must take the necessary precautions to avoid possible use of the impoundment area for recreational purpose that may cause accidents.

No touristic or recreational use of the river stretch between the damsite and the Itajaí do Norte confluence exists except for the island tourist resort located at some 8 km downstream of the damsite. The potential impact expected is a reduction of the river flow, and this impact is considered irreversible but possible to mitigate. The reduction of the water turbidity is consequently expected, and it will enhance the use of the river by the local tourists approaching the island.

(6) Forest Use

The project area is located outside of buffer and nucleus zones for the Atlantic forest ecosystem and there is no forest use. Isolated patches of forest still presents in the gulches where runoff water drains to the river. This patches are important as the last source of endemic material for reforestation. It is important to preserve this vegetation patches, specially for the ones adjacent to quarry C.

4.3.2 Population

The job availability during construction phase will generate about 400 new jobs. This impact is considered non permanent and reversible in its consequences which are analyzed in the sub-section 5.3.6.

The population to be displaced in relation to the reservoir formation is a seasonal because dwelling has been used only in short period. No major impact is considered for this population.

The population of the village of Subida will be subject to the most significant impact due to displacement, because of the family and economic relationships previously described, and they will also be subject to the intense traffic activity in the area while construction is going on.

The population of the different municipalities such as Ibirama, Lontras and Apiúna will get benefit from the indemnifications due to water use for hydroelectric power. This is considered a positive impact for the community.

4.3.3 Historical-Cultural Patrimony Sites

There are no patrimony except that represented by the stretch of railroad. It is desirable that the existing tunnel in the selected place for the quarry is maintained and this elements will constitute the nucleus for a historical park of the region.

4.3.4 Water Uses

(1) Agricultural

The water use for agricultural purposes in the project area is incipient or non existing, but there is some uses for irrigation in the upstream stretch of the damsite, along the surroundings of the left bank for cultivation of onion crops, although inconspicuous quantities are few hectares. There is no farming activity along the river stretch between the damsite and the Itajaí do Norte confluence because of the steep slopes of the river banks with rocky areas and poor drainage. No impact is expected on the agricultural sector in the project area because of no water use.

(2) Municipal

Most of the households in the upstream of the damsite depend on water from water wells and water treatment is considered substandard. In the directly affected areawhich is the rural zone of the municipalities, Ibirama, Lontras and Apiúna, the water use is incipient. There are no populations in the vicinity of the river banks along the river stretch between the damsite and the Itajaí do Norte confluence. The few isolated houses in the upper portion of the slopes do not use the river water for their subsistence and the potable water is extracted from water wells. There is no impact expected because of the interference of the project actions on the municipal water use in the project affected area.

(3) Communal Water Use

There is no communal water use in the area related to the project actions. The potable water in the different areas along the river stretch affected by the project activities is obtained from water wells with a water recharge not associated with the river hydrology. There are no impacts foreseen by the project on the communal water use of the river waters.

(4) Water Related Diseases

The usual concerns related to water related diseases in dam projects are focused mainly on the reservoir formation, its eutrophication, water quality deterioration and eventual development of water related diseases. In this project, the reservoir volume and surface area are very small with a very fast turnover rate and so with a minimum stratification probability. Then the water quality in the reservoir is not expected to deteriorate. Because of these reasons, the water born diseases are not considered as a significant possibility in the actual project scheme and no major impact is expected in this area.

4.3.5 Directly Affected Areas

(1) Lontras and Ibirama

The Itajaí river at the dam area forms the boundary of two municipalities; Lontras (right bank) and Ibirama (left bank) as shown in Fig. VI.4.1. The directly affected areas including those for temporary facilities in both municipalities are composed of 6 houses; 5 in the municipality of Lontras, and one in Ibirama. Four of them are used by the owners for their own subsistence, and remaining 2 houses are used temporarily by the owners.

The area considered as buffer zone for the reservoir area is a 100 m belt in both banks as follows:

- Right bank, municipality of Lontras, 11.1 ha must be expropriated for the buffer zone, and other 2.4 ha will be submerged.

- Left bank, municipality of Ibirama, 8.9 ha must be expropriated for the buffer zone, and other 1.6 ha will be submerged.

The impact caused by the project is considered of middle importance, and not affecting the basic economic subsistence structure of the dwelers. The permanent inhabitant is directly related to his subsistence means to the other occasional dwelers, and his relocation will probably be associated with the new recreational allocation for the occasional dwelers. An increase in the municipal budget by financial compensation by the project will become a significative positive impact for the municipalities as described previously. An increase in job availability for the area will bring positive. An overload of the existing roads in the area is a significative impact.

(2) Apiúna

The powerhouse area belongs to the municipality of Apiúna. The rural estates in the directly affected area of Apiúna will not be affected by submergence of the reservoir formation, but by the construction of the powerhouse, tailrace/substation, surge tank and other facilities. Ten estates are located in the directly affected area of Apiúna in the surroundings of the powerhouse. The community of Subida will be affected, and this impact though it is small scale will be the most significant related to the relocation of people by the project reflecting to socio-economic relationships of the dwelers.

4.3.6. Influence Area

Blumenau and Rio do Sul are considered to be second degree area of influence due to their political influence and their available infrastructure in commerce and services. No direct effect of the project actions is foreseen in these communities.

4.3.7 Alteration of the Existing Roads

Old Lontras-Subida Road (L-S): The circulation of heavy vehicles is expected to be of medium intensity. It is expected that the linear distribution of houses located at about 500m stretch adjacent to spoil bank #11 will be affected by dust during the dry season and mud during the rainy season. Due to this reason it is advisable that this road stretch be covered with asphalt to avoid the disturbance to the house dwelers and installation of traffic signs and demarcation are also advisable in this stretch to prevent accidents.

Main Highway (BR-470) : It will serve to communicate the powerhouse site and spoil banks #18 and 19, as well as with the concrete batching plant. It will also serve as alternative access to and from the powerhouse site, instead of using the south end section of the Subida community, where the density of housing, and the narrow road may cause accidents if heavy trucks are continuously circulating. In the village of Subida, the traffic will become extremely complicated due to the width of the road, and proximity of the road to houses. Some houses will have to be removed. The entrance to Subida through the bridge will require traffic light and proper signs for safe circulation of vehicles to and from the powerhouse site.

Access Road AR-1: This will serve as the access road to the surge tank and it has about 800 m in length. Since the region is of steep declivity covered with secondary forest,

some deforestation will be required.

Access Road AR-11: About 3 km long road will access to the BR-470, spoil banks #5 and #16 and damsite. There is a linear concentration of houses along the road for 500 m to the BR-470 intersection and proper traffic signs and demarcations are advisable to avoid accidents in this sector.

Access Road AR-14: About 700 m long road will communicate quarry C with the BR-470. The last 400 m before reaching the highway intersection are heavily populated with houses scattered along the road. It is recommendable that this stretch provides an asphalt cover to avoid dust and mud to the local residents, as well as proper traffic signs and demarcations are advisable to avoid accidents. After reaching to the BR-470, at some 1.7 km from the previous intersection, the trucks will access AR-11.

5. EVALUATION OF MAGNITUDE OF IMPACT

5.1 Physical Environment

5.1.1 Landscape Degradation

The degradation of the landscape may be caused by the quarry in front of the Paraiso camping area. The localized impact is considered of importance to the Paraiso camping context since the recreational role of the camping conveys the landscape appreciation. The degradation of the landscape due to the activities of the B and C quarries is considered of middle importance, from the viewpoint of degradation of the landscape on the slopes of the river banks in this area.

5.1.2 Reduction of River Flow

The reduction of the river flow downstream of the damsite is the most significant physical impact derived from the project activities.

The landscape in the project river stretch is highly degraded and there is no human use in most of this stretch of the river. The island located at about 1.6 km upstream from the intersection of the Itajaí do Norte river is considered as an area of touristic potential, with two existing houses and a restaurant in the island of Cotia formed at this river bend.

The river flow reduction will affect the landscape and tourist potential of the scenery in this area. The magnitude of this impact is considered of medium importance and reversible. It is recommended to evaluate this impact in more detail to identify the level of water and the magnitude of the flow reduction around the island.

Reduction of the velocity of river flow in the pondage area could attract swimmers and cause fatal accidents. This impact is considered reversible if proper prevention measures are taken.

5.1.3 Loss of Mineral Resources

The hills of the quarry A and the powerhouse site are the only places where exploitation of granite is affected but their areas to be affected are remarkably small. Due to this reason, the impact is considered reversible with a low importance.

5.1.4 Slope Stability

Under natural conditions, the problem of slope stability of the powerhouse site may take place because of its steep slope. The exploitation of granite and deforestationare are factors decreasing a precarious stability condition. The impact caused by the project activities is considered to be reversible and of middle importance with possibilities of mitigation.

5.1.5 Blasting

For use of explosives in the works of construction of the powerhouse, penstock line and surge tank, consideration should be given to the possibility of stability disturbance of some rocky blocks. This impact is considered reversible and of middle importance.

The use of explosives in the quarry A requires special attention towards the camping area located at 150m far from the quarry in the opposite side of the river.

5.2 Biological Environment

5.2.1 Clearing of Vegetation

The clearing of vegetation will be needed in the reservoir and the surge tank.

In the reservoir area for the dam axis B, no significant vegetation exists. In the surge tank, 1.1 ha are to be cleared. The vegetation in this area is well preserved. The species of trees to be affected are found in other regions of the state of Santa Catarina. The specific impact due to the project actions is considered irreversible, although of little importance due to the small area to be affected.

5.2.2 Alteration of Ichthyofauna

Since the construction of the dam and subsequent reservoir formation will cause the transformation of a rapid water environment into a slower water environment, the following alterations on the aquatic community will be pointed out: increase in the preying rate and decrease in the downstream submersible areas, interruption of migration, increase in the water residence of the reservoir, flow reduction between dam and powerhouse, habitat alterations, increase in water transparency downstream, and increase in the number of slow water species.

Many of the above impacts will have their effects appeased, and the rapid to slow water environmental change will only occur in 800 m long upstream of the damsite. There will not be thermal stratification in the reservoir, and the possible eutrophic condition of the reservoir will not lower the water quality because of the absence of stratification.

The strongest impact on the ichthyofauna will be caused by the flow reduction in the river stretch between the damsite and the Itajaí do Norte confluence. This condition will cause the organisms to become more vulnerable to the climatic, hydrologic and ecological conditions.

Because of the lack of studies about these impacts, it is impossible to forecast their magnitude, but the flow reduction is considered an irreversible impact of medium degree of importance. This impact has the potential of being partially mitigated by the maintenance flow, and although it is not quantified, the impacts on the biotic and anthropic context are considered of medium degree.

5.3 Socio-Cultural Environment

5.3.1 Dwelling in Reservoir Area

At the dam and reservoir site where there is no dwelling to be submerged by the reservoir formation, three dwellings are located in the 100 m buffer zone around the reservoir. One of them is used by its owner only as a leasure house. The other two belong to permanent residents and their families and caltivate adjoining flat lands. One of the residents on the left bank, takes care of the surrounding land being entrusted by the land owner. The other resident on the right bank gets income from working in the factory at Rio do Sul. Purchase of their houses and house lots and transference of the dwellers to another places are needed to use those areas as the land for the project. The impact on the dwellers is irreversible and permanent. The project should guarantee the indemnity in accordance with the restitution value of the dwellings. CELESC's participation in acquisition of new dwellings is recommendable.

5.3.2 Estates Affected by Project in Dam Area

There are 10 estates which are affected by the project activities in the dam and reservoir area as shown in Fig. VI.5.1. The assessment of the estates is as follows:

Estate No. 1: This is the Paraíso camping area. Its small part (about 0.4 ha) will be included in the 100 m buffer strip. According to tentative sounding by CELESC, owner of the camping intends to continuously occupy the area even after the formation of reservoir since the reservoir will rather enhance touristic attraction. Even if the ownership of the area is not transferred to CELESC, suitable control such as warning board and fence by CELESC will be required so as to restrict tourists approaching to the reservoir for safety. Flood water level will not differ from present condition even after completion of the dam.

Estate No. 2: Two point six (2.6) ha will be appropriated for the dam and formation of the 100 m buffer bolt. Only vegetable farm and secondary forest will be affected. In addition, the islands with 5.7 ha in total will be expropriated for submergence and buffer zone. Majority of area area of the islands are covered with bushes and grasses.

Estate No. 3: All of 0.6 ha bush area will be appropriated for the formation of the buffer belt.

Estate No. 4: Six (6) ha of secondary forest will be appropriated for the formation of the buffer belt and 2.5 ha of pasture land will be appropriated for the spoil bank SB-16.

Estate No. 5: One point five (1.5) ha of pasture land and secondary forest will be appropriated for the spoil bank SB-16.

Estate No. 6: One (1.0) ha of swampy area covered with grass and bushes will be appropriated for the yard of crushing plant. Another 1.2 ha of grass land will be appropriated for the spoil bank SB-1.

Estate No. 7: Seven (7) ha will be appropriated for the formation of the buffer belt. Most part of this area is covered with grass and bushes. The quarry site - A is located in this area and 1.2 ha will be expropriated for extraction of rocks to be used in the project work. Another 2.4 ha covered with grass and bushes will be appropriated for the spoil bank SB-1.

Estate No. 8: Four (4) ha will be appropriated for the formation of the buffer belt and another 2.4 ha will be expropriated for the intake and desanding basin. Further 5.5 ha will be appropriated for construction camp area and office/storage area.

Estate No. 9 and No. 10: Approximately 1.8 ha will be expropriated for the headrace culvert.

The impact on these estates is irreversible and permanent except for those for spoil banks and temporary facilities such as construction plants and construction camp/office. Purchase of the estates on which the impact is irreversible is needed to use them as the project land.

The project should guarantee appropriate indemnity to the ower of each estate.

5.3.3 Alteration of Standard of Living of Rural Settlement

The living alteration of the rural settlement may take place in the powerhouse area located in the village of Subida because majority of the resettlement of the houses concentrates on this place. It is expected that the increase in vehicle traffic will increase the risk of accidents and the blasting related to construction may cause the risk of accidents.

The expected construction period of time for the project works is estimated at 3.5 years, and relocation of the population is prerequisite to project implementation. This activity is one of the serious socio-economic impacts of the project implementation due to the reasons that the relocation will not only be physical but it also entails the alteration of the socio-economic dynamics. The spatial, as well as the organizational aspects of the productive basis and economic structure must be considered with a strong participation of the involved families. This impact is considered to be the most critical one in the socio-economic realm of the project actions.

5.3.4 Social Unrest Derived from Flood Stigma

The educational campaign will be needed for relationship between the construction of a dam and the flood possibility in the collective imagination of the populations of the area. The campaigning should explain the real implications of the dam and the operation of the power plant regarding the flood phenomenon. This impact is considered of medium importance.

5.3.5 Increase in Municipal Budgets

The municipalities affected by the works of the project will have the right to indemnity, deriving from the development of water resources with the purpose of generating electricity. According to CELESC, Lontras will receive US$8,174/month; Ibirama US$2,174/month; and Apiúna US$82/month. In all cases, the impacts are positive.

5.3.6 Increase in Job Availability

The job availability during construction period will generate about 400 new jobs, and the disadvantageous consequences are an increased demand for the number of households, increased demand for medical services, increased demand in the sanitation system, and an increased risk of transmissible diseases. These impacts are considered non permanent and reversible if handled properly.

5.3.7 Increased Demand on Sanitation System

The basic sanitation system in Lontras, Ibirama and Apiúna is very precarious, with no public sewage and considerable deficiencies in water supply in the urban zone.

If 400 workers require sanitary demands, it is estimated that they will produce some 40,000 liters of sewage per day. If adequate treatment is not provided for this effluent, the levels of total and fecal coliforms along with increasing concentrations of nitrogen and phosphorus will cause the increase in the organic pollution of the nearby waters. This impact is considered of high importance.

5.3.8 Overload of Road Net Infrastructure

The use of public roads will be enhanced and the Lontras-Subida road will receive a medium traffic overload, which is estimated at 2 trucks per hour. This impact is considered of low degree and it is possible to mitigate through proper traffic control, especially at the bridge entrance to the powerhouse site and in the BR-470 sector between quarry C and the damsite.

Special consideration must be given to the increased traffic through linearly disposed housing along the stretch of secondary rural roads, where possibility of accidents, especially for children and elderly one because these roads are seldom overloaded with vehicles and local people are usually not used. In the village of Subida, the traffic will become extremely complicated due to the width of the road, and proximity of the road to houses. Some houses will have to be removed. This impact is considered to be of a high degree of importance.

