 14,653-1, standards for asset appraisal in urban areas in NBR 14,653-2, and the same in rural areas in NBR 14,653-3.

9.3.2 Comparison between JICA’s Guidelines on Environmental and Social Considerations and Relevant Legislation in Brazil

Table 9.3.1 shows a comparison between JICA’s guidelines on environmental and social considerations and relevant legislation in Brazil.

Table 9.3.1 Comparison between JICA's Guidelines on Environmental and Social Considerations and Relevant Legislation in Brazil

No.	Descriptions	Relevant Legislation in Brazil and their Summaries
1) JICA Guidelines for Environmental and Social Consideration		
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected.	Not available (or follow social convention / protocol)
2.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported by project proponents etc. in a timely manner.	Not available (or follow social convention / protocol)
3	Host countries must make efforts to enable people affected by projects and to improve their standard of living, income opportunities, and production levels, or at least to restore these to pre-project levels.	<u>Article 5 of Clause 24 in the Constitution of Brasil</u> The article stipulates the procedures for land acquisition with fair and advance monetary compensation in consideration of the public benefit and necessity. <u>Decree-Law No. 3365 (June 21, 1941)</u> This decree stipulates the rules on and processes of condemnation/expropriation for public projects as well as any other purposes for public interest. The decree defines that an owner of properties expropriated/acquired for public interest shall be compensated in cash.
T	Prior compensation, at full replacement cost, must be provided as much as possible.	<u>Article 5 of Clause 24 in the Constitution of Brasil</u> Same as above.
5.	For projects that will result in large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	<u>CONAMA Resolution No. 01 (as of Jan. 23, 1986)</u> The resolution stipulates that an EIA report shall be disclosed to the public and SEENV or the municipality government should hold the public hearings or consultation meetings on a project and its potential impact. <u>CONAMA Resolution No. 09 (as of Dec. 3, 1987)</u> The resolution defines the purpose of the public hearings/consultations, outlines of public hearings/consultations (e.g., timing, timeframe, frequency, and venues), responsible agency, and the necessity of documentation of the hearings/consultations.
6.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	<u>CONAMA Resolution No. 01 (as of Jan. 23, 1986)</u> Same as above. <u>CONAMA Resolution No. 09 (as of Dec. 3, 1987)</u> Same as above.
7.	Appropriate participation by affected people and their communities must be promoted in the planning, implementation, and monitoring of resettlement action plans and measures to prevent the loss of their means of livelihood.	Not available (or follow social convention / protocol)
8.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	<u>CONAMA Resolution No. 01 (as of Jan. 23, 1986)</u> Same as above. <u>CONAMA Resolution No. 09 (as of Dec. 3, 1987)</u> Same as above.
World Bank Safeguard Policy, OP 4.12 and OP 4.12, Annex A		
9.	Upon identification of the need for involuntary resettlement in a project, the borrower carries out a census to identify the persons who will be affected by the project, to determine who will be eligible for assistance, and to discourage inflow of people ineligible for assistance. (WB OP4.12 Para 6) The results of a census survey covers: (i) current occupants of the affected area; (ii) standard characteristics of displaced households; (iii) the magnitude of the expected loss; (iv) information on vulnerable groups or persons; and (v) provisions to update information on the displaced people's livelihoods and standard of living. (WB OP4.12 Annex A Para 6)	<u>Federal Decree No. 7342 (as of October 26, 2010)</u> This decree institutionalizes the registration of the losses of properties of the persons who will be affected by a dam construction project for hydroelectric generation. Types of losses to be registered and the organization (the inter-ministerial committee) to administer the registration are defined in the decree.

