Environmental Impact Study - EIS

Implantation of a Small Hydroelectric Power Station – Santa Luzia Alto SHS

Prepared by:

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PRESENTATION

Increasing concern regarding the environment has led the country to deploy a more efficient and comprehensive environmental policy, aiming at fulfilling new environmental needs. This new environmental policy can be found in the legislation currently in force.

Environmental studies aim to ensure welfare of the today's society as well as future generations, thus we must adhere strictly to the rules governing these studies and there are further efficiency requirements and more constant oversight, to ensure compliance with environmental legislation.

The project's characteristics and the location proposed for construction, require the assessment of possible environmental impacts caused by the project within the scope of the Environmental Impact Study and Environmental Impact Report – EIS/EIR.

This work presents the Environmental Impact Study – EIS for the works to build and operate of the Small Hydroelectric Power Station – Santa Luzia Alto SHS, located on the river Chapecó, near the cities of São Domingos and Ipuaçu, State of Santa Catarina, as a basis for the environmental licensing process involving the state environmental agency, FATMA – Fundação do Meio Ambiente (Environment Foundation).

This study was developed by an independent and reputable company, with a multidisciplinary team, registered in the Federal Technical Register for Environmental Protection Activities and Instruments held by IBAMA - Brazilian Institute of the Environment and Renewable Natural Resources and with broad experience in these types of studies.

This Study aims to present technical solutions and actions to avoid or minimize various environmental impacts from the works to build operate the Small Hydroelectric Power Station – Santa Luzia Alto SHS, located on the river Chapecó, between the cities of São Domingos and Ipuaçu, which will have a 28.5 MW output.

Therefore, Construtora Gomes Lourenço LTDA., the company building the SHS, contracted a special consultancy to produce this Environmental Study to comply with the environmental legislation, specificallt CONAMA Resolution 001, of January 23rd, 1986, CONAMA Resolution No. 237, of December 19th, 1997, as well as CONSEMA Resolution 01/2006, which requires an EIS/EIR for hydroelectric power generation projects above 10 MW.

The scope of this study comprises general information, project description, environmental diagnosis, integrated environmental analysis, identification and assessment of environmental impacts, environmental control measures, culminating with control and monitoring programs for SHS deployment, in order to avoid, minimize and control negative environmental impacts and leverage positive impacts.

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1. JUSTIFICATION

In the beginning of this third millennium, developing countries are facing a dichotomy between a lack of resources on one hand, and the overarching need for investment in areas vital for economic development, on the other.

Specifically in terms of electrical power, this problem has a different scale, as without electrical power, further development is very restricted, with many implications for the welfare of the population.

The desire to achieve a certain status on the international market, however, depends essentially on energy self-sufficiency, not only in terms of generation, but also on appropriate transmission systems.

These conditions are common in various countries however, based on its size, this situation becomes more critical in Brazil.

The expansion of energy generating capacity in Brazil has been defined based on planning studies which cover different time frames. These studies, consolidated in documents such as Plan 2015 and the Ten Year Expansion Plan 1996/2005, define the sequence of generation projects and regional interconnections needed to supply the consumer market.

However, in the last few years investments in electricity generation in Brazil have not followed growth in demand. Brazil is a developing country, however the growth of generation capacity has not been proportional, thus increasing the risks of an electricity shortfall.

Energy consumption growth in Brazil is estimated to be approximately 5% a year, for the next five years. This growth estimate may vary mainly because of the following reasons: variation in per capita revenue, variation in population, need for rationing, excess capacity or low price of electric power, appearance of new products or services which consume electricity, appearance of new industrial sectors or of electro-intensive services, new technologies for electric power generation with lower costs.

The fall in government investment in the sector, which until the 80s received an average US$ 13 billion a year and in the 90s started to receive only US$ 7 billion, is pointed out by specialists as one of the main reasons the country is facing an energy crisis.

The continued increase in energy consumption and the fact that no new investments are made by State-owned companies (which control most of the distribution network) has boosted investment from the private sector, which takes on areas essential to the economy by investing capital in small projects. Within the current national scenario and with the need to supply power in the short term, this seems to be, perhaps, the only feasible alternative for the country.

Meeting growing national energy demand has required constant action from the MME - Ministério de Minas e Energia (Ministry of Mines and Energy) in order to guarantee

conditions so that the private sector can start developing new power generation units, to expand power supplies rapidly and efficiently.

According to data from the BIG - Banco de Informações de Geração (Generation Information Database) from ANEEL - Agência Nacional de Energia Elétrica (National Electric Power Agency), there are 1,619 operating projects registered in Brazil, generating 98,435,675 kW of power. For the next few years an increase of 26,298,868 kW will be provided in the generation capacity, based on the 88 projects currently under construction and another 521 which have been authorized, according to the figures in Table 01 below.

Table 01 – Description of the Brazilian Power Sector.