5.3.9 Impact on Historical-Cultural Patrimony

There is no patrimony except that represented by the stretch of old railroad. It is

desirable that the existing tunnel in the selected place for the quarry "A" is still available and this elements will constitute the nucleus for a historical park of the region. This impact is considered to be low.

6. CONSIDERATION OF NECESSARY COUNTERMEASURES

6.1 Physical Environment

6.1.1 Restoration Program for Degraded Areas

Areas which are suffered from degradation due to the construction works of the project will be subject to a restoration program. The areas to be considered are those around the dam area, quarries, spoil banks, borrow area, surge tank and powerhouse. The vegetation program shall be initiated after the completion of the project works.

After the end of project activities, the opened quarry used for construction could be utilized as a centralized quarry for the local residents of the area dedicated to this activity. The centralized quarry would allow the local authorities to control the exploitation, and it will also deminish the scattered deterioration of the landscape by small individual quarry operators. This action will entail the organization of the isolated quarry workers into an group and the participation of the environmental authorities in the organization process.

Further study on the effects of the river flow reduction upon the landscape value of the Cotia island near Ibirama should be undertaken to evaluate and possibly mitigate this impact. The study should look into the expected water level around the island after dam construction and evaluate the effect of this flow reduction on the scenic and touristic resources of the area. It may be required to provide dike across river channel to maintain an adequate water level around the island and to avoid the drying out of river areas with water sports and recreational potential.

6.1.2 River Maintenance Flow

A river maintenance flow is needed for the maintenance of aquatic life in the river stretch between the damsite and the Itajaí do Norte confluence. A detailed analysis of this flow requirement is presented in Attachment in this ANNEX VI.

The analysis offerred that the flow discharge of 3 m^3/sec to be released from the dam would be enough for the aquatic life. However, the river maintenance flow has been finally increased to 7.2 m^3/sec which corresponds to 80% of the minimum monthly discharge at the damsite so as to satisfy the DNAEE's rule.

6.1.3 Geological Impacts

A monitoring program of the geological impacts of the project works to control vibrations induced by blasting in the quarry, tunnel, powerhouse and the damsite is advisable. The program will determine the effects of the blasts and observe the stability of the hillsides. Institutions such as IPT (Technological Research Institute) will be involved in the program.

6.2 Biological Environment

6.2.1 Ecological Station and Protection Zone for Reservoir

CONAMA resolution 010/87 requests the implementation of an ecological reserve area or station. For definition of this area, the protection areas of the Atlantic forest to maintain the environmental continuity should be contemplated. The budget estimated by law for the ecological station should be allowed for the restoration of the degraded slopes of the river stretch between the damsite and Itajaí do Norte confluence. This area will be reforested with native species coming out of the scattered forest patches located in the gulches. With this measure, the project will not only be a low environmental impact project but also contribute to the regeneration of the degraded area of influence. The institutions that will be involved in this action are IBAMA, FATMA, UFSC, and FURB.

6.2.2 Conservation of Ichthyofauna Resources

The conservation of the ichthyofauna resources is directly related to the river maintenance flow and this discussion and the necessary measures are stated in Attachment in this ANNEX.

Since the scientific data on the existing populations is scarce, an ichthyological program designed to obtain more knowledge of the existing species will contribute to establish repopulation programs in areas where this resource is being depleted.

Water effluents from the concrete batching plants should be pre-settled to minimize the suspended solids and the liquid effluent should be treated to reduce the PH to a range of 6-8 according to concrete batching plant regulations in Brazil.

6.3 Socio-Cultural Environment

6.3.1 Resettlement of Population

The community of Subida will probably require resettlement, reorganization of the physical standard of living of the community. The predisposition and expectations of the community should be evaluated, and committee of the local inhabitants should keep up with the relocation process. The recomposition of the productive basis and economic structure of the community should be determined by socio-economy study.

For resettlement of the families living in the reservoir area and on spoil bank #1, access to another rural establishment should be contemplated. It will be necessary to contact with the families, explain the need and detect their disposition and expectations, evaluate another rural establishment selected in accordance with their needs, and provide infrastructure of the new location as well as schedule of the relocation with the families affected.

For the leisure houses adjacent to the dam, indemnification price evaluation and negotiation with the owners will be needed. Preliminary contacts with these people indicate a good disposition to reach to an agreement.

6.3.2 Public Communication Regarding Flood Stigma

The flood stigma associated with the dam construction is an important aspect to be considered, especially for the concerned groups of the communities of Lontras and Rio do Sul. In a lesser degree, community of Blumenau is important to obtain support in the question. A series of talks and explanations should be carried out with the organized groups of these communities such as municipal prefectures, environmental groups, and municipal associations with the purpose of clarifying the fact that the future dam will not have any detrimental effect on the occurrence of floods.

6.3.3 Manpower Qualification Program

Manpower qualification in the areas of Subida, Lontras and Ibirama will provide the conditions for the local inhabitants to take advantage of the job availability to be generated by the construction works of the project. The allocation of jobs for the qualified people of the village of Subida is considered important. This action can be considered as an added value to the compensation of resettlement. The qualification and recruitment of the

workers should entail interviews and data collection.

6.3.4 Public Health Control Program

The implementation of actions for sanitary vigilance in the project area is essential. Basic sanitary precautions, epidemiological vigilance, permanent research on transmissible diseases, and public awareness through different information procedures are countermeasures to be considered.

The sewage treatment originated by the construction camp is highly advisable to avoid a focus of disease vector reproduction. The sewage system is to be constructed according to sound sanitary engineering criteria.

6.3.5 Road Signal and Surface Covering

The overload of the road net infrastructure especially for the Lontras-Subida road and the village of Subida will require a well designed traffic signal system to minimize the accident probabilities. The program will be designed by the local transportation department (DNER) under cooperation of CELESC, with a previous briefing of the expected situation by the second to the former.

It is advisable to avoid the traffic of construction vehicles along the southern sector of the Subida community road. This action will prevent accidents and disturbance to the local population.

It is also advisable to shut off the road stretch directly in front of the powerhouse site, allowing transit of vehicles and persons only with previous authorization of a permanent post guard in this location. This will avoid injuries of people passing at any time in front of the project, where blasting and use of heavy equipment will take place. The alternate use of the bridge communicating powerhouse site with the BR-470 will require proper traffic signs and lights for trucks coming in and out the power house site.

The intersections of the BR-470 with the secondary roads leading to the quarry C site and the damsite will require proper traffic signs to alert the users of BR-470 for transportation of heavy loaded trucks to access the highway.

Sectors of secondary roads where rural settlements are linearly dispersed along the road and regular transit of construction vehicles is expected should be protected with asphalt

or another adequate surface covering to avoid dust during the dry season and muddy conditions during the rainy season.

6.3.6 Reservoir Protection Fence and Establishment of Buffer Area

It is possible that visitors to the reservoir area will try to use it as a swimming place. This activity may cause accidents, and CELESC would be legally responsible for such accidents. Consideration of countermeasures for this impact includes the expropriation of a buffer zone of 100m around the reservoir area and the fencing of this area to limit access. Proper signs of warning and transit prohibition will be effective for preventing the accident and release CELESC from legal consequences.

A buffer area has to be defined around the blasting area in the powerhouse site. The possibility of cracking walls in the adjacent brick houses may take place. To mitigate this possibility, a buffer zone must be identified according to sound engineering parameters.

7. MANNAGEMENT AND MONITORING PLAN

7.1 Environmental Control Actions of Engineering Works

It is prerequisite for implementation of the project to take measures of environmental control including the following:

- The construction process of the access roads should be carried on to minimize erosive effects. The roads should have proper drainages specially at steep locations.

- The exploitation plan for the quarries specially for the quarry A, should be compatible with the future restoration and landscape preservation in the context of the sourroundings specially for the case of landscape of the Paraiso camping area.

- Allocation of drainages for the spoil banks and adequate surface finishing should be compatible with the adjacent landscape.

- Sewage treatment at the construction camp and the establishing of health care for periodic visits will be needed especially for relationship with transmissable diseases.

- The offices to be involved will be CELESC, FATMA, contractors, the local health department and the consulting company.

Cost for this implementation as estiamted by AMBIENTAL is US$ 27,000.

7.2 Reservoir Cleaning Program

Cleaning of the area to be submerged and detachment of branches and trunks, which are hazardous to the operation of the powerplant will be needed. Elimination of foci due to pollutions such as cesspits is desireable before submerging the reservoir area. This actions will be carried out by CELESC, and estimated cost for this implementation is US$13,000.

7.3 Monitoring Program for Geological Impacts

The observation of the stability of the hillsides, mainly at the powerhouse site, surge tank and penstock line, are recommended. The offices to be involved are CELESC and the IPT-Technological Research Institute. Cost estimated for this implementation is US$ 42,000.

7.4 Restoration Program for Degraded Areas

For the restoration program for the degraded areas, offices such as CELESC, IBAMA and the associated townhalls will be engaged in such program implementation. Cost estimated for this implementation is US$ 212,500.

7.5 Implementation Program for the Ecological Area

The implementation program for the ecological area including selection of the ecological area, topographic survey of the selected area and land acquisition is the basic steps for the implementation of the project. The institutions to be involved will be IBAMA, FATMA, UFSC, and FURB. Cost estimated for this implementation is U$ 1,100,000.

7.6 Monitoring and Conservation Program for Ichthyofauna

A field investigation during summer, autumn and winter to survey the natural history of the ichthyofauna is desireable. The investigation should include physical and chemical characterization of the body of water, specially in the areas conformed as ponds. These data are related to the climatic data such as rainfall, river flow and river level to assess the efficacy of the river maintenance flow in sustaining life in the river stretch. The institutions that will be involved in this program are UFSC, FURB, and FUNPIVI. Cost estimated for this implementation is US$ 21.000.

7.7 Climatic Condition Observation Plan

This program is directly associated with the monitoring of the climatic conditions such as determination of the flood possibility. The main parameters to be monitored should reflect the rainfall, river flows and river water levels. This program should start one year before the beginning of the construction works. Cost estimated for this implementation is US$ 82,500.

7.8 Water Quality Control Program

To observe the effects of the reservoir area and the reduced flow stretch, the water quality control program will provide data to evaluate the effects of the project on the water quality of the river. FATMA will be engaged in the task provided with adequate equipment to carry on the analysis. Estimated cost for purchasing of the equipmet is US$ 40,000.

7.9 Public Health Control Program

Sanitary and epidemiologic vigilance in the working areas is desireable to avoid outburst and transmission of diseases. The program will be established in accordance with the regulation of health department of the municipalities which includes basic sanitation and lodging as well as sewage treatmet of the workers camp. The periodic visit and checkup of transmisible diseases by the qualified health personnel are desireable. Cost estimated for this implementation is US$149,500.

7.10 Manpower Qualification Program

The manpower qualification program will be implemented by CELESC, SENAI and related townhalls of the communities interested. Cost estimated for this implementation is US$7,500.

7.11 Supporting Program for Municipalities

This program is to give technical support to the municipalities of Apiúna, Lontras and Ibirama through the formation of a technical comission. The definition of the financial opportunities for project implementation will be made available. This action will be implemented by CELESC and the interested townhalls. Cost estimated for this implementation is US$ 18,000.

For estimated road length of 1000 m adjacent to populated areas, asphalt covering should be provided. This measure will avoid dust and mud in the populated areas where traffic is expected to be regular. The responsible offices involved will be the road department of the Ministry of Transportation DNER and CELESC. The estimated cost of asphalt pavement is US$48,000.

7.12 Population Transference Program

The transference of population from the community of Subida will be handled by CELESC, in accordance with committee of local inhabitants. The cost estimated for the implementation of this program is US$ 8,000.

7.13 Social Communication Program

The social communication program should be implemented through the organization of a group by CELESC and other groups of interest in the community. Various means of communication such as booklets, videos, foulders, meetings and round tables will be utilized. Cost estimated for this implementation is US$ 26,000.

7.14 Monitoring of Traffic Regulations

The periodic vigilance of the traffic law enforcement in the affected areas by heavy traffic especially for traffic in the village of Subida and related intersections with the BR-470 is recommended to avoid accidents. The control meassures will be enforced by traffic signals, lights and permanent presence of traffic official in critical traffic points. The implementation of this meassures can be achieved through the cooperation of the local branch of the Ministry of Transportation.

7.15 Prevention of Reservoir Use by Swimmers

A buffer area of 100 m with a fence and signs should be provided to avoid possible accidents, and to alert tourists of the possible danger of swiming in the reservoir area. The responsible offices involved will be CELESC and a contrctor to install the fence and signs. The estimated cost of this action is US$ 48,000.

7.16 Total Cost

Total cost for the environmental control measures as estimated above is about US$ 1.8 million.

8. EXPROPRIATION PLAN AND LAND PURCHASE

8.1 Reasons for Expropriation

Resevoir Site

Although there is no house to be submerged in the reservoir water, the formation of the 100 m wide buffer belt around the reservoir margin will affect 3 houses. Two of them are used as residences each by a family and the remaining one is a leisure house. In addition to the houses, about 49 ha of land will be needed for formation of the reservoir and to build project facilities such as dam, intake, desanding basin and headrace culvert.

Furthermore, another area of 30 ha is needed for the lands for quarries, spoil banks, access roads, construction plants and construction camp/office. Three dwellings of which two are permanent use are included in these areas.

Construction of Powerhouse

Because of the increase in traffic due to construction of the powerhouse, the possibility of accidents will increase in the village of Subida. The relocation of the community may be required.

Other possible effects will be use of explosion. The houses to be affected is as shown in Fig. VI.8.1.

8.2 Purchase Priorities

According to the development of the project activities, the purchasing priorities are considered to be the following, in order of importance:

1: Dam and reservoir area
2: Powerhouse and surge tank area
3: Quarry and spoil bank areas

8.3 Evaluation of Areas to be Purchased

Reservoir, Dam and Water Intake

Properties will be partially affected. Since there are no conflicts over the possession of land, this situation presumes a routine process of acquisition/expropiation without major problems. The owners have legal possession of the land, and it is foreseeable that a friendly process of acquisition is possible, and this will lead to the indemnity of lands and improvements. In the properties in which non-reproductive improvements (houses) are affected, the removal of the improvement or its indemnity is the alternatives. If it is not removed, the improvements must be demolished. In the case of indemnity with subsequent demolition, CELESC is in charge of the final disposition of the construction materials.

Headrace Tunnel and Penstock

In the case of underground tunnel or shaft, permissions for their construction is required and it should be given by the Mining Department, DNPM. No permission on compensation is required for the land owner on the surface above the tunnel or shaft.

Powerhouse Site

The construction process of the powerhouse needs rock blasting of a significant volume and the handling of explosives. The area to be expropiated will be of greater complexity than that of the reservoir. This area comprises properties for the extraction of granite, which also have improvements (houses) to lodge the workers. The process to acquire the properties involve negotiation for the relocation of the population.

About 5 houses will probably have to be relocated since they are very close to the site, and other 5 will probably need to be relocated due to their proximity to the roads where heavy traffic of machinery and equipment takes place. These houses will be directly affected by the above mentioned activities as shown in Fig. VI.8.1.

Spoil Bank Areas

If a work to restore the degraded areas including reforestation instead of purchasing the land is performed, it will be needed to negotiate an indemnity for damage caused during construction period. If this negotiation is not possible, the spoil bank areas must be acquired. A detailed description and location of the spoil banks are stated in Section

3.3.

Ecological Station

Negociation will be also needed for allocation of the ecological station site. The negotiation with the state government should consider a decree declaring the area to be of public utility. This declaration would greatly facilitate the acquisition process.

Reservoir Protection Belt

The CONAMA resolution No. 004/05 deals with the protection belts required for power plant reservoirs, and considers a strip of land of 100 m horizontally measured from the highest level of the reservoir.

8.4 Kind of Indemnification

The process of indemnization to be adopted by CELESC will cover the following types of compensation:

(i) Acquisition of the lands to be submerged by the reservoir formation or to be occupied by the dam, intake and powerhouse.

(ii) Compensation for reproductive improvements such as permanent cultures, forests, cultivated pastures; and non-reproductive improvements such as buildings and infrastructure.

(iii) Acquisition of lands necessary for the protection belt, environmental programs, and remaining works necessary for the project implementation.