No.	Descriptions	Relevant Legislation in Brazil and their Summaries
10.	Displaced persons may be classified in one of the following three groups: (a) those who have formal legal rights to land; (b) those who do not have formal legal rights to land at the time the census begins but have a claim to such land or assets-provided that such claims are recognized under the laws of the country or become recognized through a process identified in the resettlement plan; and (c) those who have no recognizable legal right or claim to the land they are occupying. (WB OP4.12 Para 15)	Not available (or follow social convention / protocol)
11.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. These strategies may include resettlement on public land, or on private land acquired or purchased for resettlement. (WB OP4.12 Para 11)	No regulation
12.	The resettlement plan or resettlement policy framework also include measures to ensure that displaced persons are: (i) offered support after displacement, for a transition period, based on a reasonable estimate of the time likely to be needed to restore their livelihood and standards of living; and (ii) provided with development assistance in addition to compensation measures, such as land preparation, credit facilities, training, or job opportunities. (WB OP4.12 Para 6)	Not available (or follow social convention / protocol)
13.	To achieve the objectives of this policy, particular attention is paid to the needs of vulnerable groups among those displaced, especially those below the poverty line, the landless, the elderly, women and children, indigenous peoples, ethnic minorities, or other displaced persons who may not be protected through national land compensation legislation. (WB OP4.12 Para 8)	Not available (or follow social convention / protocol)
14.	In case that impacts on the entire displaced population are minor or fewer than 200 people are displaced, an abbreviated resettlement plan may be required. (WB OP4.12 Para 25)	Not available (or follow social convention / protocol)

Source: JICA Study Team

Although legislation and regulations on land acquisition and compensation are in place in Brazil, the resettlement and livelihood support after relocation have been generally based on the social convention or protocol according to Brazilian Constitution so far. However, the environmental examination for environmental licensing has been getting strict and examining a resettlement plan with its monitoring plan in the examination as there have been many troubles and complaints caused by insufficient and improper support and arrangements in resettlement, such as i) relocation to a remote area and ii) limited opportunities for employment in a relocated area, especially those for the professions that the affected people engaged in before resettlement.

It is therefore necessary for the state government to carry out an EIA study and resettlement measures pursuant to the JICA guidelines (JICA Guidelines for Environmental and Social Consideration) and those used by the international funding institutions, such as World Bank, so that the state government could avail of the loan scheme of the international funding institutions for implementation of the Project.

Consequently, it is recommended that an EIA Study should be carried out in accordance with the draft TOR attached to this report. Considering the sound financial status of the state government, the JICA Study Team judges that it would not be much difficult for the state government to finance the conduct of the EIA study for the project.

9.3.3 General Resettlement Procedures in Brazil

(1) Basic concepts

Some basic concepts to be considered in the formulation of a resettlement program for the people who would be affected by the construction of a dam are defined:

Socioeconomic records (questionnaire) – CSE: means a structured interview survey with a set of preset questionnaires. As CSE aims to statistically analyze the socio-economic profiles of the affected families in a quantitative and qualitative manner and prepare a resettlement program for all the potential families regardless of the possession of land and other assets in the affected areas, the interview survey shall target all the families living in the potential inundation areas and construction site.

Directly affected area: or simply **“affected area”**: means the area/areas that will be used for construction or heightening of dam crests and those that might be inundated or impounded after the heightening of a dam. A strip of permanent preservation area (APP) around the permanent reservoir area is also included in this category. APP is not necessarily formed in a flood control dam in general, but it might be required when necessary.

Affected property and affected people: means assets and families associated with or located in the affected areas. The terms are used as herein defined except when otherwise explained.

Workforce (FT): means the number of available workers/laborers who are engaged in agricultural development and exploitation works. The current data on workforce are estimated on the basis of the age structure in each family.

“Target Public” of a resettlement program: means the people directly and indirectly affected by the implementation of a project, which include; land owners, illegal occupants, tenants, investor and its partners, community organizations, salaried workers, and children of land owners and the other relevant people. The target public shall be defined in each step of a resettlement program.

(2) Resettlement measures and alternatives

In general, the target public of a resettlement program under a dam construction project for hydropower generation will be compensated or provided an alternative land for resettlement. The outlines of the resettlement measures are summarized below.