Situação Atual	Tipo de Usina							
	EOL	SHS	CGH	UHE	UTE	UTN	SOL	SOMA
Usinas em Operação	15	281	204	158	958	2	1	1.619
Potência (KW)	239.250	1.696.87	108.328	74.438.69	23.129.335	2.007.000	20	**101.619.498**
Usinas em Construção	1	58	1	12	16	-	-	88
Potência (KW)	10.200	1.059.57	848	2.539.800	797.818	-	-	**4.408.236**
Usinas Outorgadas	108	190	67	22	134	-	-	521
Potência (KW)	4.681.74	2.825.79	45.495	3.987.900	10.349.703	-	-	**21.890.632**
Total Quantitativ	124	529	272	192	1108	2	1	2.187
Potência (KW)	4.931 . 1	5.582.23	1 54.671	80.966.39	34.276.856	2.007.000	20	**1 27.91**

Source: Generation Information Database – BIG / ANEEL

Of the operational power plants in Brazil, a total of 947 (59.11%) are UTE – Thermoelectric Power Plants, 277 (17.29%) are SHS – Small Hydroelectric Stations, 157 (9.80%) are UHE – Hydroelectric Power Plants, 01 (0.06%) are SOL – Solar Photovoltaic Power Plants; 15 are EOL – Aeolian Electric Power Plants (0.94%); 02 (0.12%) are UTN – Thermal Nuclear Power Plants and 203 are CGH – Hydroelectric Generating Stations (12.68%).

Brazil has massive and unexplored hydroelectric potential, especially in State of Santa Catarina. Of the above, potential Small Hydroelectric Stations – SHS are the most attractive projects because of their low environmental impact, lower level of investment, shorter maturity and legal incentives.

The investor's main objective is to generate power at a lower social and environmental cost, using this study to present technical solutions and actions to prevent, minimize and offset environmental impacts which may occur.

In this sense, the Santa Luzia Alto SHS is another step towards meeting energy demand in Brazil, contributing to local, regional and national economic development, while also addressing concerns involving the environment.

2. OBJECTIVES

This Environmental Impact Study – EIS aims to comply with the environmental legislation that addresses the need to develop environmental studies for the licensing activities that alter the environment, in particular CONAMA Resolution 001 dated January 23rd, 1986, CONAMA Resolution No. 237, December 19th, 1997, and CONSEMA Resolution 01/2006 which determines the production of EIS / EIRs for hydroelectric power generation projects exceeding 10MW.

This study will present technical solutions and actions to prevent or minimize the various environmental impacts of the works planned for the construction and operation of the Small Hydroelectric Station - Santa Luzia Alto SHS on the Chapecó river, in the municipal regions of São Domingos and Ipuaçu, with 28.5 MW capacity.

Information contained in this document complies with the rules in the *Reference Term for Environmental Study*, prepared by Terra Consultoria em Engenharia e Meio Ambiente Ltda and assessed and approved by the Environment Foundation (Fundação de Meio Ambiente) of the State of Santa Catarina – FATMA.

3. GENERAL DESCRIPTION OF THE PROJECT

3.1. General Information

3.1.1. Project Name

Small Hydroelectric Station – Santa Luzia Alto SHS.

3.1.2. Project Location

The project is located on the border between the municipal regions of São Domingos and Ipuaçu, western region of the state of Santa Catarina, about 580 km from the capital Florianópolis, Figure 01. The Santa Luzia Alto SHS will be built on the Chapecó river, main river of the Hydrographic Basin of the Chapecó river, with its physical structures, such as the construction site and power station, located on the right bank of the river, in São Domingos, located at UTM 0,347,639 E and 7,053,514 N, Exhibit 01.

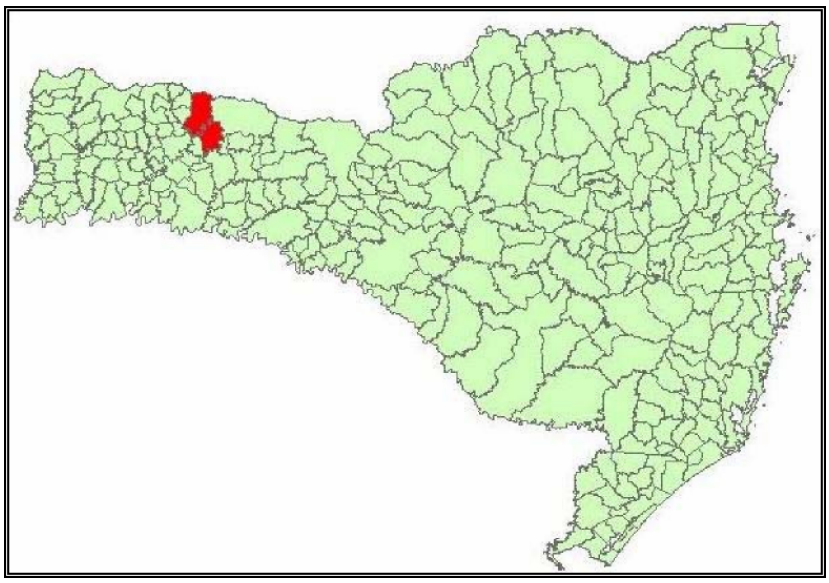

Figure 01 - Localization of municipal regions of São Domingos and Ipuaçu in the State of Santa Catarina

The SHS will be built on the Chapecó river, a tributary bank on the right bank of the Uruguay River, in the municipal region of São Domingos, 6 km south of the City Hall.

Access to the municipal region of São Domingos is along the SC - 480, branching off from the SC - 467, in the west of the state, going through Xanxerê, which connects with the BR-282 to Paraná. From the town center to the construction site area, access is along secondary unpaved roads on a journey of approximately 10 km.