8.5 Establishments to be Partially or Totally Affected

The properties to be totally affected are these to be acquired and the partially affected are those whose properties are considered either improductive or usefull for the project works. Properties to be totally affected are characterized under the estates to be purchased for the reservoir formation, construction of the powerhouse, creation of the ecological station and establishment of the protection belt around the reservoir.

Properties to be partially affected are those of the spoil bank areas and municipal

roads. If a work to restore the degraded areas in the spoil banks including reforestation instead of purchasing the land is performed, it is possible to negotiate an indemnity for damage caused during construction period. If this negotiation is not possible, the spoil bank areas must be acquired.

8.6 Determination of Values

Permanent or Temporary Crops and Forests

For methodology to be used, basically Brazilian norms for value determination, as well as the criteria adopted by CELESC should be referred. The criteria to estimate the reproductive improvements will be defined by the cost method plus the economic value of the plantations. These criteria will also include the value of displacement related to constructions.

Constructions of Infrastructure

The secondary improvements such as roads, water suplly systems, electric power networks and entries will be performed by CELESC in the location of the resettlement.

Cleared Soil

The comparative method will define the value of the bare land, taking into consideration all the factors related to the evaluation and depreciation of its market value.

8.7 Possession Issues

It is necessary to follow judicial procedures for the case of no acceptance of the values estimated. If it is impossible to achieve a solution, the property should be examined and the corresponding report must be presented so that the possession title can be issued at least 6 months before starting the filling of the reservoir.

8.8 Characterization of Areas to be Purchased

The definition of the areas necessary to implement the project depends on the function of the engineering design for the project works and the works defined in the environmental study. A characterization of these areas is presented below. This characterization will identify the process of their occupation, and the appropiate procedure to

acquire them.

Reservoir, Dam and Water Intake

These facilities will affect 3 houses. There are no conflicts over land possession and the overall situation presumes a routine process of acquisition/expropiation. The process will lead to the indemnization of lands and houses.

For the properties in which the non-reproductive improvements are affected, two alternatives may be offered, the removal of the houses to the remaining area of the indemnity, or the demolishion of it. In the case of indemnity with further demolition, CELESC is to indicate what is to be done with the construction materials.

Powerhouse and Surge Tank

The powerhouse site will be defined not only by the work site but also by the conditions imposed through the construction process. The process entails rock blasting of a significant volume with dispersion of fragments and the handling of explosives. These activities will define the area to be affected. The area to be acquired to meet these needs will presumably be of greater complexity than that for the reservoir. This area comprises sites for the extraction of granite, which also have houses to lodge the workers.

The resettlement process will involve the negotiation for the relocation of the population. This negotiation will indicate whether the owners will receive an indemnity or whether the houses will be exchanged for improvements to be built.

Spoil Banks

Spoil bank areas to be used are degraded areas with no infrastructure and pronounced slopes and covered with grasses. If a work to restore the degraded areas in the spoil banks including reforestation instead of purchasing the land is performed, it is possible to negotiate an indemnity for damage caused during construction period. If this negotiation is not possible, the spoil bank areas must be acquired.

Access Roads

Access roads should be built to integrate into the road infrastructure of the region and will have the characteristics required for public use.

Ecological Station

The definition of this area depends on the negotiation with the environmental offices. This negotiation will define how the demand will be staisfied. A negotiation with the state government should take place aiming at the issue of a decree declaring the chosen area to be of public utility. This will greatly facilitate the acquisition process.

Basic Prices for Land Acquisition

Basic prices have been estimated to offer the baseline for more accurate estimates. Further analysis of prices will entail cadastral work and field survey.

The price survey was carried out by AMBIENTAL Consultora de Planejamiento in Feburary 1993, based on the engineering designs indicated in the report of the Hydro Inventory Study - 1991 (JICA) in which the dam was to be located on the axis C. Its result is as follows:

	Unit	Price (US$)
Land, plain area mechanizable	ha	1,500
Land, hilly area not mechanizable	ha	850-1,000
Building at damsite (axis C)		
Dweling house	no.	6,000-8,000
Livestock shed	no.	400~1,500
House lot along road (powerhouse site)	no.	100

These prices are referred for estimation of the basic prices for land acquisition required for the project.

9. RESETTLEMENT PLAN

9.1 Organizational Capacity for Resettlement

Responsible Offices

The offices responsible for the resettlement plan are CELESC in coordination with the resettlement department of ELETROSUL.

The participation of a sociologist is important, specially for the relocation of the inhabitants of Subida where the socio-economic and family structure require more elaborate planning. For the Subida relocation, the municipal authority or Veriador seems to have the closest institutional contact and authority with the community.

Assistant Agencies

Agencies to assist in the resettlement plan are the municipality of the area through the Veriador, the resettlement department of ELETROSUL, and the in charged department at CELESC.

9.2 Participation of Affected People

This is a crucial aspect for the effective solution of the relocation plan. Strategies for the participation of settlers, as well as strategies for the participation of the host population have to be designed for the successful achievement of resettlement. Dissemination of information about the relocation, settlers rights, compensation procedures, available choises etc. is an indispensable premise for the participation. This requires an organized and systematic communication mechenism.

Initial resistance or hostility to the idea of resettlement is normal and should be expected. The responses will greatly depend on establishing good communication and on encouraging their participation in finding solutions. Participation of the local leadership is another basic requirement underlying the recommendations for resettlement.

Strategies for Participation of Settlers

The participation of the settlers will be initially approached by the Veriador with a previous briefing of the project activities. This briefing should include inconveniences

expected for them, possibilities of a more adequate site for relocation, need for their participation in the solutions, and finally, possibility of participation of workers for the project.

Previously identified communal activity centers such as a church or communal center or others of the like could serve as physical context to meet the settlers. In this context, an explanation of the project will serve to expose the reasons for resettlement, and in a second stage to listen to the needs and expectations of the settlers in respect to their future location. This feedback information coming from the settlers will serve for the location of adequate areas and conditions for resettlement.

Strategies for Participation of Host Population

It is important to consider also the host population who will receive the new settlers. The participation of this population is also considered as feedback to the resettlement plan which will point out possible conflicts arising from the action of relocation.

A similar strategy of approaching the host population is considered adequate namely initially briefing of the project, then establishing the need of relocation and third a characterization of the incoming settler population.

After the presentation of the situation has been made, the feedback coming from the host population will serve to adjust the conditions of a possible relocation to the studied area.

It is advisable to relocate the dwelers of Subida as close as possible from their actual living space. This action will greatly simplify the effects upon the host and the settler population.

Although host populations may react favorably to the arrival of the displaced people, serious conflicts may arise as increased demands are placed on land, water, services etc. Equitable treatment should be provided as far as possible to both host and settler populations. The previously set out measure will be needed to avoid jealousy of the host population because of better housing or conditions provided for the settlers than those of host population.

9.3 Baseline Data on Affected Area and Population

9.3.1 Population Census

Population census have been issued by IBGE census department every 10 years. In order to obtain the data on actual status and socio-economic structure in the affected area, this cencus should be fully utilized and correlation between these data and actual on-site cencus should be studied by means of contact with related community direct interview and the use of questionaries prepared by a sociologist.

The description of the productive systems existing in the area and the main social groups (employees, merchants, farmers etc) and the form of social organization that depends upon them (ownership, tenure system, etc) should be identified. The description of groups of higher risk such as elderly, handicapped, women head of house etc. should be considered. The description and inventory of public and common areas, infrastructure and other productive or social resources like school. church, health center, grazing lands, quarries, adjacent forests etc. should be considered.

9.3.2 Demarcation of Land Use for Livelihood

The demarcation of land use for livelihood should cover not only the living space and the space dedicated for agriculture, but also the spatial relationships linking the economic activities and the flux between such spaces. In this regard, the spatial relationship among quarries, factories, provision of food, education, recreation, religious and communal centers must be identified. The result will be a net of spaces and relationships which will compromise the context of space use for livelihood.

9.3.3 Environmental Resource Use

The use of environmental resources including the raw materials associated with the energy flux through the economic structure of the community should be identified. Environmental resources such as quarries, wood for cooking, water, pasture for animals etc. must be identified in order to establish the needs to be fullfilled in the new settlement area.

9.3.4 Environmental Constraints

Environmental constraints of the affected population must be identified in order to

provide better conditions in the new location.

9.3.5 Inventory of Common Use Areas

Areas of common use such as school, church, communal center, clinic and recreational place must be identified. The identification of these areas should be carried out to evaluate the needs of the population for such areas, or to identyfy the absence of them. The purpose of this inventory is to provide equal or better conditions for common use areas in the recipient area.

9.3.6 Social Infrastructure

The development oriented resettlement requires social infrastructure such as school and health services and access to employment opportunities and, if applicable, the dwellings should be planned to meet the needs of resettler's growing families taking into account, if possible, at least the first and second generation in the settlement.

9.3.7 Public Health Conditions

The public health conditions of the population must be evaluated to avoid transmisable diseases to reach the host population. A development oriented resettlement will look after improving the public health conditions by allocating the population in an area with access to public health services.

9.4 Resettlement Policy and Legal Framework

A definition of the resettlement policy and development policy to be applied has to be decided. Replacement of land and other productive resources house reconstruction, cash compensation levels and terms for individuals or groups have to be defined. A legal definition of the rights of the displaced population must be achieved. These will include resettlement grants institutional assistance for land replacement and land alteration procedures at new sites technical and financial assistance for bringing new resources into production; rights of the landless and those in non agricultural sectors.

9.5 Development Plan for New Sites

9.5.1 Plans and Layouts

Objectives of development for the displaced group should include alternative development strategies among which families can choose and a further study on the implementation of each alternative is made.

9.5.2 Subsistance Plans

Permanent employment opportunity development of small industries and the investment required for the creation of new jobs as well as temporary employment opportunities in the construction works of the project should be considered.

9.5.3 Monitoring Arrangements

The objective of monitoring resettlement operations is to assess resetlement progress, identify difficulties, ascertain problem areas, and to provide early warnings calling for attention to make corrections needed. Monitoring and will be performed by a specialized group.

The monioring entity should be able to make differential assessments about the social groups exposed to higher risks from resettlement like small marginal farmers, landless laborers, unskilled laborers, children and elderly, and women without support.

Specific processes to be covered by monitoring studies during the preparation of the resettlement operation include:

- communication with and reactions from the prospective resettlers,
- information of the resettlers about their entitlements, available options, alternative development opportunities, relocation of timetables etc.,
- visits by prospective new settlers to potential new sites,
- valuation of property to be lost,
- disbursement of compensation,
- trends of land markets in the arrival areas and trends in prices of house construction materials.

When physical transfer of the people starts, the monitoring system should be

performed for the people to be removed and their belongings to the receiving areas, as well as the allocation of replacement assets. Once transpering works have begun, weekly situation reports should be issued.

After the resettlers evacuation and arrival at the new sites, monitoring should focus on the delivery of services and inputs, issues of titles, reconstruction of dwellings, preparation of fields, assessing of people economic adjustment, and relationships between resetlers and hosts.

9.5.4 Enviromental Protection

The resettlement plan must be drawn with a definite orientation towards preventing environmental deterioration. The key indicator for the resettlement plan is the ratio between the incoming resettled population and the host population already inhabiting in the receiving area. This would measure the incremental population density per unit of land caused by resettlement and the likely increased pressure on the area's natural resources.

In sum, well balanced resettlement plans tend to proceed towards re-establishing the population in a development-oriented and environmentally sound manner. To achieve well balanced resettlement, the program must incorporate production-based development packages, adequate compensation, new setllement infrastructure, health and environmental protection measures, as well as the strenghtening of the social organization.

9.6 Transfer Arrangements

Information Campaign: Information dissemination between the displaced and host people should explain the resettlement policies, the rights of the dispalced people, the legal provisions, the schedule for displacement, and the transport means available among other usefull information for the transfer.

Transition Monitoring: The transition monitoring should cover aspects such as availability of food, fuel, wood, medical services among other needs presented during the lag time between moving out of the old site and the time to be economically settled.

Movilization Schedule: Logistics or routes prepared to facilitate access and exit from old sites to new sites, vehicles to be used for hauling belongings, livestock, house materials, etc. and those for hauling persons are to be scheduled for a proper execution of the transition.

9.7 Implementation of Resettlement

Financing Plan

The financing for the resettlement costs will be made from several sources such as state or central government, as well as from the project funds. The project management will identify the financing plan to follow, according to the baseline information gathered from the expropiation plan and the usual mechanisms utilized by CELESC.

Implementation Schedule

Resettlement timetable should be coordinated with the chronogram of construction and other project activities. A diagram should be drawn up to summarize the resettlement plan showing all critical path activities by month for years -2, -1, 0 (0=transfer year), +1, +2 and so forth, until transfer is completed.

Costs

It is convenient to establish the cost accounting and the economic analysis according to broad stages of the resettlement process: preparation, relocation and re-development. A typical cost and benefit check list for resettlement is given for the followings;

Preparation and Compensation Costs

(1) Cost of census of the affected population and inventory of properties,
(2) Compensation for properties lost;
    - Cost for residential site assessment in receiving area,
    - Cost of purchasing replacement land.
    - Cost of preparation of replacement land.

Relocation Costs

(1) Cost of moving and transport,
(2) Cost of replacement of housing,
(3) Cost of village infrastructure at relocation site.
(4) Relocation/replacement of other infrastructure,

(5) Subsistence packages, and
(6) Special welfare services during resettlement.

Re-development Costs

(1) Cost of communal re-development,
(2) Cost of household re-development,
(3) Incremental services (health, education etc.), and
(4) Environmental enhancement packages.

Administrative Overhead Costs:

The administrative overhead costs should includes cost for physical facilities, vehicles, materials, operational staff, support staff, training, monitoring, evaluation and technical asistance.

Care for Resettlement

Involuntary resettlement is often approached as a salvage and welfare operation, rather than one pursuing development objectives. Involuntary resettlement dismantles a production system and a way of life. In specific case, this action is relevant to the powerhouse site and the community of Subida. If it is approached in a creative way, the resettlement action to be carried out for community of Subida will serve to improve the quality of life of the community.

In the case of the reservoir site, the relocation of the rural estate belonging to a peasant family is the most delicate situation in the area. This relocation as same as in the case of the community of Subida should provide the creative means for a re-establishing of the family as self-sustained producers or wage earners.

Table

Table VI.3.1 List of Road Alternatives

Road No.	Length (km)	New or Existing	Location	Environmental Aspect	Final Selection (*)
AR-1	0.9	New	From L-S road to surge tank & adit No.1	Region is steep declivity and covered with secondary forest and some deforestation will be required.	O
AR-2	0.4	Existing rural road	From L-S road to SB-11	Road improvement will result in some deforestation and traffic will increase.	
AR-3	1.0	Existing 0.6km and new 0.4km	From L-S road to SB-7 & adit No.3	New construction and improvement of road will result in slight deforestation.	
AR-4	1.4	Existing 0.7km and new 0.7km	From L-S road to dam axis-C through SB-8 and branched to tunnel portal	New construction and improvement of road will result in slight deforestation.	O
AR-5	1.2	Existing	From AR-4 to dam axis-D and to SB-9	Road improvement will not result in notable deforestation.	O
AR-6	2.0	Existing	From AR-5 to quarry-B along right bank of river	Railway track is used. Partial widening and improvement are required.	
AR-7	1.5	Existing	From quarry-B to SB-21 through crushing plant yard CP-3	Some deforestation will be required for road improvement.	
AR-8	1.0	Existing	From L-S road to AR-9	Some deforestation will be required.	
AR-9	2.0	New 0.7km and Existing 1.3 km	From L-S road to dam area C through dam axis B and branched to tunnel portal	Most part is on railway track. New road is in agricultural land.	O
AR-10	0.3	Existing	From L-S road to SB-1	Deforestation will be scarce.	O
AR-11	2.7	Existing	From BR-470 to dam axis B through SB-5 & SB-16	First 500m is in village. Remaining part is in agricultural land. This road will be used frequently by heavy vehicles when excavating dam foundation and when transporting rocks from quarry C.	O
AR-12	0.5	Existing	From AR-11 to SB-4	Deforestation will be scarce.	
AR-13	1.2	Existing	From dam axis C to SB-7 along left bank	Partial deforestation will be required.	
AR-14	0.6	Existing	From BR-470 to quarry-C	This is used presently for quarrying.	
AR-15	0.5	Existing	From SB-1 to quarry-A	Some deforestation will be required.	O
AR-16	0.7	Existing	From L-S road to SB-10	Deforestation will be scarce.	
AR-17	0.8	New	From powerhouse to drainage adits	This is in already degraded area.	O
AR-18	0.8	Existing	From L-S road to construction camp CC	Deforestation will be scarce.	O

Notes (*) : selected for scheme of dam axis B.
"L-S road" denotes Lontras-Subida road. SB denotes spoil bank.