Compensation consists of the total or partial acquisition, with cash payment, of affected properties and/or areas including the unfeasible remaining areas⁷ and any profits to be generated from the economic activities based on/in the affected properties as well as areas. The amount of the compensation will be determined by a mutual agreement between a proponent and the respective affected families/persons.

Provision of alternative lands means to provide the target public with alternative lands and assists them in relocating themselves to such lands. It consists of the following types of measures.

- a) Collective Rural Resettlement (RRC): where rural lots with basic social infrastructure will be allotted to the whole communities in the affected areas.
- b) Small Rural Resettlement (PR): where individual electrified houses and barns with a water supply system will be allotted to the affected families.
- c) Individual Resettlement (Commitment Letter, CC): where the individual affected families will have negotiations with a proponent and determine the value of the affected areas and properties. In principle, each family is responsible for searching his/her relocating land and its associated facilities, which should be equivalent to the values of his/her affected

⁷ The unfeasible remaining area means the area located outside the affected area but owned by the same owner and where the owner will not be able to gain profit from any economic activities based in.

properties/areas. The acquisition and registration of such properties shall be done by a proponent.

- d) Resettlement in Remaining Area (AR): where land use rights for farming will be granted to the affected families. The areas that will neither be affected by a project nor be designated as APP among those acquired by a proponent for a project will be used for this purpose.
- e) Resettlement in Special Cases (CE): where a special arrangement, such as arrangement for urban lots or downsizing of lots from the original plan, will be made for the affected families that have persons in need of special attention (e.g., the aged and disabled).

Due consideration shall be given to the socio economic aspects of the affected families in the preparation of a resettlement program. In particular, the conservation of customary norms/customs related to land and traditional culture in the affected areas shall be considered in a resettlement program.

Furthermore, in case CSE reveals that any indigenous communities or special social categories (such as Quilombos) might be affected by a project, specific standards should be employed to pay due attention to their traditional and cultural characteristics and peculiarities.

In principle, each target public shall select the resettlement measure by themselves considering the respective socio-economic as well as traditional characteristics and according to the guidelines and criteria based on the case studies in the past.

Furthermore, after the estimated values of the affected areas are presented to the target public, additional options should be determined and selected on the basis of the results of CSE in a participatory manner. Such a participatory process and continuous discussions would enable them to appraise their own conditions and determine appropriate resettlement measures.

9.3.4 Procedures for Compensation and Land Acquisition

The following sections describe the procedures taken for compensation and land acquisition in a dam construction project for hydropower generation as an example for the administrative procedures for compensation and land acquisition. Although these procedures are considered applicable to a project for the construction of a flood control dam in principle, there is a need to further examine whether or not all the procedures described below can be applied to the proposed project in a further study, since the existing flood control dam projects are rather scarce as compared to those for hydro-generation dams.

Based on the mutual agreements on land acquisition between a proponent and the affected families/people, compensation for the affected properties and lands and assets including the lands remaining unused due to a project should be made in money in principle. The close communication and good relationship between a proponent and the affected families/people is crucial to smooth progress of the land acquisition process as the land acquisition is based on negotiations with owners of the affected properties in principle. The amount of compensation for the affected lands and properties will be estimated on the basis of data and information collected through a market research on the prevailing market prices, in addition to the comments from the representatives of the owners of the affected lands and properties.

A field survey is to be carried out to assess the affected lands and properties with the presence of the land owners or their delegates/agents. The survey shall cover the lands that would not be directly affected by a project but should remain unused due to project activities and the properties owned by tenants or illegal occupants who do not have the ownership of the lands as well.

In case a proponent and land owners can not reach a mutual agreement on compensation, the compulsory land acquisition process will be taken based on the Public Declaratory Resolution on Public Facilities in the Affected Areas issued by the National Agency of Electric Energy (ANEEL). The Resolution is applicable to only the case when an amicable agreement with land owners is judged impossible to reach.