The city has a bus station, with seven departure and boarding platforms, inaugurated in 1988, located on Rua Major Azambuja, 212.

3.1.3. Entrepreneur's Details

Company name: Construtora Gomes Lourenço Ltda.

- CNPJ: 61.069.050/0001-10
- Address: Av. Antônio Ramiro da Silva, n.º 250 – Butantã – São Paulo/SP
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3.2. Project Characteristics

This SHS is part of the hydropower project for the Chapecó river, in line with the water head divisions based on the Review of Inventory Studies drawn up in May 2001 and approved by ANEEL.

The project presented, prepared by RA Engenharia e Consultoria, has been developed in line with the standards and recommendations in force in the energy sector for the preparation and presentation of studies and projects for Small Hydroelectric Stations.

The implementation of the Santa Luzia Alto SHS aims to supply power at competitive costs to the consumer market.

The basic project and the engineering studies of the Santa Luzia Alto SHS were developed out by Construtora Gomes Lourenço Ltda. based on the instructions issued for SHS studies, projects and standards by ANEEL, relevant Brazilian standards and previous studies on site.

After field investigations and analysis of existing studies, we can safely say that the location specified for the Santa Luzia Alto Small Hydroelectric Station offers good conditions for construction, within the criteria established by ANEEL.

The proposed hydroelectric project for the Santa Luzia Alto SHS, for power generation, is located on the river Chapecó, 180 km from its mouth, on the border of the municipal regions of Ipuaçu and São Domingos, at UTM coordinates 0,347,639 E and 7,053,514 N.

The project will form a lake with a total area of 7.09 km² and an area, excluding the river, of 5.58 km², in other words, 709 ha and 558 ha respectively, Exhibit 02.

In developing the Basic Usage Project for Santa Luzia Alto, motorization studies were performed to analyze 24.0 MW, 25.5 MW, 27.0 MW and 28.5 MW output capabilities, in order to evaluate optimal output levels.

The power studies conducted allow us to evaluate the energy benefit of each alternative, in terms of the average power generated by the plant. In order to define the power output for the Santa Luzia Alto SHS, a study of energy/economic analyses, on a marginal cost-benefit basis, was performed considering the alternate configurations, their costs and energy benefits, seeking to obtain the best configuration in terms of the availability of water resources and the feasibility of construction.

In this analysis, we used the following criterion:

- The energy benefits were estimated based on the average monthly flows for the Santa Luzia Alto SHS, for 24.0 MW, 25.5 MW, 27.0 MW and 28.5 MW configurations;
- The costs of implementation were calculated at the Santa Luzia Alto SHS, for 24.0 MW, 25.5 MW, 27.0 MW and 28.5 MW configurations, with the costs based on June/2006;
- The period considered for amortization of the investment was 30 years, with the capital recovery at 10 % per year;
- The operation and maintenance cost were estimated at 12.00 R$/MWh;
- The sizing reference cost for expanding the electricity sector was equal to 131.00 R$/MWh;
- For upstream water level a normal maximum value of N.A. 589.00 m was used;
- For downstream water level the corresponding normal maximum value of N.A. was used for the plant immediately downstream from Santa Luzia Alto, called UHE Quebra Queixo, specified in Inventory Studies of the Chapecó river, and equivalent to 552.00 m.

In the current phase of studies for the Santa Luzia Alto SHS, in which the Basic Project is being consolidated, based on SIPOT/ANEEL data we found that the maximum N.A. at the Quebra Queixo plant, which is already in operation, is equal to 549.00 m, or three meters less than expected.

This increases the energy generated at the Santa Luzia Alto SHS, based on to the higher head available at the location (since N.A. of Quebra Queixo at a height of 552.00 m would "drown" the output from the power station at Santa Luzia Alto). With the change to 549 m, the power station is freed up, the reservoir retreats, leaving the power station above the still water level, draining immediately after it ends. This aspect allowed us to change the optimum capacity at Santa Luzia Alto SHS to 28.5 MW.

Thus, we again find that with the reduction in the level at UHE Quebra Queixo the Santa Luzia Alto power station water outlet will no longer empty into the UHE reservoir, although it is within the riparian range originally planned.

From an environmental standpoint the boost to 28.5 MW is positive, because the size of the lake will not change. Increasing the capacity at Santa Luzia SHS will not reduce or increase its negative impacts, however, there would be a considerable increase in positive impacts, especially in socioeconomic environment, encouraging economic activity and increasing the supply of electricity in the region.

We also noted, from an environmental standpoint, that the new position of the power station, does not alter the impact previously diagnosed, as the water output not only does not reach the Quebra Queixo reservoir, but also does not affect the aquatic biota or the sedimentary aspects of the section in question.

3.2.1. General Project Layout

The project to build the Santa Luzia Alto SHS presents a block formed by a dam with concrete spillway located on the river bed and by two small earth abutments completing the closure of the river on the left and right banks.

The concrete dam, to be built in C.C.R. (concrete compacted with roller), will be built on a section of riverbed and in the spillway. The spillway will be the free flowing type, with a crest at an elevation of 589.00 m, and total length of 350 m. The rest of the concrete dam will crest at an elevation of 594.00 m, will be 5.0 m wide, with an upstream vertical face and with slope 0.75 H:1.0V downstream. The maximum height of the foundation will be 35.0 m.