Table VI.3.2 List of Spoil Bank Alternatives

No.	Location	Dimension (m)	Capacity (m3)	Houses (nos.)	Environmental Aspect	Adequacy
SB- 1	RB, near Quarry-A	200 x 200 x 10	400,000	1	Vegetation is mainly grasses with no flora, fauna nor cultural values of interest	O
SB- 2	RB, 0.7km from dam B	300 x 100 x 15	120,000	non	Vegetation is secondary and degraded, with a small water creek (Piave affluent) drains into this u-shaped depression. This water must be canalized properly when used as spoil bank.	
SB- 3	RB, 0.6km from dam B			non	located at batcher plant yard BP-3, and not used as spoil bank.	
SB- 4	LB, 0.7km from dam B	200 x 60 x 20	160,000	1	L-shaped land with limited high hill. Occupied by a peasant family related in their activity to Paraiso Camping operation. They have domestic animals and a vegetable garden for own use and for selling to Paraiso restaurant. For this reason, use of this area as spoil bank is not considered adequate.	
SB- 5	LB, 1.5km from dam B	150 x 50 x 5	37,000	non	This area has some citrics planted and no other vegetation of interest.	O
SB- 6	LB, 0.6km from dam C			non	This area is covered with altered primary vegetation in a good regeneration process. It is not advisable o use this site as a spoil bank because of the importance of the isolated vegetation patches.	
SB- 7	LB, 1.2km from dam C			non	This area is also covered with altered primary vegetation in a good regeneration process. By the same reason, it is not advisable to use this site as a spoil bank .	
SB- 8	RB, 0.8km from dam C	250 x 100 x 15	150,000	non	Located on a creek surrounded by secondary forest.	O
SB- 9	RB, 1.3km from dam C	250 x 220 x 10	550,000	non	Vegetation consists of grasses without agricultural lands and there is no flora and fauna or cultural resources of interest. Present road has to be improved to facilitate access.	O
SB- 10	RB, 3.8km from surge tank	200 x 30 x 10	60,000	non	located on a creek without important vegetation.	
SB- 11	RB, 3.4 km from surge tank	180 x 80 x 10	70,000	non	This area is located closely to a small number of permanent residencies. Main concerns are inconveniences of dust and noise to the residents. This area is covered with grasses and pasture, and good as spoil bank	
SB- 12	RB, 1.2km from surge tank	250 x 150 x 30	150,000	non	This area does not have any vegetation of interest,. This area is covered mainly with grasses and isolated bushes with some banana trees on slopes, which were planted by a adjacent family. However, the disposal of material will not affect this family.	O
SB- 13	RB, 0.8km from powerhouse	200 x 40 x 5	30,000	non	The site is relatively flat and covered with grasses. The site is suitable for use as construction office area OA-2.	
SB- 14	RB, 0.4 km from powerhouse	150 x 40 x 4	20,000	non	It is used as a small quarry being exploited by dwellers of Subida. Disposal of materials in this area will worsen the relationship between them and the project personnel. This site is considered not suitable.	
SB- 15	LB, 1.5km from powerhouse	150 x 50 x 30	150,000	non	Vegetation is degraded, mainly consisting of grasses and shrubs; no vegetation of interest was detected. Road leading to this site is narrow and it is difficult to enlarge the road width because of rock formation limited by cliff in several sections. This site is not adequate.	
SB- 16	LB, 0.3 km from dam C	150 x 150 x 20	200,000	non	Covered with grasses. There is no vegetation of interest.	O
SB- 17	RB, 0.4 km from intermediate tunnel adit	200 x 100 x 15	300,000	non	Covered with grasses without any vegetation. Existing creeks must be treated properly. Adjacent to the site, wooden houses and 2 shacks are located, which must be respected while these do not need relocation.	
SB- 18	RB, 3.8 km downstream from powerhouse, 100m from BR-470	250 x 200 x 6	300,000	2	2 families reside adjacent to this area and they need relocation. The site is covered with brush vegetation, grasses and isolated bushes, and no vegetation of importance is evident. There is a small brook that has to be considered for its proper drainage.	O
SB- 19	RB, 3km downstream from powerhouse, along BR-470	200 x 50 x 7	70,000	non	The site is covered with grasses and used for grazing horses. There are power line posts near the highway which need relocation.	O
SB- 20	RB, 0.7 km from powerhouse	60 x 40 x 5	12,000	non	The site is next to a road and eroded by river eddy. This area can be used to dispose mainly rocks to avoid further erosion to the road bank.	O
SB- 21	RB, 1.4 km from quarry B	200 x 100 x 30	200,000	non	Covered mainly with grasses and no vegetation of interest is found. This site is used to dispose of non rock material coming out of quarry B.	

Notes RB : Right Bank of river. LB : Left Bank of river.

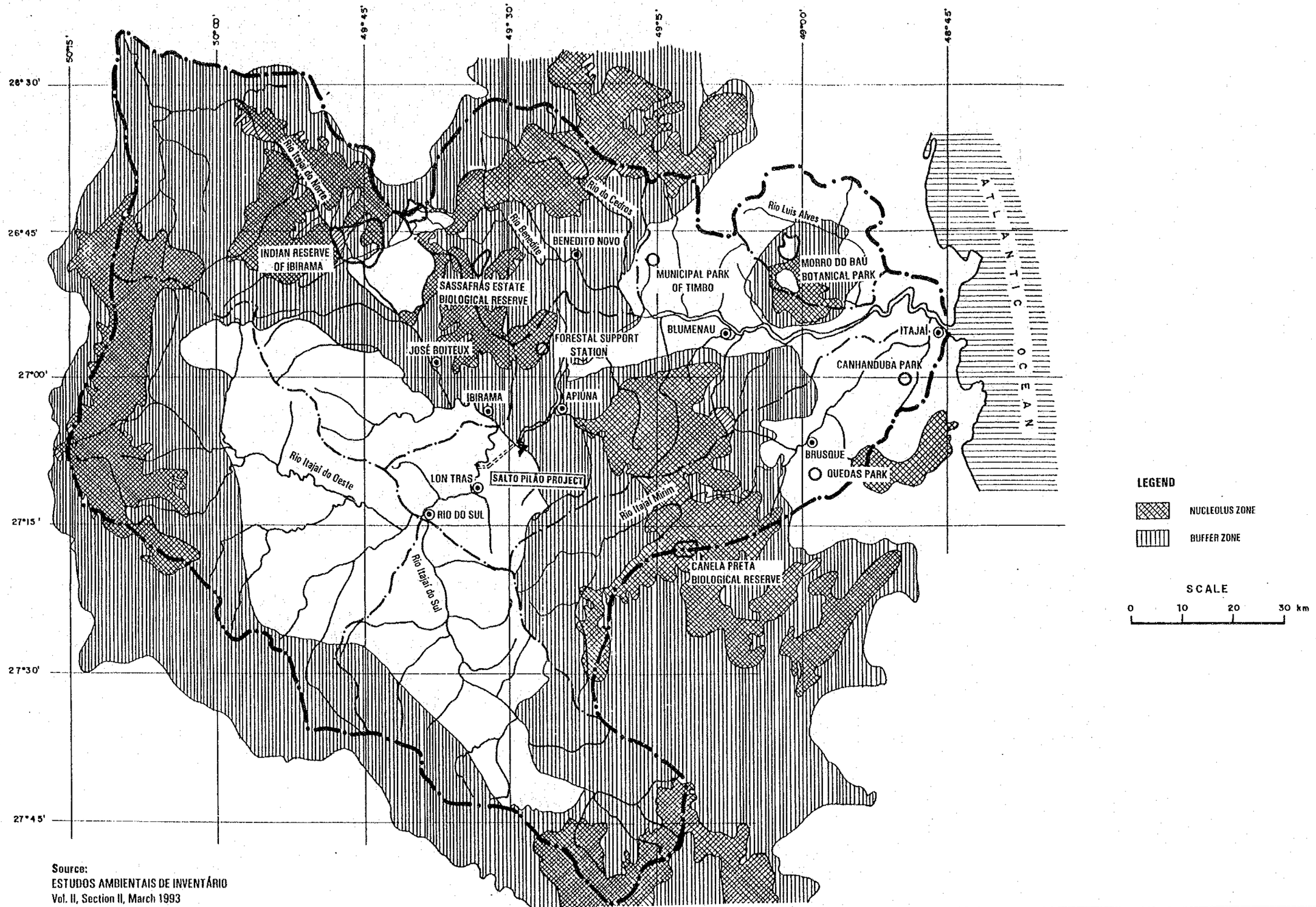
Table VI.4.1 Acquisition of House and Land and Number of People to be Resettled

Item	Unit	Quantity		Item	Unit	Quantity	
1. Dam & Reservoir							
(i) Left Bank and Island							
Flat area				Access road (AR-4,9)	ha	0.9	
Reservoir Area	ha	0.5		Quarry (Q.A)	ha	2.6	
Buffer Area	ha	1.3		Spoilbank (SB-1)	ha	3.6	
Quarry (Q.C.)	ha	2.0		Spoilbank (SB-8,9)	ha	10.6	
Spoilbank (SB-5)	ha	3.1		House R-1 (Reservoir)	nos	1.0	(0)
Mountain area				House R-2 (")	nos	1.0	(12)
Reservoir Area	ha	1.1		House R-3 (SB-1)	nos	1.0	(0)
Buffer Area	ha	7.6		House R-4 (C.C)	nos	2.0	(10)
Diversion & Dam	ha	1.9		Sub-Total			
Access road (AR-11)	ha	0.4					
Spoilbank (SB-16)	ha	6.8		**2.**			
Island (5.3ha)	L.S.			Powerhouse	m	280.0	
Resort Area (Camping Area)	L.S.			- do -	ha	5.9	
House L-1	nos	1.0	(5)	Surgetank	ha	1.1	
Sub-Total				Work adit No.1	ha	0.7	
				Access road (AR-1,17)	ha	1.3	
(ii) Right Bank				Spoilbank (SB-12)	ha	2.2	
Flat area				Spoilbank (SB-18,19)	ha	6.0	
Crushing Plant (CP-1)	ha	2.0		Concrete Plant (BP-2)	ha	0.6	
Concrete Plant (BP-1)	ha	0.5		Office & Work Shop (O.S)	ha	1.3	
Office & Work Shop (O.	ha	8.0		House (powerhouse)	nos	10.0	(40)
Construction Camp (C.C	ha	10.5		House (BP-2)	nos	3.0	(0)
Mountain area				House (SB-18.19)	nos	2.0	(10)
Reservoir Area	ha	2.4		Sheds	nos	2.0	(0)
Buffer Area	ha	11.1					
Diversinon & Dam	ha	0.5					
Intake & Desanding basi	ha	2.1					
Open Culvert	ha	1.6					

( ) : Number of people to be resettled

Total Land : 100 ha
Houses : 23 nos.
(including sheds)
People : 77 persons
Household : 16 families

Figure



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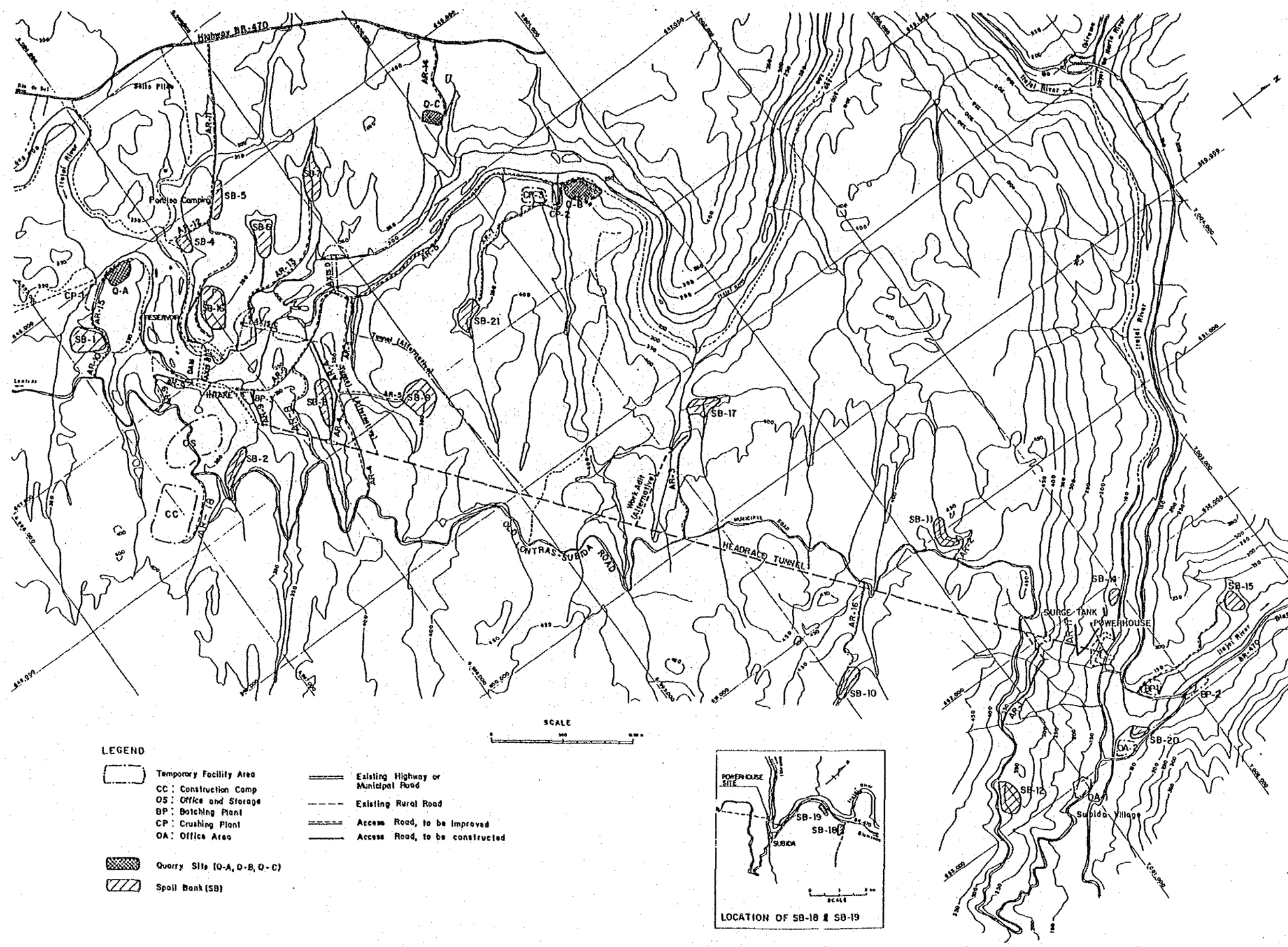
JAPAN INTERNATIONAL COOPERATION AGENCY
CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL
SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT

Fig. VI.2.1
Zoning of Atlantic Forest Ecosystem



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Fig. VI.3.1 Location of Project Facilities