The procedures for compensation along with the implementation of a project are summarized below.

a) Preparation of the Registration Sheet

Prior to the field assessment surveys on the lands and properties that would be affected by a project, project outlines and other relevant information shall be disclosed to the owners or persons responsible for management of the properties as the first step of the process. In simultaneous with the disclosure of the project information, a proponent shall explain the procedures for land acquisition and compensation as well as the applicable guidelines on the same to them. At the same time, a field survey team will take the formal permission from the owners for entering the affected areas for assessment. The survey team shall prepare the Registration Sheet for each owner's properties filling in data and information of the target properties and obtain informed consent for the sheet from the owner with his/her signature.

b) Demarcation of Maximum Flood Elevation Line and of the Permanent Preservation Area (APP)

A field survey shall be carried out to delineate the maximum flood elevation level and boundaries of APP along the permanent reservoir⁸ so as to clearly demarcate the areas to be inundated/impounded.

c) Determination of the Acquired Land and Properties

The distribution and areas of the potential land use types in the acquired lands shall be clarified by delineating the boundaries of the acquired lands and classifying the potential land use types in the same.

d) Market research on prices and determination of unit values

Unit values for buildings (non-reproductive immovables) and for the perennial crops (reproductive immovables) will be set to estimate the costs of replacement and reproduction. The information related to agricultural production (e.g., agricultural input, labor, and other operational costs including sales) and any other economic activities in the area shall be used for setting the unit values.

The value of the bare land will be estimated on the basis of information and data collected from the market research and interviews to available sources, such as realtors, notaries, brokers, unions, municipalities, banks, and other agricultural experts. It is necessary to collect sufficient information to set the reliable prices/values in line with the standard prices in the region.

An inspection survey shall be carried out to clarify the features of the lands, such as potential land capability, current management practices, and accessibility, for land acquisition. The unit value for compensation shall be determined by estimating the price of the bare land based on a statistical analysis of the above-mentioned data and assessing the quantity as well as quality of buildings and perennial crops existing in the lands.

⁸ There is no official comment from environmental agency (FATMA), it is not clear whether it is necessary to set APP around the temporal reservoir.

The procedures described above are essential to ensuring the reliability of appraisal of the amount of compensation and avoiding future disputes that might be caused by any speculations.

The market research shall be carried out by an expert. A proponent and the affected families/people shall select the representatives who will verify the process of the survey to ensure the validity of the results of the research. In general, the market research shall target the affected families/people and those who own similar properties in the surrounding areas/municipalities.

Once the surveys for setting the unit values are completed, a matrix table showing the amounts of compensation shall be prepared. The table shall be reviewed and examined by a proponent and the representatives of the affected families/people for approval. The amounts of compensation shall be reviewed every six months and updated whenever the market prices rise drastically.

Table 9.2.3 shows the sample amounts of compensation described in Commitment Letter for individual houses around Oeste Dam.

Table 9.3.2 Cost Estimation for Commitment Letters

SITUATIONS	HOUSE VALUE	ROOF VALUE	LAND VALUE	TOTAL (R\$)
House Type I = 54.00 m ²	31,398.00	33,480.00	202,550.00	267,428.00
House Type II = 63.00 m ²	35,961.00	33,480.00	202,550.00	271,991.00
House Type III = 72.00 m ²	40,963.00	33,480.00	202,550.00	276,993.00
House Type I. Minimum S = 40.50 m ²	23,388.00	0.00	45,000.00	68,388.00
House Type II. Minimum S = 45.00 m ²	24,536.00	0.00	45,000.00	69,536.00
House Type III. Minimum S = 50.00 m ²	23,388.00	0.00	45,000.00	68,388.00
House Type I. Maximum S = 40.50 m ²	23,388.00	23,315.00	137,500.00	184,203.00
House Type II. Maximum S = 45.00 m ²	24,536.00	23,315.00	137,500.00	185,351.00
House Type II. Maximum S = 50.00 m ²	26,659.00	23,315.00	137,500.00	187,474.00