The earth abutments on the left and right banks will crest at an elevation of 594.00 m with lengths of 228.3 m and 235.6 m respectively, with embankments sloping at 0.0V:2.0H upstream and downstream. The maximum height of the foundation will be 26.0 m.

The river diversion for construction of the dam will use concrete penstocks built on the left bank, formed by 03 cells 4.50 m wide and 8.0 m tall. Its total length will be 35m.

The supply pipeline circuit, to be built on the right abutment, will consist of the following structures: adduction channel, water intake, a set of three penstocks, power station with three horizontal Francis units and tailrace. Given the relative proximity of the power station and the water intake, the latter will act as a cargo chamber, not requiring the balance funnel.

The substation will be conventional, a single line with three entry bays and two line bays. The substation courtyard will be located on the right side of the power station and downstream from the tailrace, in an area approximately 800m^2 available at an elevation of 565m.

The general layout of the works can be seen in Exhibit 03.

3.2.2. River diversion

The river diversion was designed so that the dam could be built in a dry area, and this is a simple and low cost diversion.

The river diversion will use concrete sluice gates comprising three 4.50 m wide by 8.0 m high cells, to be built on the river's left bank, and two rock cofferdams, one upstream and the other downstream.

This gallery, scaled in order to allow an outgoing flow of 843m^3/s, which corresponds to the output with an ROI of 25 years within the quarterly period of January/April, will have a total length of 30m, with a floor at an elevation of 559m.

The diversion gallery mouth will be provided with two closing grooves, one upstream for the flow-cut metal floodgate and downstream for the concrete cofferdam gates. After closing the first cell with the metal flow-cut floodgate and concrete cofferdam gate, the flow-cut floodgate will be removed for use in the second cell and so on until final closing.

The cofferdams will be constructed using a 12.00 m wide crest, made of foundation rock with external clay soil sealing. Sand filters and transitions made from processed granular materials will be inserted between the soil and foundation rock.

The upstream and downstream gallery will be excavated with channels to adduce and return the gallery diversion waters. The upstream channel will be approximately 170 m long and the downstream channel 100m long and they will be partially excavated in soil and rock.

In the first phase the river will flow along its natural bed. The left and right bank works will be executed dry to shelter natural barriers, therefore maintaining a 570 m elevation for the natural terrain. This level is higher than the river water level for output over a period of 5 years in terms of the complete hydrologic year.

In this phase, the following works will be required:

- Partial excavation of the upstream and downstream channels for the diversion gallery (left bank);
- Excavation and construction of the diversion gallery (left bank);
- Link wall with the earth dam, at least up to an elevation of 573.0 m;
- Left bank dam, at least up to an elevation of 573.0 m;
- Left bank dam, at least up to an elevation of 573.0 m;
- Closing in the area between the excavation and the spillway blocks using a cofferdam, upstream and downstream from the gallery

On the right bank, all services up to an elevation of 570 m, may be executed in order to avoid works creating a bottleneck in the 2nd Phase of the diversion which will be only 4 months long.

In the second phase of the diversion, which will be carried out during the dry season, the excavations of the upstream and downstream channels will be completed, allowing the water to run through the gallery diversion.

Upstream and downstream cofferdams will be built in sequence at respective elevations of 573.60m and 565.60m.

The cofferdams will be built at an embankment point, using foundation rock with external clay soil sealing. Processed granular transition materials will be used between the soil and foundation rock.

3.2.3. Dam

The concrete barrier measuring 430m will be the main structure of the dam. In the central part above the bed of the river there will be a free-flowing spillway 300m in length and a crest at an elevation of 589,00m, which corresponds to normal water level for water-level plants. Closing the abutments on the left and right banks we will use concrete blocks connecting with the earth embankments, both at an elevation of 594m.

The dams on the left and right banks will have vertical and horizontal drainage for controlling percolation.

The earth dams, which complete the enclosures on the left and right abutments, will crest at an elevation of 594,00m, and length of 228,3m. The upstream and downstream embankments will slope at 1.0V:2.0H.

In Exhibit 04 the plant and barrier sections are presented.

3.2.4. Spillway

The spillway will use a gravity type concrete structure, and will function hydraulically with a free-flowing weir, releasing floodwaters along its 250m length.

The crest of the spillway will be at an elevation of 589.00m, which corresponds to the normal water level of the plant, which will operate at water level.

The spillway structure will be fully supported by rock. The downstream face, in a stepped format, will allow the dissipation of most of the effluent energy flow.

The spillway will allow the passage of the maximum flood levels, whose peak value is equal to 3,877.0 m^3/s, with a maximum height of 3.00m.

A dispersion valve will be installed in the concrete dam structure on the left bank to guarantee the environmental flow discharge necessary downstream from the barrier.

Upstream from the dispersion valve a gate vale will be installed for maintenance purposes.

3.2.5. Dispersion valve

In the concrete dam structure on the left bank a dispersion valve will be installed with 3.60m³/s output, which will guarantee the environmental flow necessary downstream from the barrier.

The flow will be taken in frontally, on the upstream face of the spillway, through an opening 1.40m by 1.40m, equipped with a grille. A 900 mm diameter pipe will conduct this flow to the dispersion valve, with a diameter of 700 mm.