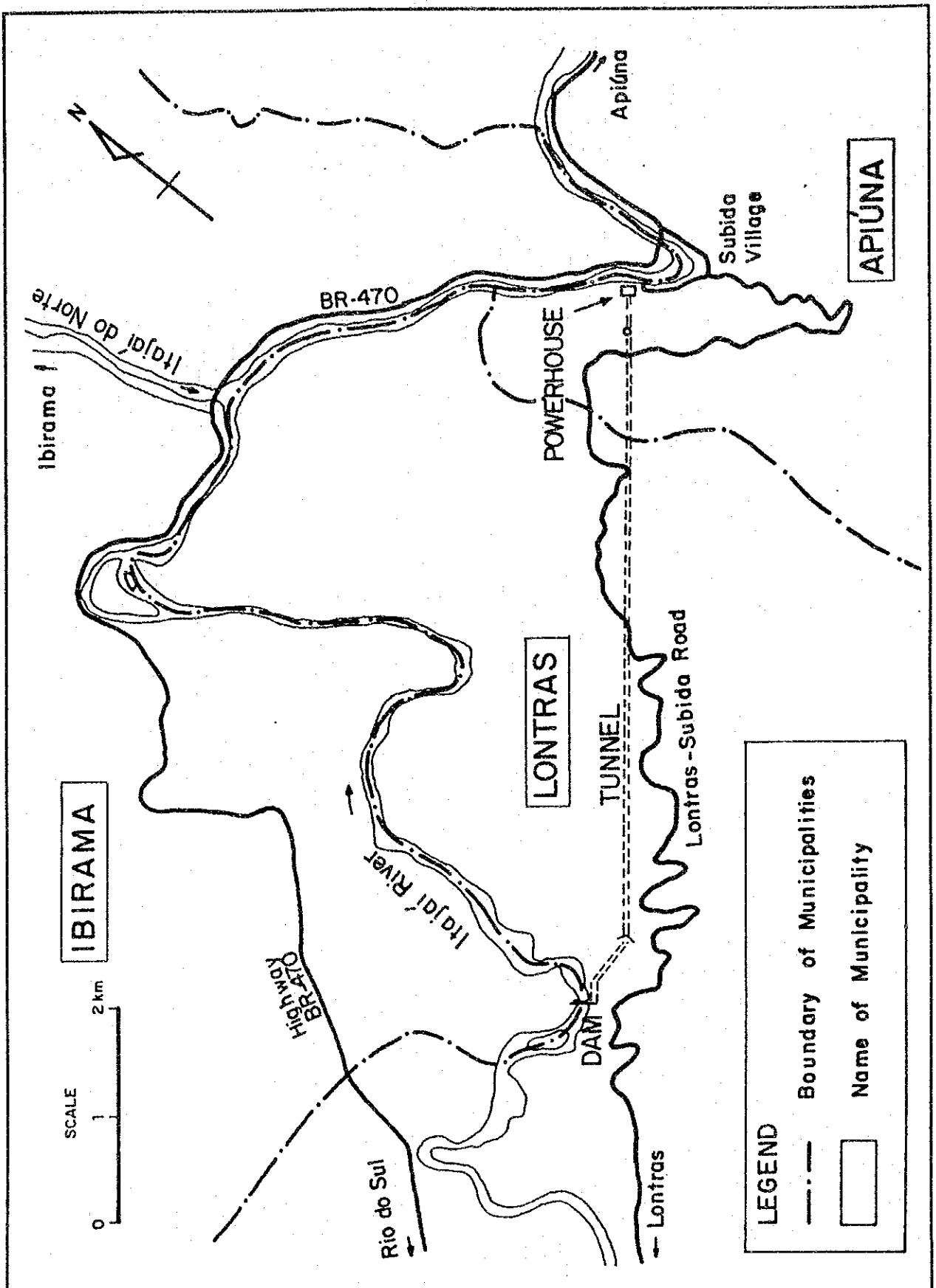


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Fig. VI.4.1
Boundary of Municipalities

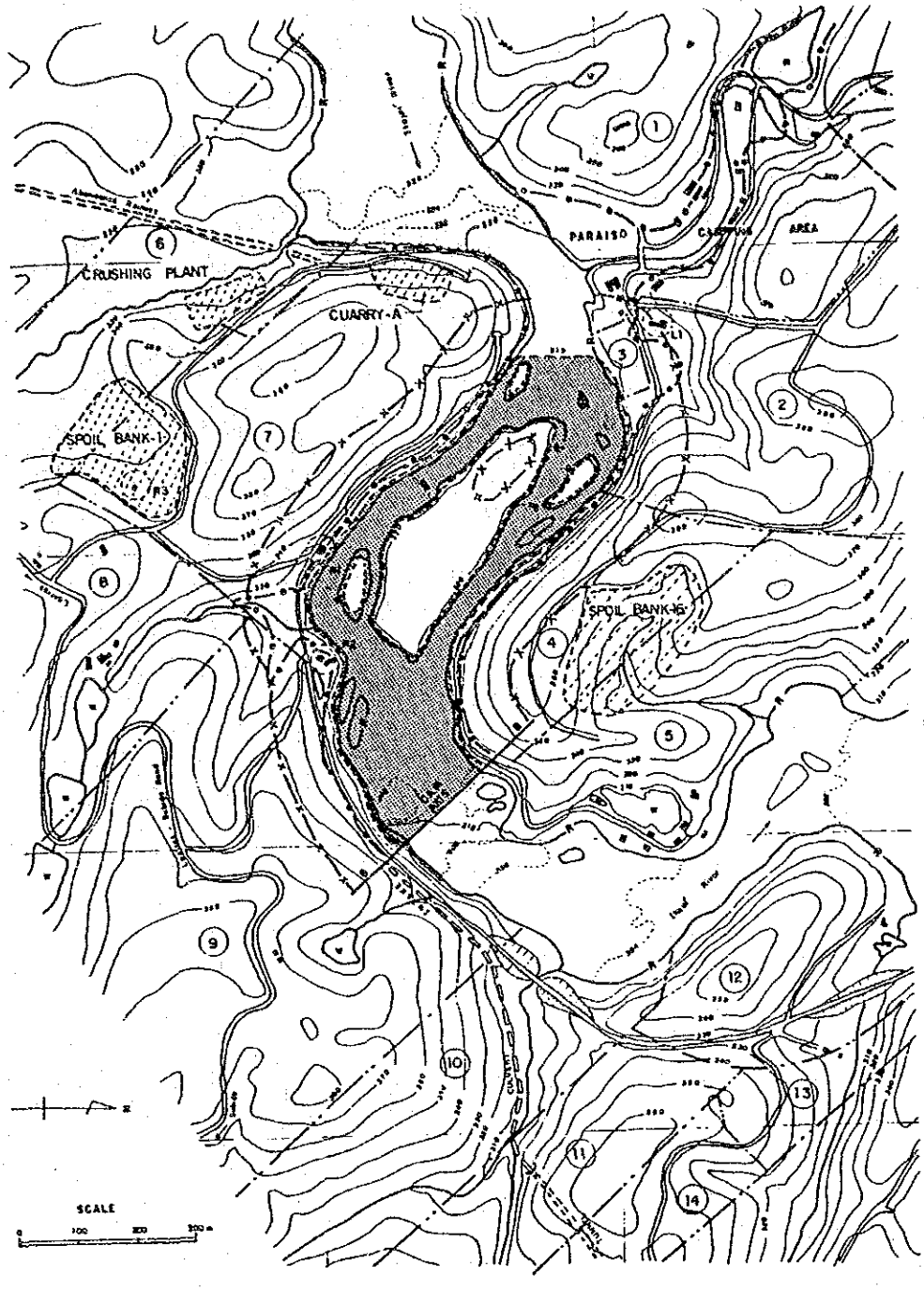

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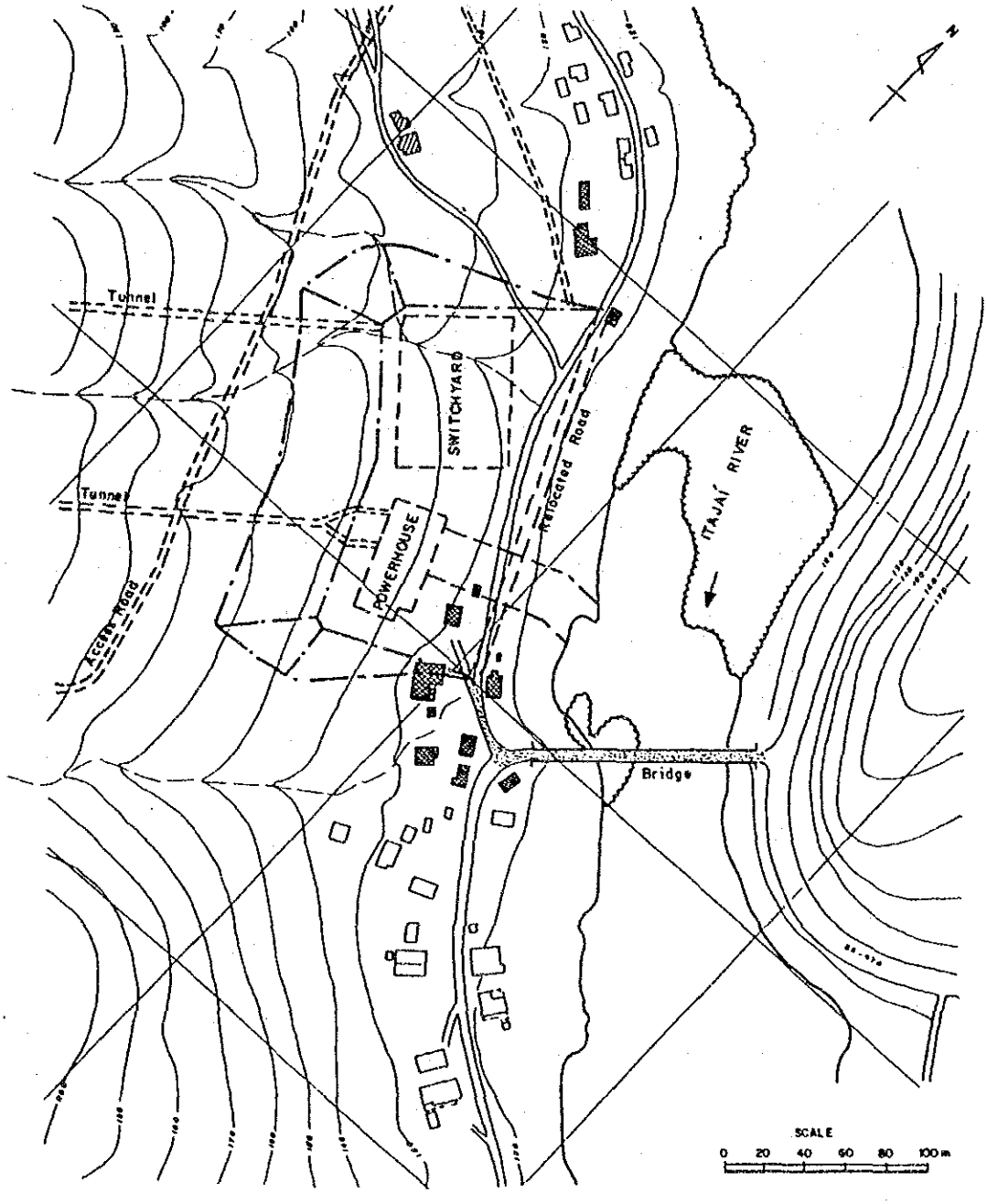
Fig. VI.6.1
Location Map of Affected Estates and Houses at Dam Site



LEGEND

- Houses to be Relocated
- Houses Inaccessible due to Road Interruption
- Road to be used during Construction
- Project Works
- Excavation Boundary

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Fig. VI.8.1
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ATTACHMENT

STUDY ON RIVER MAINTENANCE FLOW

Attachement to ANNEX VI
STUDY OF RIVER MAINTENANCE FLOW

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1. GENERAL

Study on the river maintenance flow (R.M.F) was made from two aspects, hydrology and environmental aspects. From hydrological aspect, river flow condition in the downstream stretch of the proposed river site with and without project was studied. While for environment aspects, biological and anthropeic situations in the downstream stretch of the proposed weir site and expected effect on the river flow reduction were analyzed.

2. HYDROLOGICAL STUDY

2.1 Recorded Drought Runoff

The long-term runoff at the weir site for the period of 50 years from 1941 to 1990, has been estimated based on the runoff data supplied by ELETROSUL/DNAEE. The annual minimum daily mean discharges at the weir site are listed in Table A2.1. According to the table, the followings are remarkable drought in the upstream of the proposed intake weir for the past 45 years;

Drought Year	Minimum Daily Mean Discharge (m^3/s)
1952	4.1
1968	4.3
1986	4.7
1945	4.8
1985	7.6
1943	7.9
1944	7.9

The duration of months in which small discharge last is within one month in the normal year, and 2 months to 5 months in the aforesaid drought years.

2.2 Flow Condition with the Salto Pilão Hydropower Project

The duration of months in which there is no water release to the downstream stretch from the weir site was examined by using the average flow duration curve for the period from 1941 to 1990 as illustrated in Figure A2.1 and assuming the several maximum plant discharge. The result is listed as follows:

Maximum Plant Discharge (m^3/s)	Duration (days)
80	210
70	185
60	160
50	130

In case of the maximum plant discharge of 71.9 m^3/s designed in the pre-feasibility study, there will be no released discharge for 6 months from the intake weir through a year with the project.

3. ENVIRONMENTAL STUDY

3.1 Physical Characteristics

3.1.1 Landscape and topography

The envisaged river stretches in the Itajai river between the proposed intake weir site and tailrace site is 15 km in total river length. A large tributary, the Norte river joins at about 10.2 km downstream from the intake river site.

River gradient of the river stretch is about 1:60 and river banks shows v-shaped section. Many small tributaries flows into the Itajai river by way of small waterfalls. Due to these several river characteristic access to the river is rather difficult.

Along the steep river banks, rock of granite is exposed, popping out throughout the hill side. Majority of them have been exploited or are under exploitation as masonry stone. Clearing by fire is common in these areas to expose rock and to find quarries, leaving no vegetation cover.

3.1.2 River course

The envisaged river course will be divided into four stretches by landuse.

In the river stretch between the proposed weir site and about 1.5 km downstream of the weir site, the areas in both river banks are limited for use of annual crops, fruit growing and pasture and reforestation due to high acidity and abundant presence of rocks. In the river stretch between 1.5 km and 7 km downstream of the weir site, both banks areas are improper for any kind cultivation including commercial forests and any other crop of economic importance due to extremely rocky topography and poor drainage. In the river stretch between 7 km and 8.5 km downstream of the weir site, both banks area have been utilized for annual crops due to slightly hilly topography and well drained condition. In the river stretch between 8.5 km downstream of the weir site and confluence with the Norte river, the left banks area is improper for any kind cultivation including commercial forests and any other crops of economic importance due to extremely rocky topography and poor drainage. While in the left bank area, there is limitation for use of fruit growing, pasture, reforestation, and annual crop.

The river stretch between the proposed weir site and confluence with the Norte river, is characterized by rapid current and high flow velocity, brown colored water throughout the year and a series of small cascade as well as many tributaries flowing into the Itajai river from both banks. Catchment area between the proposed weir site and confluence with the Norte river is around 200 km^2 and discharge from these tributaries is assumed to be approximately 0.2 to 0.3 m^3/sec in total.

A series of depressions are formed in the river bed along the envisaged river stretch and these will be used for some fishes and invertebrate species as areas to rest and dwell for food. The estimated area of these depressions are around six portions and estimated volume of the depression is the range from 90 to 700 m^3 with average depth of 0.6 m as shown below;

Location from weir site (km)	Dimension (l) x (w) (m)	Depth (m)	Volume (m^3)
0.05	120 x 20	0.6	720
0.8	30 x 20	0.6	180
1.5	20 x 20	0.6	120
4.6	20 x 20	0.6	120
5.6	20 x 20	0.6	120
6.0	15 x 20	0.6	90
Total			1,350

3.2 Biological Characteristics

3.2.1 Aquatic fauna

(1) Invertebrates which are considered

There are no invertebrates reported and surveyed for economic or scientific interest nor there are invertebrates considered to be endangered or protected.

(2) Herpetofauna

Due to degradation of environment, many species of amphibious animals and reptiles have been affected for their inhabit and therefore disappeared depleting the environment of its original biological diversity.

The number of the amphibious animals through the survey was far less than expected. Degradation of environment makes different subsistence of these animals especially these that are more suspeptible to environmental changes.

(3) Fish

The survey for fishes was made for the following three stretches;

1) Upstream of the proposed weir site near the Paraiso camping
2) On the axis chosen for the weir site
3) Downstream of around 1.5 km from the weir site.

Five families and twelve species were observed. The most representative families were;

1) Loricaridae representing 49.7% of the specimens captured,
2) Characidae family represents 25.5% of the total
3) Pimelocidae family represents 13.7%
4) Cichlidae family represents 9.9%
5) Curimatidae family represents 1.2%

It was noticed that few species occurs in exclusively limited area, and the most representative families occur over all the area, showing great adaptive plasticity. According to information from local inhabitants, there are abundant fishes in the past and they were caught easier than the present fishing situations. This is an indication of the over fishing and of the deteriorated conditions of the river in these days. Captured species at the different sampling stations show total maximum lengths from 10.3 cm to 29.1 cm, with maximum weights from 13.39 g to 259.72 g respectively.

(4) Endangered and protective species

There are no endangered or protective species recorded or found in this area, neither there are species of commercial or scientific interest reported. The fish populations in the area are very plastic, and occur in the upper and lower reaches of the river, and are not dependent on long migrations for their subsistence.