Source: JICA survey team

e) Literature Survey

A literature survey shall be carried out to review and analyze the processes necessary for i) transfer of ownership of the lands and properties and ii) acquisition of easements recorded in the recording office and notary public office. Furthermore, this survey aims to i) confirm the ownership of the affected lands and properties; ii) identify the potential beneficiaries of compensation; and iii) collect other documents relating to lands and properties (e.g., legal documents, payment of taxes, registration of pledge, and registration and transfer of mortgage), to verify the validity of compensation.

f) Assessment of Affected Properties

To assess the lands and properties affected by a project in a qualitative and quantitative manner, a field survey shall be carried out to clarify the land-related information (i.e., i) classification of potential land capability, ii) present land use, iii) forest classification, iv) vegetation and forest covers, and v) density of forests in the affected areas) and to make an inventory of the existing properties and facilities, such as perennial crops, buildings, roads, electric power lines, telephone lines, wells, ponds, springs being used for water supply, community facilities, and tourism facilities.

The field survey shall be conducted by experts or a professional company with a wide range of expertise, and its results will be evaluated and validated by a proponent.

g) Appraisal of affected properties

The appraisal of properties shall be conducted in accordance with the official standards of the country for land evaluation⁹, namely NBR 14653-3 and NBR 14653-2, which shall be applied to rural and urban properties, respectively.

Criteria for appraisal of reproductive immovables, such as perennial crops, and non-reproductive immovables, such as buildings, shall be determined by a evaluation method for immovables and economic values for crops.

The appraisal of buildings shall be estimated on the basis of the costs estimated for wrecking of buildings, transportation of materials, and rebuilding. In the case of residential buildings, the amount of appraisal estimated in the same manner shall be the basis for determining the range of the rental cost.

On the other hand, the appraisal of lands shall be based on the land capability, which has the following eight (8) classes.

Class I: Arable land without any limitations on production of annual and perennial crops, usage of pasture, and planting of trees. The soils are fertile and have a deep effective soil layer with a high capacity of water retention. The area has a low risk of flood and no shallow groundwater.

Class II: Arable land with few limitations on crop production and soil conservation. For example, the soils indicate either less or excess CEC (Cation Exchange Capacity) and needs some amendment for crop production. However, the area can be used for crop production with proper management in general.

Class III: Arable land with some limitations on crop production and soil conservation. The area would be rapidly degraded without application of soil conservation measures or other necessary management practices. The area might need to introduce complex conservation measures for production of annual crops suitable for the climatic conditions. In case of sloping land, the area is further classified into sub-classes according to the slopes. Intensive farming will accelerate the possibility of soil erosion. On the other hand, a risk of flood is the major limitation of this class of area in the plain land.

Class IV: Land only used for cropping in a short period of time and not used for crop production continuously over years. The soil fertility is low to medium and clay content in soil texture is 15~60%. The soils are generally deep and rather well drained.

Class V: Land suitable for perennial crops, pasture, and trees, but not for annual crop. The soils are rather shallow (less than 1.2 m) and have gravel fraction (less than 5 % gravel content). The area is rather dried.

Class VI: Land in which perennial crops, pasture and trees can be grown but no annual crop can grow. The soils are infertile, well drained, and with 5~10 % gravel content, although the area is flat with rather deep soils (more than 2 m).

Class VII: Land in which perennial crops and trees may not grow well. Like the area categorized as Class VI, the area needs to introduce appropriate soil conservation measures and other land management practices to minimize the soil erosion/degradation potentials. The soils

⁹ Developed by Brazilian Association of Technical Standards (ABNT)

extending flat to gently rolling terrain are infertile, well-drained, and rather shallow (less than 0.5 m). The area is dried.

Class VIII: Land not suitable for crop production or afforestation/reforestation. Consequently, the area can be used only for habitat for wild animals, sites for recreation, and water storage or harvesting facilities. Inundation area, mangrove forest, and barren or rocky area are classified as this class.

Even if the area is owned by Navy, the same procedures for appraisal shall be followed. A simplified estimation is not allowed for the land owned by Navy.

If any floras of native species exist in the remaining unused area, the value of such floras shall be appraised and compensated along with other properties. However, those in permanent preservation area (APP) shall be kept untouched and maintained as they are. The value can be appraised but any alternation is not allowed.