Upstream from the disperser valve a slide valve will be installed, 700 mm in diameter, for maintenance of the disperser valve.
The axis of the disperser valve is positioned so that its discharge flow is above the downstream water level.

The valves, both the butterfly and dispersion vales, will be operated manually. **3.2.6. Adduction Channel**

The adduction channel in the trapezoidal section was designed so that the speed of the flow will not exceed 1,0 m/s, as part of the channel will be excavated from the soil, without a lining. The length of the channel will be about 202m.

3.2.7. Water intake

The location of the water intake aims to reduce the length of the penstocks as much as possible.

Based on this, the water intake structure was placed on the top of the natural slope, with suitable foundation structure and easy access.

The water intake structure will be a gravity type supported on solid rock. Its total height will be about 20m reaching an elevation of 595m.

For the operating conditions of the intake, with a flow of 85,0m3/s, the maximum speeds through the grille and in the emergency floodgate section are 1,0 m/s and 2,0 m/s, normal values in hydraulic designs for this type of mechanism. The submergence adopted for the water intake is sufficient for the maximum turbine flow.

The analysis of the global stability and security revealed that the structure of the water intake is secure, with security factors and tension levels in the foundation compatible with normal values, under all conditions.

3.2.8. Penstock

The penstocks at Santa Luzia Alto SHS are exposed, open air, anchored and supported by concrete blocks set on rock. The general layout of the penstocks was based on the proposed geometry of the adduction circuit, of the

position chosen for the water intake and for the power station.

When defining the diameter of the penstocks, the economic aspects and operating conditions of the turbines were considered, namely: turbine regulation and efficiency.

The operating conditions for the turbines depend on the inertia of the water column in the penstock, in other words, the sum of the products of the speed and length of each section of the penstock.

They therefore depend on the diameter and length of the pipe. Following consultation with the manufacturers, for adequate regulation and efficiency of the turbine-generator group, each penstock needs to be 2.8m in diameter, requiring three penstocks around 285m in length.

3.2.9. Power station and Tailrace

The Santa Luzia Alto SHS with a total output of 28.5 MW will include a power station located downstream from the dam and built on the right bank of the Chapecó river, Exhibit 05.

The structure of the power station was designed to contain three horizontal Francis turbo-generators units providing 9.50 MW.

The power station is 25.8m long and 54.9 m wide, including the assembly area. The electrical and mechanical galleries, as well as the command room are located upstream from the units.

Downstream, a group of cofferdam floodgates will close the suction pipes of the units.

The tailrace was designed based on the hydraulic conditions, the size of the power station and the turbine suction pipe, as well as the topographic characteristics on site. The trapezoidal channel will have a mouth 45.0m wide and about 100m long.

3.2.10. Mechanical Equipment

Mechanical Equipment installed at the Santa Luzia Alto SHS:

Water Intake Metal Grills: Metal grills will be installed to retain submerged materials larger than 50 mm, thus protecting the turbines.

Water Intake Wagon Gate: The wagon gates protect the penstocks. Each wagon gate will be made of a single panel and will sealed upstream, which will facilitate aeration of the penstock downstream of the floodgate and reduce the hydrodynamic effects when closed.

Water Intake Overhead Crane: The overhead crane will be installed on a concrete structure at the top of the water intake and will be used for assembly and maintenance services involving the wagon gate grills and the rake that cleans the grills.

Penstock: The penstocks will feed three turbines. They will be installed externally and inclined with the upstream ends supported by the structure of the water intake, with intermediate sections supported by concrete blocks and the downstream ends directly connected to the input system for the 3 turbines.

Hydraulic Turbines, Regulators and Valves: In the Power Station there will be three groups of similar horizontal turbine generators installed, each group made up basically of one generator with 10,0 MVA rated power at 13.8 kV and frequency of 60 Hz, and one Francis hydraulic turbine with rated power of 9.5 MW under rated net head of 35.9m.

Power Station Overhead Crane: In the Power Station there will be an overhead crane with a capacity of 350 kN which will help to assemble the hydro generator and auxiliary equipment After generator group startup, the cranes will be used for Plant maintenance operations.

Suction Pipe Cofferdam Gate: The cofferdam floodgate for the suction pipes empty the turbines by sealing the water inlet in the suction pipe tailrace. In the Power Station there will be a floodgate cofferdam made of a single element, with the same front and lateral floor height which can therefore be installed in any of the three suction pipes.

Electric Downstream Hoist: In the External Area Downstream an electrical pulley will be installed to operate the cofferdam floodgate for the Suction Pipe.

Filling and Emptying System The emptying and filling system will completely empty or fill the penstock, spiral casing and suction pipe for the generator units. The penstock filling will use gravity, through one pipe installed upstream of the floodgate for the Water intake. The spiral casing and suction pipe will be emptied by a pump.

Drainage System: The drainage system will collect all of the water in the Power Station from percolation, infiltration, equipment discharges, pipe leaks and floor cleaning and transport it to the tailrace.

Compressed Air Service System: The compressed air service system will produce, store and provide compressed air for the Power Station, for piping, equipment and surface cleaning, operation of pneumatic tools and air supply for instruments. This system will include 1 (one) air compressor, one air reservoir and one feeding pipe and a pipe network.