3.2.2 Flora

(1) Terrestrial flora

Vegetation covering the envisaged river stretch area has been fairly degraded due to deforestation, burning of trees by inhabitant and clearing of bush to expose rocks for finding granite quarry. The degraded vegetation above the slope of the banks has no or very minimum relationship with water resources of river, resulting steep slope of the banks and rather impermeable characteristic of soil in this area.

In general, the whole project area is located outside the area considered as nucleus or buffer zones for the remaining flora of interest. Some patches of secondary forest are isolated by large open area of grasses and these patches are associated with small gulches where small tributaries flow and they derive water resources from these tributaries not from the Itajai main stream.

(2) Aquatic flora

There is no aquatic flora of economic or scientific interest. Suspended soils in river water offer condition of brown colored water of low light penetration. Due to this river phenomena, aquatic flora do not almost exist.

(3) Endangered and Protective species

There is no endangered and protective species in this area nor there are species of commercial or scientific interest. Since this area is located outside the buffer or nucleus zone of terrestrial vegetation, aquatics flora is incipient and almost do not exist.

3.3 Characteristics of Anthropeic Context

3.3.1 Landuse

(1) Farming : There is no farming activities of this river stretch areas due to steep slope of river banks. The river bank areas in about 1.5 km long river stretch downstream of the proposed weir site is not suitable for annual crops due to rocky and hilly topography and high susceptibility for erosion. The river bank area is about 8.7 km long stretch between 1.5 km from the proposed weir site and confluence with the Norte river and improper for any kind cultivation including commercial forest and any other crop of economic importance due to rocky topography and poor drainage. The river banks along the envisaged river stretch will be classified as open field area with patches of secondary growth and bushes.

(2) Pasture : Some cattle raising has been carried out in the upper reaches of the slopes in the river stretch but its activity does not depend on river water since river banks present an obstacle for animals to approach the river.

(3) Industry : No industrial activity has not been performed in the river stretch and no water use for industry is expected. No pollutant sewerage has not been recorded or found to be released in the river.

(4) Residential Use : There are no noticeable residential areas in the vicinity of the river banks above the river stretch and only few isolated houses are located in the upper reaches of the slope. They do not depend on river water of the Itajai for their living and potable water has been extracted from water well.

(5) Tourism : This river stretch does not offer swimming place due to high velocity of river water and difficulty of access to the river side owing to steep slope of the banks. Sport fishing is considered poor due to strong current and no tourism facilities do not exist along this river stretch.

3.3.2 Water use

(1) Fishing : High velocity of river water offers no chance for sport or commercial fishing and this area is considered poor for local fisherman.

(2) Municipal/industrial : There is no water use of municipal and industrial activities.

(3) Irrigation : There is no use for irrigation since there are no agricultural activities in this area.

(4) Effluent disposal : No disposal of effluent, sanitary or industrial origin are found or reported in the river stretch since there are no urban or industrial activities in this area.

3.4 Expected Effects on Flow Reductions

3.4.1 Government regulations

DNAEE stipulates in its rule 02 for the approval of Hydropower Generation Studies for public Service item 3.7, that:

"For working out the studies and the basic project conception one must take into consideration that the remaining flow in the water course downstream of the dam shall not be less than 80% of the monthly mean minimal flow which is calculated based on the historical series of natural flows comprising at least 10 years. The cases for which the criteria above mentioned are not applicable and the reservoirs in cascade will be examined by DNAEE".

CELESC submits the study on the proposal for the river maintenance flow to the environmental department of ELETROSUL for revision and approval, it was discussed with the environmental expert of ELETROSUL, that the criteria set by DNAEE is in fact dependent on the natural and socio-economic environmental context of the body of water compromised, given that in some cases it would be necessary to allow more than 80% of the minimum monthly flow discharge as the remaining flow, and in other cases it would be justified to allow less than the stipulated 80% of the minimum monthly flow discharge as the river maintenance flow, to maximize the hydropower production with a minimum environmental impact on natural and socio-economic aspects.

3.4.2 Expected effects on human environment

(1) Landuse : No major effect is expected to be derived from reduction of river flow since no demand on the river water is needed for actual landuse.

(2) Water use : There are no water use by human activities such as communities, municipalities, tourism and commercial activities.

3.4.3 Expected effects on biological environment

(1) Flora

(i) Terrestrial flora : No detrimental effects on the terrestrial flora are expected due to reduction of river flow since vegetation in this area is scarce and depends on other water resources.

(ii) Aquatic flora : No detrimental effects are expected due to river flow reduction since there are no aquatic flora.

(2) Fauna

(i) Terrestrial fauna : There is no terrestrial fauna to be affected severely due to river flow reduction since natural habitat is remarkably degraded and absent.

(ii) Aquatic fauna

(a) Invertebrates : There is no invertebrates of scientific or commercial interest in this area.

(b) Fish : No important fish species from scientific and commercial standpoints and endangered or protective species do not exist in this area. The fish species living in the river are considered to be very plastic and they do not necessarily move through a long distance in the water for their perpetuation.

A reduction of river flow will imply reduction of submersible area with consequent alternation of natural habitat which will be limited to deeper areas of the river bed. Preservation of this submersible area will be contemplated basically for estimate of river maintenance flow. According to the recent survey performed by local consultant, maximum length of fish "Jundia" of the family Pinclodidae is 29.1 cm and maximum height is presumed to be 9.7 cm. It is assumed that two times of this height is maximum water depth to allow the fish to mobilize.

3.5 Mitigation of Possible Impacts of Icthyofauna

Reproduction of native equivalent species under fish biology program will be considered as a measure to minimize possible impact on population reduction. A fish farm "Quinta das Tilapias Duoradas" which is located in aquaculture facility in Rio Das Pedras offers possibility of purchasing catfish fingerlings at a cost of US$ 75/1000 nos. The reproduction program will be performed if posterior fish biology study verifies necessity of this action.

For estimation of river maintenance flow, fish morphology, habit and morphometries will have to be considered. Maintenance of submerged area which will be formed by small river flow in the v-shaped river bed in the dry season is important for habitat of the incthyofauna. A minimum water exchange rate of 200% of the volume per day in the worst case and 500% water exchange in the normal period should be maintained to assure water quality and oxygenation condition of their habitats.

The water requirement for the submerged area to ensure minimum exchange rate of 500% of the volume per day in the normal period was calculated assuming that total river length of 10.2 km between the proposed weir site and confluence with the Norte river is one submerged area. For width and depth of the submerged area, it is assumed that the envisaged river stretch is formed by v-shaped river channel and top width (B) with triangular section is in the range between 10 m and 20 m and its deepest depth (D) varies from 0.1 m to 0.5 m. The water requirement is calculated as follows:

$$Q = \left(\frac{DxB/2xL}{86400} \right) \times 5times$$

where; Q : flow discharge (m^3/sec)
D : depth (m)
B : width (m)
L : total river length (= 10,200m)

The water requirement calculated under these conditions is as follows:

D(m)	B (m)		
	10	15	20
0.2	0.59 (m^3/sec)	0.89 (m^3/sec)	1.18 (m^3/sec)
0.3	0.89	1.33	1.77
0.4	1.18	1.77	2.36
0.5	1.46	2.21	2.95

4. STUDY ON R.M.F.

For study on R.M.F consideration should be given only for the aquatic fauna especially for river water required for migrating fish in upstream and downstream of river in the envisaged river stretch of 10.2 km between the proposed weir site and confluence with the Norte river.

Relationship between the required river discharge and water depth was studied assuming that the envisaged river stretch is formed by v-shaped river channel and top width with triangular section is in the range between 10 m and 20 m. The required depth for migrating fish including allowance is assumed to be 0.2 m (0.1 m x 2 (allowance)). The assumed river bed slope is 1:60.

The deepest depth of river channel was calculated by the following formula;

$$Q = (B \times H/2) \times (1/0.03) \times (H/2)^{2/3} \times (1/60)^{1/2}$$
$$= (B/2 \times H^{5/3}) / 0.369$$
$$H = (0.738Q / B)^{3/5}$$

Where; Q ; Discharge (m^3/sec)
B ; Top width of triangular shaped river channel (m)
H ; Deepest depth of river channel (m)

The calculated relationship among river discharge, width of river channel and deepest depth of the river channel is as follows;

Q	B (m)		
(m^3/s)	10	15	20
1	0.21 (m)	0.16 (m)	0.14 (m)
2	0.32	0.25	0.21
3	0.41	0.32	0.27
4	0.48	0.38	0.32
5	0.55	0.43	0.36

The above table shows that river discharge to meet the required depth, 0.2 m is more than 2 m^3/sec for case of the top width of river channel, 10 to 20 m. Considering some allowance for the required depth, river discharge of 3 m^3/sec can meet the requirement.

In order to determine appropriate R.M.F, the following two conditions should be satisfied;

(i) to ensure the river discharge for migrating fish, and

(ii) to ensure the river discharge to be needed for minimum exchange rate of 500% of the volume per day for keeping water quality and oxygenation condition of fish habitats.

From the viewpoint of migration of fish, minimum water requirement of 3 m^3/sec has been proposed. Then the water requirement to maintain the submerged area for keeping water quality and oxygenation condition of habitat of fish was examined against the river discharge of 3 m^3/sec. The deepest water depth for several top width (10 to 20 m) of river channel has been calculated. Then, water requirement to ensure minimum exchange rate of 500 % of volume per day against the calculated deepest depth and selected width of river channel is presented as follows;

B (m)	Deepest Depth for Fish Migration (m)	Required discharge for Minimum Exchange Rate (m^3/s)
10	0.41 (0.4)	1.18
15	0.32 (0.3)	1.33
20	0.27 (0.3)	1.77

Note ; Figures in brackets show the water depth used for calculation of water requirement to ensure minimum exchange rate of 500 % of the volume per day.

The estimated required discharges to ensure minimum exchange rate of 500 % of the volume per day against different widths of river channel are all less than 3 m^3/sec.

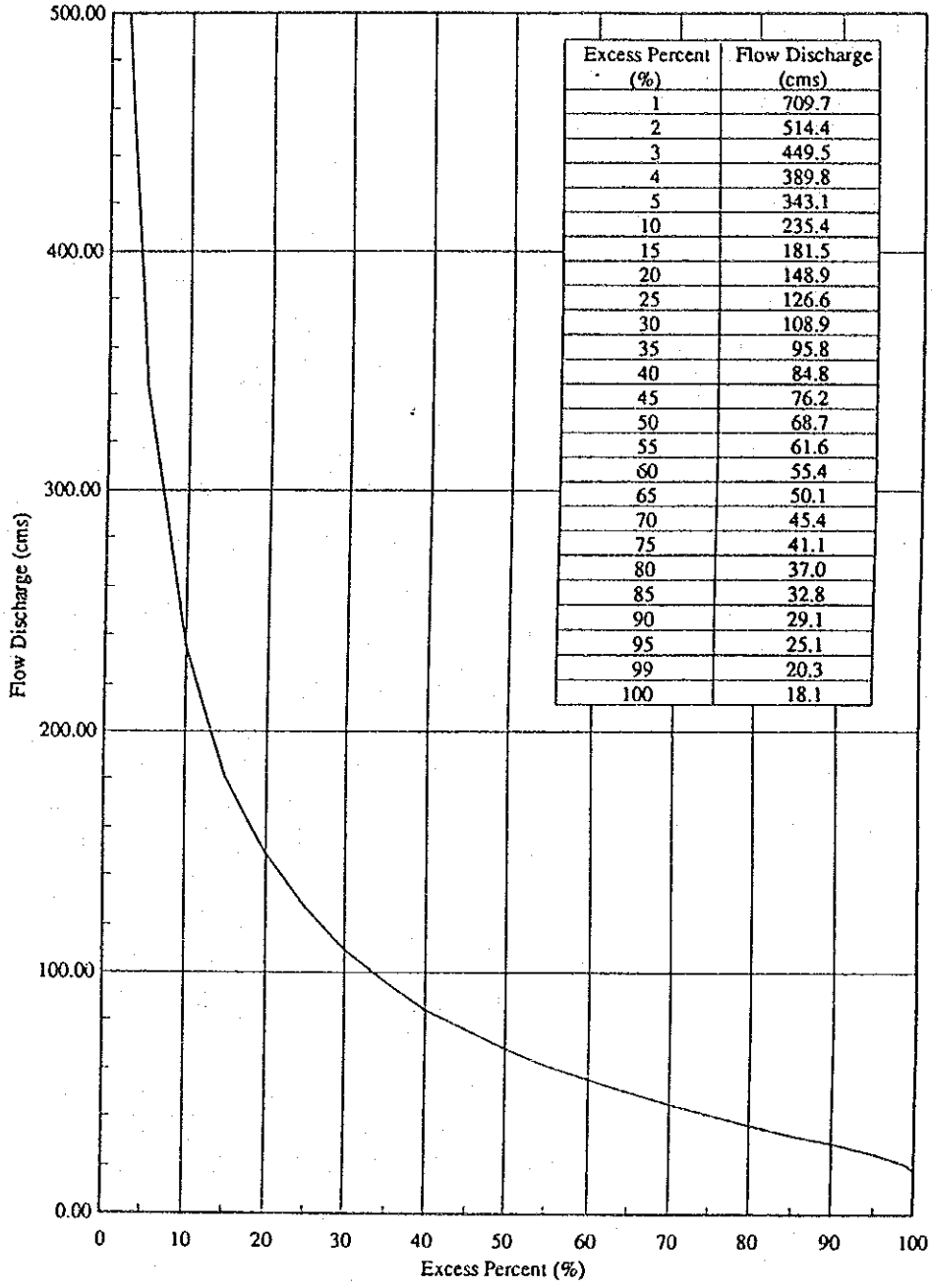
In consideration of the study result so far carried out, it is recommended to apply 3 m^3/sec for R.M.F in this project.

5. CONCLUSION

Discussion meeting on determination of suitable R.M.F was made among the JLCA study team, CELESC and DNAEE. It was concluded in this discussion meeting that the study result made by JLCA study team is appropriate and reasonable value, however, in view of the environmental aspect in overall Santa Catarina state, especially for tourisim, it was determined to increase R.M.F up to 7.2 m3/sec which meets the requirement of the DNAEE's regulation on R.M.F. and corresponds to 80% of the minimum monthly discharge in the recorded/estimated period at the proposed damsite.

Table A.2.1 Annual Minimum Daily Mean Discharge at Damsite

Date	Minimum Discharge (cms)
1941 Apr. 16	28.6
1942 Dec. 31	16.5
1943 May 19	7.9
1944 Dec. 22	7.9
1945 Jan. 18	4.8
1946 Dec. 9	19.0
1947 Apr. 16	15.8
1948 Dec. 30	13.3
1949 Feb. 14	10.3
1950 Jul. 6	17.4
1951 Sep. 15	8.8
1952 May 19	4.1
1953 Aug. 16	8.8
1954 Dec. 9	18.1
1955 Jan. 29	15.2
1956 Jan. 5	24.6
1957 Jan. 6	21.4
1958 Feb. 14	18.1
1959 Dec. 30	13.3
1960 Jul. 24	10.3
1961 Aug. 29	14.9
1962 Sep. 8	17.4
1963 Sep. 6	14.2
1964 Mar. 24	19.8
1965 Feb. 17	13.6
1966 Aug. 19	27.8
1967 May 20	26.2
1968 Sep. 11	4.3
1969 Aug. 22	21.4
1970 Dec. 7	19.5
1971 Dec. 31	10.3
1972 Jan. 1	11.9
1973 May 20	33.7
1974 Jun. 6	16.5
1975 May 11	21.4
1976 Apr. 30	23.8
1977 Jul. 22	19.8
1978 Jun. 5	10.6
1979 Feb. 5	14.3
1980 Jun. 19	29.9
1981 Aug. 23	18.1
1982 Jan. 27	18.8
1983 Apr. 1	61.8
1984 Feb. 21	34.9
1985 Dec. 31	7.6
1986 Jan. 9	4.7
1987 Dec. 17	21.6
1988 Jan. 9	13.7
1989 Dec. 28	23.0
1990 May 28	43.2



Excess Percent (%)	Flow Discharge (cms)
1	709.7
2	514.4
3	449.5
4	389.8
5	343.1
10	235.4
15	181.5
20	148.9
25	126.6
30	108.9
35	95.8
40	84.8
45	76.2
50	68.7
55	61.6
60	55.4
65	50.1
70	45.4
75	41.1
80	37.0
85	32.8
90	29.1
95	25.1
99	20.3
100	18.1

Note :
This duration curve is prepared by average method using the flow discharges from 1941 to 1990.