Compensation for short-term crops will not be made if the notice of the date of resettlement is made more than six months before. On the other hand, if the notice is made less than six months before and short-term crops can not be harvested by the time of resettlement due to time constraints, the value of short-term crops shall be compensated.

Roads, wells, water supply systems, and electric lines in the affected areas shall be compensated by rebuilding/reconstructing the same based on the cost evaluation method.

h) Administrative Technical Reports

An administrative technical report, which is to be used for the reference for compensation, shall be prepared for the respective properties. The report describes i) the expected values of land/property, ii) the potential effects caused by a project, and iii) the amount of compensation.

i) Negotiations

The negotiations for property acquisition shall not involve anyone who might envision obtaining economic or political benefits from the negotiations, but be made through a direct communication with each owner of property

Compensation shall be based on the administrative technical reports on the respective affected properties. A proponent for a project shall be responsible for issuance of a deed of transfer and registration of the lands to be transferred to the affected families/people in the recording office. The final payment of compensation shall be adjusted by deducting the expenses for registration of new properties for the affected families/people.

j) Payment

A proponent shall make a payment within 30 days, on the condition of the submission of an ownership certificate, from the date of the mutual contract on the amount of compensation. In the cases of Individual Resettlement (CC) and Special Cases (CE), a part of the final payment might be used for procurement of new properties.

k) Deadline for Transfer of Properties

In case that the payment of compensation is made or Individual Resettlement (CC) is selected as the method for acquisition, the owner shall transfer the occupied land to a proponent by the deadline for transfer. The deadline shall be determined by a proponent in principle, but it should be adjusted with the conditions of the owners, especially when buildings/facilities are removed in the affected area.

As long as an implementation schedule of a project is not affected, the deadlines for transfer of the affected lands can be extended within a certain timeframe as an exceptional case. In that case, a proponent shall make an agreement on free use of the acquired land with the affected families/people, so that they could use such areas until the new deadlines set by the agreement.

l) Compulsory acquisition in accordance with Public Utility Declaration Resolution - DUP

Compulsory land acquisition shall be carried out in accordance with the ANEEL Resolution No. 279/2007 otherwise known as the Public Utility Declaratory Resolution. DUP would be applied in case the amicable land acquisition can not be made due the breakdown of the negotiations on compensation or the defect in the documents on land ownership, which are the bases for a proponent to pay compensation. In some projects, compulsory compensation might be undertaken at the state or municipal level.

In the early stage of the project, sufficient deliberation on whether or not the Resolution can be applied to a flood control dam project shall be made in consideration of the nature of the project. In fact, the Resolution stipulates the legitimacy of land acquisition for a hydropower project, and therefore, the same is considered applicable to a flood control dam as its nature is similar to a hydropower dam.

m) Granting of Ownership

In case the legal process (or compulsory acquisition) for granting of ownership is required due to the breakdown of the negotiations or disputes over the conveyance of estate, an expert report relevant to the issue shall be prepared for granting of ownership at least six months before the start of impounding.

n) Prioritization of Properties to be acquired

The land acquisition of the inundation areas shall be carried out in both river banks, from the downstream to upstream if possible. Furthermore, the following lands should be prioritized.

- Construction site and access roads to the site
- Areas to be fully affected or fully acquired
- Areas to be partly affected and whose owners prefer to have partial compensation
- Areas identified as partially affected

o) Criteria to Examine the Possibility of Continuation of Livelihood Activities in the Remaining Areas

The existing livelihood activities in the remaining areas shall be assessed to examine the possibility of the continuation of them. If the assessment reveals that i) the cost incurred for basic infrastructure necessary for the existing livelihood activities in the remaining areas will be higher than that for resettlement or ii) the remaining areas are too remote from basic infrastructure to maintain the existing livelihoods, the continuation of the livelihood activities would be judged impossible. In addition, in case the remaining areas are susceptible to landslide due to its slopes or geological characteristics, the continuation of the livelihood activities would not be allowed.