Hydraulic Measurement System: The hydraulic measurement system will include the following measuring instruments: Measurement of the Downstream Levels of the Plant, Measurement of the Water levels upstream, Measurement of Load Loss at the Grills, Detection of Balance of Pressure in the Wagon Gate and Measurement of the Flow in the Spiral Casing, Measurement of Pressure of the Spiral Casing, Measurement of Pressure in the Suction Tube.

3.2.11. Transmission Line for interlinking with the System

The project at Santa Luzia Alto SHS includes interconnection of the pumping and maneuvering substation SE-SL to the 138 kV dam at the Ludesa SHS substation, using a 138 kV single circuit transmission line approximately 6 km long.

3.2.12. Sanitary Flow

In order to evaluate the minimum flow over 7 consecutive days associated with a 10 years of return period, in the basin of the Chapecó river at the Abelardo Luz station (code ANA 73600000), a series of daily average flows at the station was used, covering the period from April/1953 to January/2006, with data missing from a few years: 1953 and 1956, inconsistent values for 1990 and 1991 and more extensive periods with no data in 1966 and 1967.

Based on the series of daily average flows, the moving averages for 7 consecutive days were calculated, establishing the minimum discharge over 7 days for each year, building a series of 47 values, as presented in Chart 02.

Table 02 – Minimum weekly flow.

Year	Minimum 7 Day Flow (m^3/s)
1953	----
1954	9.8
1955	4.9
1956	4.2
1957	4.6
1958	3.9
1959	9.8
1960	4.9
1961	7.3
1962	7.3
1963	8.0
1964	9.8
1965	7.3
1966	----
1967	----
1968	6.1
1969	16.8
1970	11.0
1971	10.4
1972	11.0
1973	16.8
1974	11.0
1975	11.0
1976	12.0
1977	6.7
1978	2.9
1979	4.6
1980	12.0
1981	9.8

1982	8.0
1983	17.8
1984	11.0
1985	10.8
1986	8.1
1987	9.4
1988	6.8
1989	22.6
1990	32.0
1991	23.8
1992	22.6
1993	18.0
1994	18.0
1995	10.1
1996	13.8
1997	13.8
1998	18.0
1999	13.1
2000	13.1
2001	18.0
2002	7.8
2003	9.4
2004	10.5
2005	11.6
Average (m^3/s)	11 .44
Standard (m^3/s)	5.84

Initially, we define the reduced and variable data expressed through (Gumbel distribution line): y = $_a$ * (x - $_3$) , being $_a$ and $_3$ the parameters:

$_a$ = - $_y$ / $_x$ and $_3$ = μ_x – (μ_y / $_a$)

Based on the sample size (50 values), we obtained the following table values: $_y$ = 1.1607 (function of sample size); and

$_x$ = 5.84 (standard sample diversion) which provides = 0.1988

μ_x = 11.44 (sample average); and

μ_y = 0.5485 (function of sample size) which provides $_3$= 8.68

Finally, utilizing the Gumbel distribution expression:

-0.1988 * ($Q_{7,T}$ – 8.68) = - ln * (-ln (1 – 1/T), for T = 10 years with:

$Q_{7.10}$ = 5.03 * ln (- ln (1 – 1/10) + 8.68 , we obtained:

$Q_{7.10}$ = 2.624 m^3/s which corresponds to the flow for 7 consecutive days and 10 year return period.

Based on the equations defined by Tucci (1991) for the 18 homogeneous regions in Rio Grande do Sul, an evaluation was made based on the data from the Abelardo Luz station.

In the regions defined by Tucci, the course of the Chapecó river corresponds to region 5, providing for T_R= 10 years a minimal adimensional flow of 0.50.

Using the proposed methodology, a minimal flow of $Q_{7,10}$ = 2,68 m^3/s was obtained, a value which is compatible with that defined by Gumbel's equation (2,624 m^3/s), adopting the latter.

In order to define the flow for 7 days and 10 year return period at the Santa Luzia Alto site, we transferred the flow obtained at the Abelardo Luz station to the project location, applying a factor based on the drainage area ratios in both locations, obtaining:

$AD_{Sta\ Luzia} / AD_{A\ Luz}$ = 2,540/1 850 = 1.3730

Applying this factor to the minimum flow from Abelardo Luz, the following flow was obtained for the SHS:

Q 7.10 = 1.3730 * 2.624 = 3.60 m^3/s

3.3. Construction Planning

Planning mainly aims to define the building sequence for the services based on an adequate methodology in relation to the local conditions, establishing support logistics for the construction, complying with the deadlines and reasonable and technically optimized costs. This involves construction of the Santa Luiza Alto SHS power plant with the power station built in the right bank of the Chapecó river and includes the following structures:

- Works on the River
  - Diversion:
  - Cofferdam
  - Detour Sluice
- Work on the Generation Circuit
  - Adduction Channel; Water Intake;
  - Penstock; Power Station and
  - Tailrace.
- Barrier and Control works:
  - Free-flowing Spillway in CCR;
  - Lateral Walls in CCR;
  - Earth dam on the right bank
  - Earth dam on the left bank
  - Lateral Walls
  - Control of Sanitary Discharge
- Work on the Associated Transmission System:
  - Pumping Substation
  - Transmission Line

Prior to the constructive planning per se, the general aspects of the project construction area and the regional logistics were analyzed.