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Fig. A2.1
Flow Duration Curve at Damsite

ANNEX VII

PLAN FORMULATION STUDY

ANNEX VII PLAN FORMULATION STUDY

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1. INTRODUCTION

The Salto Pilão project was once studied by pre-feasibility analysis in the Hydro Inventory Study - 1991 and identified as the most promising hydropower scheme in the Itajaí river basin. The project utilizes a 200 m natural drop of river level in a 7 km distance from intake site to powerhouse site. Average river flow at the intake site is 108.2 cms in the discharge record for 50 years from 1941 to 1990.

In this Chapter, plan formulation for selecting the optimal development scale is studied on combinations of several alternative options in respect of the following items :

- Selection of damsite
- Dam scale including full supply level (FSL)
- Installed capacity of power plant

Possible maximum storage volume in prospective reservoir is limited to about 10 million m^3 due to topographic reason. This volume is relatively small and is insufficient to regulate seasonal variation of river flow of which monthly volume fluctuates between 23 million m^3 and 2,700 million m^3. Hence, idea of reservoir type power plant capable of monthly or seasonal peak generation is discarded and only a run-of-river type scheme is subjected to this study. However, a small pondage is inevitably formed by intake dam and it is useful for daily regulation of flow. Effect of the daily regulation by the pondage is therefore analyzed in this study.

For selection of alternative options of FSL, the highest limit of FSL is examined. The limitation is so determined that backwater of the dam does not affect to the wide flat land above a waterfall located 1 to 2 km upstream of prospective damsites. Only one tunnel alignment is selected for this study considering the topographic conditions. The powerhouse site is fixed at the same place as proposed by the previous study since its location is not decisive factor for selecting the development scale. For dam scale, two cases are contemplated, i.e., without and with daily regulation pondage to make daily peak operation of the power plant.

After designing components of the alternatives, construction cost and energy output of each combination of alternatives are calculated. From these cost and energy, unit cost of generated energy and net benefit are obtained for each combination. Referring the costs and benefits, and considering environmental constraint as well as possibility of daily regulation, the optimal combination of damsite and FSL is selected. The installed capacity is optimized

on the selected combination of damsite and FSL based on the ELETROBRAS's optimization method so as to maximize its net benefit. Flow of the optimization study is shown on Fig. VII.1.1.

The following maps prepared in the present investigation was utilized for this study.

- 1/5,000 map with 2 m contours covering the whole project area.
- 1/2,000 maps with 2 m contours covering each of dam area and powerhouse area

After the optimal development scale has been determined, the selected alternative will be further studied in ANNEX VIII for the following items :

- Tunnel alignment
- Necessity of concrete lining of tunnel
- Diameter of tunnel
- Type of penstock
- Type of surge tank
- Number of generating units

2. ASSUMPTIONS AND CONDITIONS FOR STUDY

2.1 Discharge for Power Generation

Daily discharge series for 50 years from 1941 to 1990 is used for estimation of energy output. The daily discharge of the Itajaí river at the intake site was estimated in ANNEX III from run-off records at Rio do Sul and Apiúna. This discharge is applied to all three dam site alternatives since differences of their catchment areas are negligibly small (c.a.: 5,597 km^2 above axis B, 5,602 km^2 above axis C and 5,604 km^2 above axis D).

Electric power generated by the Salto Pilão project is planned to be supplied to power network of the South system which is in integration with the Southeast system. This integrated system mainly relies on hydropower; 97 % of the system's supplying electricity is shared by hydropower. Run-off patterns of rivers in the whole area covered by the integrated power system are different to each other. Hydrologically most critical period as a whole of the integrated system defined by ELETROBRAS is 92 months from April 1949 to November 1956. Estimation of energy output is made on the basis of the following two discharge series;

- Critical period series : Apr. 1949 to Nov. 1956 (92 months)
- Long term series : Jan. 1941 to Dec. 1990 (600 months)

Duration curves of those two discharge series at the damsite are illustrated in ANNEX III. Average of the daily discharges is 86.3 cms in the critical period and 108.2 cms in the long term period.

2.2 River Maintenance Flow

If river water was completely extracted, except for high flow periods, at the intake for power generation, river flow in the downstream stretch between dam and powerhouse will drastically decrease and especially a 10km stretch above the junction with the Norte river will become almost dry for long periods. In order to secure biotic life in the downstream river stretch, water has always to be released from the dam as the river maintenance flow as stated in ANNEX VI. The rate of discharge to be released was decided to be at least 7.2 cms which corresponds to 80 % of the minimum monthly discharge ever recorded. Discharge usable for power generation is thus determined by deducting 7.2 cms from the natural discharge at the damsite.

2.3 Design Floods

(1) Design Flood for Dam and Spillway

Magnitude of flood for designing dam and spillway varies with scale of dam and its reservoir as well as with scale of hazard risk resulting from failure of dam. ELETROBRAS, in its guideline, stipulates the flood magnitude to be applied to different scales of dam and hazard risk which are classified into several categories. The Salto Pilão dam under study is only 15 m to 25 m in its height and less than 5 million m^3 in its reservoir volume. As the dam is small and river stretch downstream of the dam forms steep gorge, failure of the dam will not result in serious hazard. Such dam is classified as the category of "medium dimensions, low risk" in the guideline. Design flood to be applied for this category is the 100-year probable flood or 1/2 of the probable maximum flood (PMF). The PMF approximately coincides with the 10,000-year flood. Discharges of the 100-year flood and the 10,000-year flood are 3,600 cms and 7,400 cms, respectively as estiamted in ANNEX III. The discharge of 3,700 cms was applied as the design flood for the dam and spillway in the initial stage of plan formulation study.

The magnitude of design flood was, however, increased to the 1,000-year flood (5,300 cms) for further safety of the dam after discussion with ELETROBRAS. This increase in the flood magnitude was made on the alternative selected by the first screening study.

(2) Design Flood for Powerhouse

Based on the ELETROBRAS's standard, the 10,000-year probable flood; 12,000 cms at the powerhouse site, was applied as the design flood for powerhouse.

(3) Design Flood for Construction

As mentioned above, major part of the dam is built with concrete and is relatively small scale. Anticipated construction period of the dam is only 3 years. Dam structures under construction, even if overtopped by flood will not cause serious damage on the dam itself as well as on the downstream river stretch. The 2-year probable flood was thus applied as the design flood for river diversion works. Discharge of the 2-year flood at the damsite was estimated at 1,100 cms taking into account retardation effect of both upstream Sul and Oeste dam reservoirs, as stated in ANNEX III.

2.4 Free Board

Based on the ELETROBRAS's practice, free board between the design flood water level and top of dam or ground level of the powerhouse was determined as follows :

Dam, concrete section	: 0.0 m	(1000-year flood)
Dam, embankment section	: 1.0 m	(- do -)
Powerhouse	: 0.0 m	(10,000-year flood)

The above free board criteria for dam was adopted taking into account that the 1000-year flood is the ultimate condition for the project. By the way, water level at the 100-year flood will be 1.4m lower than that of the 1000-year flood. In case of the 100-year flood, any overtopping will not take place because waves on reservoir water generated by storm will not exceed 0.9m in height.

2.5 Maximum Limit of Full Supply Level

There exists a resort complex on left bank river side at 1 to 2 km upstream of the prospective damsites. The resort complex is located at scenic site just downstream of a waterfall. Lowest elevation of the resort area is approximately 319 m along the river side. Major resort facilities are located on flatter area between 321 m and 326 m. At the initial stage of this study, inundation of this resort area by reservoir storage was considered undesirable since it seemed very important for local tourism development. However, it was revealed later by CELESC that partial inundation of the resort area would be permissible and resulting loss would be compensatable.

On the other hand, river stretch above the first waterfall near the resort complex has very flat gradient; 1 in 13,000. Top of the waterfall is 324 m to 326 m in elevation. Land extending along the upstream stretch is also flat and relatively wide up to the city of the Rio do Sul located 25 km upstream of the prospective damsite. The flat land is already developed for agriculture and municipalities and located almost above 330m in elevation except numerous low areas scattered along the river margins. Normal river water level in the upstream stretch is 327 m to 329 m in elevation.

In order to avoid any influence of the Salto Pilão reservoir to the upstream streach above the first waterfall, the maximum limit of the reservoir's full supply level (FSL) was set at 324 m in elevation.

2.6 Power Plant Operation Mode

The CELESC power system is operated presently at daily load factors of 65 to 70 %. Load peak time is 3 hours a day. It is preferable for flexibility of system operation that the Salto Pilão plant is operated so as to follow the daily load variation though the project is the run-of-river type plant which is operated in principle at base load or unvariable load through a day. For the daily variable load operation, sufficient reservoir capacity to store and regulate water for peak-time generation is indispensable.

The Salto Pilão reservoir under study is relatively small in capacity and will be filled up with sediment in early stage of the project life. However, regular removal of the sediment deposit enables to keep necessary storage capacity for the daily regulation. Taking into account these conditions, semi-base load operation is applied only in the case where storage capacity for the daily regulation can be provided in the reservoir. This semi-base load operation mode consists, in principle, of 3-hour peak operation and 21-hour off-peak operation. Daily combined load factor under this operation mode was determined at 60 % taking into account of daily load variation expected in the future. The case without daily regulation was also studied as pure base load plant.

2.7 Criteria for Economic Analysis

ELETROBRAS requires that economic analysis of power projects in Brazil is made in accordance with ELETROBRAS's criteria. The criteria on economic analysis are as follows :

(1) Firm energy is defined as the average energy generated in the hydrologically critical period of the power system in reference; i.e., integrated South/South-east system.

(2) Secondary energy is defined as the energy generated in excess of the firm energy and calculated as the difference between the long term average energy and the firm energy.

(3) Plant operation is stopped for planned maintenance or unplanned troubles. ELETROBRAS's standard figures with regard to the period of stoppage in percentage of total time span under study are as follows:

Plant Capacity: P (MW)	Length of Stoppage: ß (%)		
	Planned	Unplanned	Total
$30 \leq P < 60$	1.6	5.1	6.7
$60 \leq P < 200$	2.5	7.7	10.2

Effective energy suppliable to the system is therefore (100-ß) % of the energy producible without stoppage.

(4) Guaranteed peak power is defined as the peak power generatable at 95 % of permanency in the system.

(5) Construction cost is estimated in accordance with cost estimation criteria and format of ELETROBRAS. Cost of transmission line is excluded from the project cost. Interest during construction is computed by applying the rate of 10 % per annum and included in the project cost.

(6) Economic comparison for dimensioning of the project is made applying the project life of 50 years and the annual discount rate of 10 %.

(7) The mean cost of generation (unit cost of firm energy) is one of basic factors to evaluate competitiveness of a power project and is compared with the marginal cost of expansion of power system. Mean cost of generation is defined by the following equation.

$$CMG = \frac{CAI + COM - 8760 \cdot CRES \cdot ES - 1.000 \cdot CMP \cdot PG}{8760 \cdot EF}$$

where, CMG : Mean cost of generation (US$/MWh)
CAI : Annualized investment cost (US$/year)
COM : Annual cost of operation and maintenance (US$/year)
CRES : Reference cost of secondary energy (US$/MWh)
CMP : Reference cost of peak power (US$/kW/year)
ES : Secondary energy (MW year)
PG : Guaranteed peak power (MW)
EF : Firm energy (MW year)

(8) The reference costs in the above expression are closely linked to the marginal costs of expansion of system. Values of the reference cost are defined by ELETROBRAS based on its study of long term program for generation

expansion of each regional power system. Those values are reviewed and revised every year by ELETROBRAS.

The reference costs of firm energy and peak power defined in March 1993 for the South System in which the Salto Pilão is involved are as follows :

Year of Commissioning	Reference Cost: Firm Energy (US$/MWh)	Reference Cost: Peak Power (US$/kW/year)
up to 2000	51	0
2001 - 2005	60	0
2006 - 2010	62	0
2011 - 2015	64	0
2016 - 2020	69	0
2021 - 2029	70	0

(Note : These values are applicable for dimensioning of projects.)

The reference cost of secondary energy corresponds to fuel cost for thermal plant, which is defined to be 11.92 US$/MWh.

The reference cost of peak power is defined as nil because the system is composed of majority of hydropower plants and most of them are reservoir type plants capable of easily generating peak power required in the system.

(9) Unit benefit of generation is computed by applying the reference costs mentioned in (8) above.

(10) Dimensioning of major project components including installed capacity is made so that the net benefit is maximized; i.e., the cost necessary for a certain incremental variation of the component is close to but does not exceed the benefit attributable to such incremental variation. This is expressed by : $\Delta B > \Delta C$

$$\Delta B = [(\Delta EF) \cdot CRE + (\Delta ES) \cdot CRES \cdot 8760 + (\Delta PG) \cdot CMP \cdot 1000] \cdot a$$

Where, ΔB : incremental capitalized benefit (US$)

ΔC : incremental investment cost (US$)

CRE : reference cost of firm energy (US$/MWh)

a : annuity cost factor (50 years, 10 % rate), a = 9.9148

Δ : expression of increment

The others are defined in (7) above.

(11) Unitary cost of installation in the power development for a simple comparison between two or more projects is defined as below :

Unitary cost of installation (CUI) :

$$CUI = \frac{\text{Investment Cost}}{\text{Installed Capacity}} \quad (US\$/kW)$$

3. FIRST SCREENING FOR SELECTING DAMSITE AND FSL

3.1 Study Flow and Study Cases

Damsites and full supply levels (FSL) of the reservoir are first screened to select the optimum combination of their alternative options. This optimum combination is subjected to the succeeding second screening to select the optimum scale of power plant capacity. Flow of the study is shown in Fig. VII. 3.1.

For the first screening, the following alternative options were selected.

- Dam location : Axes B, C and D
- Full supply level (FSL) in elveration,
  - For axis B : 319 m, 324 m
  - For axis C : 310 m, 315 m, 319 m
  - For axis D : 305 m, 310 m, 315 m
  - Other intermediate FSLs are supplemented in optimization of FSL.
- Maximum plant discharge for each combination of dam axis and FSL:
  - 30, 45, 60, 75, 90 and 105 cms.

Fig. VII.3.2 shows general alignment of major project components considered for the plan formulation.

3.2 Alternative Options

3.2.1 Damsite Alternatives

The dam axis C is located at the same location as selected in the Hydro Inventory Study - 1991. The axis B is located on top of a rapid located 500 m upstream of the axis C. Scheme of the axis B having FSL of El. 330 m has been studied previously in 1991 using map of 1:10,000 scale. That scheme has been abandoned because it required large inundation area for reservoir. However, the axis B was chosen again for the present study since the site is topographically and geologically attractive and reservoir inundation area can be minimized by lowering FSL below El.324 m. River bed elevation at the axis B is El.309 m which is preferably 7 m higher than that at the axis C.

Another axis D is located at 500m downstream of the axis C. This site has relatively steep abutments on both left and right banks and was deemed as a good damsite.

The axis D is 8 m lower than the axis C in river bed elevation. This disadvantage in head for generation is expected to be offset by reduction of head loss owing to shorter length of headrace tunnel.

3.2.2 Full Supply Level

Full supply level (FSL) of reservoir is restricted below El.324 m due to the limitation of reservoir level to avoid flooding of the upstream flat land.

At the axis B, reservoir level lower than El.319 m is not practicable because river bed elevation just upstream of the dam is El.317.5 m and the concurrent reservoir depth of 1.5 m is considered to be the minimum depth to flow the required discharge for power generation.

At the axis C, since the river bed level is El.302 m, the lowest limit of FSL was decided to be El.310 m in order to accommodate intake facility below that level. Two other FSLs; El.315 m and El.319 m, were chosen not only to examine effect of increased head but also to examine the possibility of providing daily regulation storage.

At the axis D, the lowest limit of FSL was decided to be El.305 m since the river bed level is El.294 m. Due to topographic restriction of the right bank ridge for dam abutment, the highest FSL was set at El.315 m. This highest FSL and another intermediate FSL; El.310 m, were also selected for comparison.

3.2.3 Plant Discharge

In the Inventory Study - 1991, the maximum plant discharge of 71.9 cms was proposed. Taking this discharge into account, six different discharges; 30, 45, 60, 75, 90 and 105 cms were selected as the maximum plant discharges for the present study. Dimensions of hydraulic structures relating to power generation are dependent on the maximum plant discharge.