In case any investment have been made for agricultural development even in the area where no agricultural activity had been undertaken before a project, the possibility of continuation of the agricultural activities in such areas shall be deliberated.

If the existing agricultural activities, namely livelihood activities, can be continued in the remaining area, a proponent shall only acquire the areas to be inundated/impounded and its surrounding areas for protective vegetation strips (APP).

On the other hand, if the continuation of the existing activities is considered impossible or infeasible to support the livelihoods of families, a proponent shall acquire the whole area including the remaining area unless the owners of the areas officially request the exclusion of the remaining areas from land acquisition.

9.3.5 Typical Resettlement Monitoring Program in Brazil

(1) Introduction

Due consideration should be given to: i) agricultural production and economic activities (e.g., agricultural activities, any complementary activities, market supply, and commercialization); ii) social interaction (e.g., resumption of community activities and reformation/restructuring of social structure); and iii) arrangement of basic infrastructure (e.g., houses, education facilities, health facilities, and transportation facilities) during the process of resettling the affected families/people. To this end, a systematic monitoring program needs to be implemented during the process of resettlement, so as to ensure the transparency of the process and remedy the resettlement activities when necessary.

(2) Justification

The main aim of the monitoring program is to identify the positive and negative aspects of the various measures (monetary compensation, commitment letter, resettlement in the remaining areas, individual resettlement, and special arrangements/cases) taken for development of new communities in the course of resettlement

The monitoring program is to target three families/people resettled/relocated (“resettled/relocated families/people”). Having analyzed the negative aspects identified, the monitoring program is to provide effective alternatives and means to minimize the negative factors, such as provision of technical and social guidance.

Forcing people to change the living environment by any reasons other than personal interest might cause social disruption or seriously threaten the basis of civil society. It is therefore important to restore the lifestyle of the affected families/people, provide necessary support for restoration, and continue monitoring of the resettled/relocated families/people in new areas. The monitoring program would be helpful in having the feedbacks from the resettled/relocated families/people and identifying the needs of technical and social assistance for them.

(3) Objectives

The main objective of the monitoring program is to collect the information relevant to the resettled/relocated families/people in the different stages of a resettlement program to evaluate the process of resettlement from the economic and financial viewpoints and to propose any improvement when necessary. Specifically, the program aims to:

- evaluate the changes in lifestyle of families/people living in the areas directly or indirectly affected by a project in the different stages of a resettlement program
- validate the effectiveness and validity of a resettlement program
- monitor the families who recognize the discrepancy between the plan of a resettlement program and the results of the same or who propose revising the guidelines adopted for resettlement

(4) Goals

The goal of the monitoring program is to propose the necessary activities for improvement of a resettlement program as described above. The milestones to be achieved by the monitoring program are to monitor and survey all the resettled/relocated families in different locations at the respective stages (i.e., T0, T1, T2, and T3 stages) within three years from resettlement.

(5) Environmental indicators

Information to be monitored are: i) the level of satisfaction, ii) the level of family income, and iii) the level of solidarity of new communities of the resettled/relocated families. Furthermore, the following environmental indicators shall be monitored for three years.

- Opposition movement of resettled families/people against the results of the resettlement program;
- Proportion (Percentage) of resettled families/people satisfied with the effectiveness of resettlement;
- Proportion (Percentage) of resettled families/people who remove to other places in a short period of time;
- Degree of crop diversification;
- Proportion (Percentage) of resettled families/people who are able to engage in a job/occupation that enable them to enhance their standard of living;
- Level of increase of crop productivities
- Changes in average family income
- State of adaptation of resettled families/people to the respective new locations
- Level of improvement of social indicators
- Degree of discrepancy between the plan and results of the program
- Degree of introduction of new technologies in agricultural production.

(6) Target groups

The monitoring program is to target: i) directly-affected people, ii) people forced to relocate, iii) people without house or employment, and iv) people who are not able to obtain property compensation.