For a better understanding of the general planning for the works, the presentation was laid out as follows:

- Construction Planning, where various construction and assembly phases were defined, the sequence of construction by structure, the work plan, the resources needed in terms of equipment and the construction site;
- Detailed physical timetable, showing the sequence of construction works detailed by type of service and structure.

The description of the above items intends, in a simple and objective manner, to present the events which will occur during the works, the sequence and form in which they will be executed and all the necessary logistical support, such as: Resource mobilization, supplies, construction site and other support infrastructure works.

Prior to beginning the works, the detailed engineering design is required, as part of the planning process, which will consist of scaling, detailing and consolidating earth and concrete structures to be built, as well as electromechanical equipment, such as: turbines, generators, hydromechanical equipment, cargo moving equipment and electric equipment. Based on the guidelines adopted in the basic project the size, location, form and composition of each structure and equipment will be defined and consolidated, based on local conditions.

Thus, January 2007 was the date set to start detailing the detailed engineering design, which may be modified as a result of ANEEL's releases and approvals, consequently causing some alterations and changes to the schedule, but without affecting the final deadline for the works.

3.3.1. Construction Planning

Specific Considerations

The plans for the works at Santa Luzia Alto SHS and for the Transmission System were developed after a detailed analysis of the basic project, the local conditions and logistics supporting the service fronts, also based on a preliminary evaluation of the specific details in the detailed engineering design in order to ensure technically and economically consistent building methods are used in the construction area.

Initially the basic assumption for our planning was that the works would begin in mid-August 2007 (month 01) and the operations would start up in May 2009.

It is essentially a SHS project with quite specific characteristics, in which the works on the generation circuit and the dam (VT) are isolated and concentrated at the river's right bank and bed. This means they can be built at any time, completely reusing the materials dug in earth or rock.

The works present a moderate movement of earth and rock from cuts and embankments, with production hardly influenced by the rain. May, June, July and August are the most unfavorable months for excavations, when it is more risky to carry out construction work on land, requiring

continuous and temporary drainage works. 30 to 50% of the time spent working during this period will be lost.

Because of the very good location of the power station at the foot of a slope, the planning for excavation works during the first months takes into account the expansion of the area at an elevation of 552m with the use of material dug from the foundation of the power station, heading partially towards the river, creating a protecting cofferdam in the final section of the tailrace, fully encompassing the excavation area at the power station. That protection will use the material from of the initial excavations of the power station and will be placed directly in the river. Subsequently, the excavations and the respective protections will be built.

The excavation of the adduction channel can be performed at any time will not be influenced by the water levels, which will always be at elevations below 570m.

The following parameters were deemed critical factors during planning, in addition to a careful study of the basic project:

- Volume of services;
- Local topographic conditions;
- Climatic conditions;
- Work support logistics;
- Definition of proper construction methods;
- Productivity of construction equipment.

Among the items above, we shall quickly cover the Work Support Logistics, as the others are covered in specific items. In this category we grouped all measures expected to provide the sites with facilities required for its construction, as well as ensuring continuity at service fronts. Within this area, the following issues are highlighted:

- Mobilization Plan;
- Supply Plan;
- Availability of equipment;
- Stock of fuel and basic materials;
- Availability of qualified personnel and accurate forms of hiring;
- Employees' meals, rest and leisure;
- Hospital and medical care;
- Proper application of safety standards;
- Regional supply sources;
- Infrastructure and work site.

It is important to point out that within the support logistics, we have included the activities required to comply with Hygiene and Occupational Medicine regulations, as well as the standards on Safety and Accident Prevention.

3.3.2. Construction and Assembly Phases

The construction and assembly stages require different construction phases within the conditions established by the project. They must always comply with the technical and economic conditions in order to conduct of the services within acceptable costs parameters and periods, describing the difficulties involving support infrastructure and supply conditions.

In the executive planning, four construction phases and assembly phases are highlighted and presented in Exhibit 06.

First Phase

The first phase of services characterized below, involve mobilizing the construction company, building the infrastructure and work site. The initial phase of the detailed engineering design includes establishing further details as well as confirmation and evidence of services carried out in the field.

The first phase involves keeping the river in its natural bed and the beginning of the excavation works for the diversion channel and dry sluices at the left bank.

At the same time, the earthworks for the generation circuit include the power station and tailrace, water intake and penstocks.

Initially the excavations for the power station will be carried out by raising the protection wall downstream from the tailrace and slopes of the power station, initially used as a protecting cofferdam. This will stop the water from penetrating the excavations for the power station and tailrace.

This work shall be supplemented by the embankments for the substation and assembly area. Next, additional access ways shall be completed so that excavation services can be carried out at any time of the year. Additionally, note that the barrier downstream from the tailrace will act as a cofferdam up to construction of the floodgates for the suction pipe. Among the other services and works in this phase, the following are highlighted:

- Surveys and supplementary investigations;
- Detailing of the detailed engineering design
- Deforestation and clearing of the work site areas and structures at the right bank;
- Construction of the support works (work site, service roads and others);
- Excavation of the adduction channel between the downstream and upstream barriers (ME);
- Excavation of sluices and blocks 01 and 02 of the embracing wall (ME);
- Treatment of foundation and concrete application of sluices and blocks 01 and 02 of the spillway next to sluices at an elevation of 573 (ME);
- Excavation of the power station, water inlet and adduction channel (MD);
- Earthwork of the substation and assembly areas;
- Excavations of the power station, tailrace and penstock.