Duration curves of plant discharge usable for generation after deducting the river maintenance flow of 7.2 cms are illustrated in Fig. VII.3.3. Those curves are derived from the daily discharge series at the damsite.

3.2.4 Reservoir Storage Capacity

Fig. VII.3.4 shows reservoir area and storage capacity curves for the dam axes B, C and D. As stated in Section 2.6, it is preferable, if practicable and feasible, to operate the power plant in the semi-base mode of the 60 % load factor. For this variable load operation, the reservoir has to have a storage space necessary for daily discharge regulation. Volume of the storage space required for the daily regulation is determined as follows:

$$V = (Qp - q) \cdot 3h \cdot 3600 \text{ sec}$$

where, V : required daily regulation storage volume (m3)
Qp : plant discharge in peak operation (cms)
q : daily mean reservoir inflow (cms)

In case of the 60 % load factor, V is maximized when peak operation is made with the maximum plant discharge (Qmax) and q becomes 60 % of Qmax. Accordingly, the required maximum storage (Vmax) is given by $Vmax = 4320\ Qmax$.

On the other hand, when the load on each generating unit is lower than a certain limit, 30 to 50 % of the rated load, the unit is not operable. This occurs also when discharge for generation decreases below 30 to 50 % of the maximum plant discharge per unit. In this study, this limit is assumed to be 40 %. As 2-unit power plant is considered for this study, any unit becomes inoperable in low flow periods when q is less than 20 % of Qmax unless regulation storage is provided in the reservoir. The inoperable period becomes longer with increase of unit capacity. If water stored daily in the reservoir is used for generation, at least one unit of power plant becomes operable for several hours a day at the lowest load of 40 %. This is effective for saving energy which may be lost when the plant cannot be operated. Duration of the daily operable time in the low flow period depends on amount of daily reservoir inflow. Reservoir storage volume required for the low flow period is expressed as:

$$Vf = (Qf - q) \cdot t \cdot 3600$$

where, Vf : storage volume required for minimum operation (m^3)
Qf : plant discharge at minimum operable load factor (cms)
q : daily mean reservoir inflow (cms)
t : daily operation duration (hour)

Vf becomes the maximum when q equals 1/2 of Qf and t = 12 hours. As the Qf is 40 % of the maximum plant discharge per unit, i.e., 20 % of Qmax, the maximum storage volume (Vfmax) required is;

$$Vfmax = 0.1\ Qmax \cdot 12\ hr \cdot 3600\ sec = 4320\ Qmax$$

This Vfmax just coincides with the maximum storage for peak operation (Vmax). Therefore, active storage volume for power generation is computed by Vmax = 4320 Qmax.

Reservoir volume, full supply level (FSL) and minimum operation level (MOL) of each alternative are as shown in Table VII.3.1. As three low dam alternatives (B319, C310 and D305) are insufficient in height to accommodate intake facility below MOL if they provide the regulation storage, no daily regulation is considered for them in this study.

3.2.5 Reservoir Sedimentation

Sediment volume flowing into the reservoir has been determined at 246,300 m^3 /year on an average as stated in ANNEX III. The sediment flow is composed of bed load, suspended load and wash load. The bed and suspended loads consist of silt and sand which easily settle in reservoir where flow velocity drops. The wash load consists of very small particles floating in water and they will flow out from reservoir without any deposit.

According to measurement of grain size of riverbed material sampled at Lontras, content of silt smaller than 0.075 mm is 50 % to 80 % of total. From this fact, the wash load corresponding to 50 % of total sediment load is regarded as reasonable estimate. Sediment deposit in the reservoir was thus estimated at 50 % of the total sediment flow into the reservoir, which is approximately 123,000 m^3 per year.

Meanwhile, even in the case that the daily regulation is incorporated, the reservoir volume below the minimum operating level is not sufficient to fully store the sediment deposition for the 50-year project life as shown below:

Dam site	FSL (m)	MOL (m)	Reservoir Volume below MOL (m^3)	Filled up by sediment (years)
Axis C	315	314.38-312.68	1,319,000-995,000	11-8
"	319	319/55-317.35	2,327,000-2,003,000	19-16
Axis D	310	309.69-308.87	2,674,000-2,350,000	22-19
"	315	314.75-314.11	5,081,000-4,757,000	41-39

In order to secure continuous plant operation throughout the project life, sediment deposit in the reservoir after filling up to MOL will have to be removed by dredging.

In the other low dam alternatives, reservoir capacity below FSL is smaller than those of the above cases, which will be filled with sediment deposit up to FSL within 2 to 9 years. Daily regulation by reservoir storage is impossible in those alternatives.

Sediment deposit accumulated in front of power intake is flushed out through a sand flushing gate provided adjoining the power intake.

3.3 Tentative Design of Project Components

3.3.1 Dam and Spillway

(1) Type

River channel at the damsites is a flat trapezoidal section with width of about 200m. Height of dam under study is 25 m at the maximum. Types of dam conceivable for these sites are concrete gravity type and rockfill type. Necessary spillway is rather large compared with the size of dam since flood flow to be handled is as large as 3,700 cms. The spillway types conceivable are non-gated type and gated type. Economic comparison to select the best configuration of dam and spillway was made in ANNEX VIII. Three configurations such as concrete dam with non-gated spillway, concrete dam with gated spillway and rockfill dam with gated spillway were compared. The result showed that concrete dam with non-gated spillway is most economical. In the case that reservoir volume is extremely small as in this project in comparison with flood inflow volume, the non-gated spillway is much safer than the gated spillway which needs delicate gate operation for releasing flood flow. Accordingly, concrete dam with non-gated spillway was adopted in the plan formulation study. General arrangement and typical sections of dam and spillway for each dam site are shown in Fig. VII.3.5 to VII3.8.

(2) Foundation Geology and Seepage Cut-off Measures

Hard granite is exposed in river bed in all dam sites. However, overburden consisting of soil and soft decomposed granite is considerably deep; 20 to 30 m, on both left

and right abutments except at the right abutment of the axis B. The overburden is slightly permeable.

The foundation rock in its surface zone contains joints and cracks. A 2 m surface zone of the rock is excavated to found the dam thereon. Both abutments are costly in digging down to the rock surface because of deep overburden. Concrete dam section is ended at left side of the spillway. A short embankment section is provided between concrete dam and abutment soil body left unexcavated. In order to avoid excessive seepage through the abutment overburden, a clay blanket covering reservoir shore slope is provided, which is connected with the embankment section of dam and extended upstream up to a length of 10 times the water depth at dam axis.

Foundation of the dam and blanket bottom is treated by consolidation grouting with cement slurry up to the depth of 3 m.

(3) Spillway

Concrete ogee weir spillway without gate is provided across the river channel. Overflow width was determined to be 200 m for all cases so that it approximately equals the width of downstream river channel. Crest elevation of the ogee weir was set at the same level of FSL. Overflow capacity of the ogee weir is computed by :

$$Q = C \cdot B \cdot H^{1.5}$$

where, Q : overflow discharge (cms)
B : length of ogee weir (m)
H : overflow depth (energy head) on crest (m)
C : coefficient of overflow
C = 1.6 (after sediment deposit in reservoir)

The overflow depth of the design flood (3700 cms) was estimated at 5.2 m. Downstream foot of the ogee weir is protected by concrete apron with thickness of 1.0 m extending up to the length equal to dam height. No other protection nor energy dissipater is provided because river bed rock seems unerodible.

(4) Dam Crest Level

Top of dam in non-overflow section is set at 1.0 m and 2.0 m above the flood level at discharge of 3,700 cms for concrete section and embankment section, respectively.

(5) Sand Flush Way and River Outlet

A sand flush way to remove sand accumulated in front of power intake is provided in the dam adjoining the intake. Discharge capacity of the sand flush way was determined to be 1.5 times the maximum intake discharge so that sand deposit in the area around the intake can be flushed out completely. Sill elevation of the sand flush way was so determined that sand flushing slope of 5 % is kept below the intake.

A double-leaf roller gate was equipped in the sand flush way. Its upper leaf is an overflow type and is utilized as a river outlet facility to release the river maintenance flow of 7.2 cms from the reservoir. Also floating debris gathered in front of the power intake can be flushed out by operating this upper leaf. When it is needed to flush sand deposit, both upper and lower leaves are fully opened. In order to avoid unnecessary wasting of water, sand flushing operation is preferably carried out at the time when the reservoir inflow discharge exceeds intake discharge.

(6) River Diversion

For river diversion during dam construction, two options are conceivable. One is by bypass tunnel and the other is by bypass channel. Design flood for the river diversion is 1,100 cms of 2-year probable flood.

Because soil overburden is very deep in tunnel portal areas planned on left bank for axes B and C and on right bank for axis D, huge excavation is required to build the bypass tunnel. Thus, the tunnel option becomes rather costly than the channel option. Due to this reason, the channel diversion was adopted in this Study.

The channel diversion option consists of two-stage diversion; the first stage is composed of a wide diversion channel partly excavated into river bank and a cofferdam to enclose a half of dam to be constructed in the river floor on opposite side, and the second stage is composed of another cofferdam to enclose a remaining half of dam to be constructed in the bypass channel area and river flow is diverted through four or five temporary diversion conduits built in the partly completed concrete dam body. In the low dam cases, as the temporary conduits are impracticable to build, flood is flowed over the partially completed spillway. The temporary conduits will be closed with stoplogs after whole dam body is completed. The stoplogs are handled with mobile crane set on a temporary platform provided above the stoplog slot. The conduits are finally plugged with concrete.

The cofferdam is a clay embankment protected with large rock blocks piled on water side slope.

(7) Fishway

No fish ladder nor other fishway is provided on dam since it has been stated in the environmental report that there exists no fish transmigrating across dam area in the river.

3.3.2 Power Intake and Waterway

(1) Power Intake

Intake for a run-of-river scheme is generally located at right angle to the river flow direction and immediately adjacent to a sand flushing channel in order to minimize the intrusion of sediments into the intake. Additionally the sill of the intake is located in such a way that sediment accumulation which forms in front of inlet should be below the level of sill assuming that sediment will accumulate at a slope of 1:20. The intake of this project is based on these concepts.

Trash racks are installed on intake. Sizing of trash racks is based on the maximum plant discharge and allowable maximum velocity of 1.0 m/sec at the trash racks for the surface type intake. This velocity is considered to be the maximum limit for raking of trashes. A mechanical trash-raking equipment is provided, which moves on top platform of trash racks.

Dimension of the trash rack is calculated by H : W = 1: 4, where H is vertical height and W is overall width. Where it is difficult to provide H deeper than 3m due to limited reservoir depth, H is fixed at 3m. Top elevation of the intake structure was set at the same level as the dam crest.

Immediately downstream of the trash rack structure, the intake is divided into 2 to 4 channels, each leading to a bay of desanding basin. A steel roller gate is equipped at upstream end of each channel to enable closure of the intake. The maximum velocity in the channel was set at 2.0m/sec so as to avoid sediment accumulation in the channel.

(2) Desanding Basin

River water at the dam site is considerably turbid especially at flood time, which seems to contain much silt and sand as the sediment load. Those silt and sand will intrude into the intake when power plant is in operation. Large particles of sand causes erosion of penstock as well as turbine.

In order to remove harmful large particles of sand contained in power water, a desanding basin is provided immediately downstream of the intake. The desanding basin is composed of 2 to 4 trapezoidal shape basin and designed according to the following concepts.

- Particle size of sand to be removed is 0.3mm or more.
- Allowable maximum flow velocity in the basin is 0.3m/sec.
- Ratio of basin width (w) to depth (h) is approximated by : $2 > w/h > 1$.
- Length of basin (L) is approximated by the following empirical equation :

$$L = 2h/(v \cdot u)$$

where, v : average flow velocity in the basin

u : settling velocity of 0.3mm sand (=0.45 cm/sec)

Sand deposited in bottom of the desanding basin is periodically drained to outside of the basin from sand drain gates equipped at the bottom of each bay. For draining sand, water is poured into the basin by partial opening of the intake gate. Sand draining is performed one by one of basins. Power plant is always operable using remaining basins already sand-drained.

Top elevation of the desanding basin was set at the same level of dam crest so as not to spill out from the desanding basin. Downstream end of the desanding basin is connected to headrace tunnel or culvert. Fig. VII.3.9 shows typical sections of the intake and desanding basin.

(3) Headrace Tunnel

Headrace tunnel to lead water from the intake to penstock is aligned so as to maintain external water pressure higher than internal pressure in order to avoid excessive water leakage from the tunnel and to enable application of unreinforced concrete lining even in the portion where rock needs structural support. To prevent hydraulic fracturing of rock

surrounding the tunnel, the minimum rock cover (in m) is kept as 50 % of the internal water pressure (in m).

According to the past and present exploratory drilling (8 holes in total for tunnel and penstock), and geologic survey on or around prospective route of the tunnel, rock on majority of the tunnel route is hard and massive granite from inlet portal of the tunnel to the point about 100 m upstream of the surge tank. Rock in the vicinity of the surge tank is hard rhyolite which contain many joints. Most part of the granite rock is considered strong enough to selfstand in long term. Such good rock portion is assumed to occupy about 90 % of total tunnel length. The remaining portions; 600 m in their total length are assumed to be weak granite and cracky rhyolite.

Non-lining of the tunnel is cheaper in construction cost but it results in reduction of generated energy due to high loss of head compared with concrete-lined tunnel having the same diameter. In order to select an appropriate type of tunnel section for the plan formulation study, a tentative economic comparison was made on the following four types of tunnel:

Type 1: Fully concrete-lined circular section, driven by blasting
Type 2: Shotcrete-lined horseshoe section with concrete invert, driven by blasting
Type 3: Unlined horseshoe section with concrete invert, driven by blasting
Type 4: Unlined circular section with concrete invert, driven by tunnel boring machine (TBM)

Roughness coefficient (Manning's coefficient) on which head loss calculation is based was estimated to be 0.013 for concrete surface, 0.024 for shotcrete surface, 0.035 for blasted rock surface and 0.016 for rock surface driven by TBM.

As the result of cost comparison as detailed in ANNEX VIII, the Type 2 was decided as the most economical tunnel type. The shotcrete-lined section was thus applied to most part of the tunnel except weak rock parts; 600 m in total, which are fully lined with concrete.

Based on the above result, diameter of the tunnel was so determined empirically that the maximum velocity of flow in the tunnel becomes 2.5m/sec in the shotcrete-lined section or 3.5m/sec in the concrete-lined section, while the minimum diameter is set at 1.8 m. Thickness of the shotcrete lining is 10 cm. Thickness of plain concrete lining is 25 cm which is considered to be the minimum for easiness of construction. Conventional drilling

and blasting method is considered for tunnel excavation. NATM is effectively applied for rock support where required. Fig. VII.3.10 shows profile and typical sections of the tunnel.

(4) Surge Tank

For the purpose of turbine governing as well as for control of water hammer, a surge tank is provided at the end of the headrace tunnel. Type of surge tank selected is simple cylinder type. In up-surging analysis, rapid closure of governor at 100 % load is considered. In down-surging, rapid increase of load from 50 to 100 % is considered. Up-surge and down-surge were analyzed with the use of the Calame-Gadan monogram. Outline of the surge tank is obtained by the following formulas :

$$D = 3d$$

$$\text{Top elev. of surge tank} = \text{FWL} + \text{up surge} + 1.0$$

$$\text{Bottom elev.of surge tank} = \text{FSL} - \text{head loss} - \text{down surge} - d$$

where, D : diameter of surge tank (m)
d : diameter of shotcrete-lined tunnel (m)
FWL : flood water level of reservoir (m)

Most part of the surge tank is located in underground. Concrete lining with thickness of 5 % of the tank diameter is applied to the whole length of the shaft in order to prevent excessive water leakage. The shaft is excavated by NATM. Typical section of the surge tank is shown in Fig. VII.3.10.

(5) Penstock

Base rock in the area for penstock is also hard rhyolite with many joints and cracks. Lower part of the area is covered deeply with soil overburden; 28 m at the maximum depth. At one drill hole 20 m into rock on alternative penstock route, ground water level was not found through the hole. Rhyolite rock in this area is deemed locally permeable. Accordingly, single steel penstock embedded in an inclined underground shaft and lower horizontal tunnel was adopted for this study as shown in Fig. VII.3.10, The mean inside diameter of steel conduit was determined so that the maximum velocity becomes 6.0 m/sec. The minimum excavation diameter for shaft and tunnel was assumed as 2.5 m. The inclination of the penstock shaft was set at 48°. Space of 40 cm between steel liner and internal excavated surface is considered.