(7) Basic concepts

The resettled families/people should be followed up and the resettlement measures and their process shall be evaluated in the different stages of a resettlement program. The results of CSE/socio-economic survey will be used for evaluation.

<u>Stage</u>	<u>Aims of monitoring</u>
T0-T0 Stage (when the monitoring activity starts):	Survey and grasp the socio-economic conditions of the affected families/people prior to resettlement through CSE.
T1- T1 Stage (six months after resettlement):	Evaluate the current situations of the resettled/relocated families.
T2- T2 Stag (18 months after resettlement):	Assess the socio-economic conditions of the resettled/relocated families.
T3- T3 Stage (30 months after resettlement):	Evaluate the stability of the resettled/relocated families

(8) Methodological procedures

The monitoring program is to employ quantitative and qualitative surveys, a questionnaire survey using a set of questionnaires, and a semi-structured interview survey to grasp the feelings and sentiments of the resettled/relocated families. A quantitative survey can reveal the level of satisfaction/dissatisfaction and other qualitative socio-economic aspects before and after resettlement, while the quantitative survey can measure the inter-annual changes in the pre-determined milestones and environmental indicators. Those surveys to be employed shall encompass different approaches that have the respective pre-determined timeframe, interrelate each other, and have the respective clear aims and methodologies.

The results of CSE shall be used as the baseline data to clarify the changes in socio-economic conditions of the resettled families/people through periodical monitoring activities.

Monitoring activities will be carried out in accordance with the following timeframe:

- T0: Before resettlement of families
- T1: Six months after resettlement
- T2: One year after T1
- T3: another one year after T2, when the life of the resettled/relocated families would become stable

(9) Development of program

The monitoring program is to be developed in consideration of its timeframe and methodologies required.

a) “T0” STAGE – Before resettlement

An interview survey will be carried out to determine the baseline of the resettled/relocated families before resettlement. Hence, the families to be affected by a project will be targeted by this monitoring activity. The changes in the socio-economic conditions will be assessed on the basis of the data collected in this stage.

b) “T1” STAGE – Six months after resettlement

A semi-structured interview using questionnaires will be conducted six month after resettlement to assess if the resettled/relocated families are adaptable to their new environment and evaluate if the unification of the resettled/relocated families as a new community progress as planned. Feelings and sentiments of resettled/relocated families along with good and bad points of the results of resettlement will be grasped through such an interview survey.

c) “T2” STAGE – One year after “T1”

The survey at this stage aims to grasp the socio-economic conditions of the resettled/relocated families considering the vulnerability of the respective families. Data on the second year cropping, such as area cultivated, crop yields, and sales of products, will be collected and analyzed for this purpose. The same questionnaires used in T0 Stage will be used in this stage.

d) “T3” STAGE – One year after “T2”

This stage aims to assess the degree of social stabilization of the resettled/relocated families by evaluating the effect of compensation payment on the household economy at the third year.

Hence, a structured questionnaire survey, which would enables a quantitative economic and financial analyses with cross-checking and social interaction analysis of the resettled/relocated families, will be carried out in this stage.

9.3.6 Environmental Management and Monitoring Programs

All the activities relating to environmental management, supervision and monitoring in the construction and operation phases shall be planned in EIA/RIMA as the environmental management and monitoring programs in accordance with the methods/procedures defined by the relevant environmental legislation in Brazil. Contents and composition of environmental management and monitoring programs will be determined and finalized in consultation with the relevant organizations in the process of the preparation of EIA/RIMA.

The following items shall be included in the environmental management and monitoring programs.

- i) Environmental Licence: It shall describe the environmental impact assessment study and the proposed measures to avoid and mitigate the expected impact.
- ii) Environmental Management and Control: It shall include the descriptions about environmental training for laborers, health management of laborers, and pollution preventive measures (e.g., dust, traffic, noise, and vibration).
- iii) Environmental Monitoring: It describes a monitoring plan in the construction and operation phases.

A proponent shall be responsible for environmental monitoring, but its implementation (e.g., field monitoring activities) is generally contracted out to a consulting firm/consultants or university.