Second Phase

The second phase diverts the river with the underwater construction of the first stage of cofferdams upstream up to an elevation of 573m and downstream at an elevation of 567m, completely closing off the river.

This phase involves the excavations of other works for the generation circuit and execution of the river diversion, concreting the diversion gallery and excavations of the water inlet, adduction channel and control inlet. Subsequently, the concrete works on the power station, penstocks, and spillway, as well as the stabilization of the balancing berms for the embankments formed by cuts and land-fills. This is also when assembly of the fixed parts and moulds of the suction pipes begins. The following services are highlighted at this stage:

- Closing off the cofferdam between VT-ME blocks and natural slopes 573;
- Removal of the upstream and downstream barrier ME;
- Construction of both cofferdams upstream and downstream;
- Excavation and lining of the VT foundation of river bed;
- Treatment and concrete application for the foundation for the power station;
- Concrete Application of the VT in CCR up to an elevation of 573;
- Concrete Application VT up to an elevation of 589 and walls up to an elevation of 595 ;
- Execution of the land dam for the ME;
- Execution of the land dam for the MD;
- Concrete application for the structures of the power station and penstocks;
- Concrete application for the drain structures and walls;
- Excavation of the foundations for the water inlet, adduction channel and control structure;
- Excavation and treatment of the foundation for the protection dike.

Third Phase

Completion of the dam works – VT, Walls, BTMD and BTME. The following services are highlighted:

- Concreting of the power station and water inlet;
- Concrete application of the foundation blocks for the penstocks;
- Construction of built-in metal items;
- Assembly of the penstocks;
- Construction of the earth dikes on lake abutments;
- Assembly of electro-mechanical equipment.
- Treatment of the adduction channel;
- Assembly of hydromechanical equipment;
- Assembly of the lifting and cargo transportation equipment.

Fourth Phase

The fourth phase involves receiving the first turbine on site, starting the electro-mechanical assembly of the generating equipment through to commissioning, testing and commercial generation.

The following services are included:

- Covering and finishing of the power station;
- Assembly of turbines and generators;
- Assembly of electric equipment;
- Civil works and assembly of substation and transmission line;
- Plugging the galleries – river through the spillway.
- Commissioning and Testing
- Commercial energy production
- Assembly of turbines and butterfly valves;
- Assembly of generators and accessories;
- Assembly of auxiliary mechanical equipment;
- Assembly of electric and accessory equipment
- Assembly of substation;
- Commissioning and Testing
- Commercial energy production.

The works on the 138 kV transmission line that connects the substations at Ludesa SHS and Santa Luzia Alto are external works included in this phase, forming, the entire generation and transmission system.

3.3.3. Construction Site Planning

The facilities on the works site, Exhibit 07, were designed based on field surveys at the work site, experience at similar sites and requirements drawn up from executive planning. The size of the facilities always considered the peak needs of each work front, both cumulatively and individually.

The work site and accommodation will be modular and pre-fabricated so that they can be used again, a critical condition for selection because of the short period of time they will remain on site.

The site accommodation will be sufficient to accommodate employees during peak work periods and, if required, the projected modules can be enlarged. The project takes into account the fact that some employees will be hired from neighboring cities and will be driven to work daily. The canteen will be able to serve up to 120 people in three shifts.

The following facilities are highlighted here as the main facilities:

- Accommodation;
- Leisure Area;

- Administrative Technical Office;
- Warehouse;
- Out-patient clinic;
- Guard house and Chapeira;
- Soil and Concrete Laboratory;
- Store-room for Sacked Cement;
- Concrete Centre and Wet Chamber
- Mould Centre;
- Frame Centre;
- Storeroom for Explosives;
- Crushing Centre;
- Assembly and Maintenance Workshop;
- Deposits of Fuels and Lub-oils;
- Water Collection and Reservation System.
- Treatment systems of Sanitary Effluents and others.

The Crushing Centre and Concrete Centre provided for on site will be installed close to the quarry located downstream from the power station.

The work site will be located on a plateau located between the 600 m and 615 m elevations upstream from the generation circuit on the right bank, at approximately 900 m from the geometric center of the power station. The explosives storeroom will be designed accordingly and be built at the hillside downstream, complying with the relevant safety standards.

Construction at a strategic location aims to offer better services on sites and facilitate the machine, vehicle and equipment traffic, without interfering with the service units.

The proposed layout includes independent areas for each activity, be they management, accommodation or production areas.

In addition to the facilities at the main work site, we have included field WCs for the service fronts and an auxiliary work site close to the power station on the right bank, basically comprising of a large service tent, field office and WCs.

When building the work site, earthworks and adaptations as well as infrastructure works, such as electric network, supply of drinking water, water networks, sewerage systems and individual concrete cesspools for each facility and drainage services are included. The maintenance workshops will include sand / pebble boxes for the collection of oily water, preventing contamination of local water sources.

The mobilization of the work site will begin immediately, starting with the earthworks and implementation of the inspection and builder's offices, mechanical workshop, kitchen and canteen and outpatient clinic. Afterwards, the industrial facilities will be built and the store-areas for rock, pebbles and sand will be defined.

3.3.4. Physical Schedule

The physical timetable submitted reflects the general course of services and works, showing the construction sequence, their deadlines and the inter-relationship among the events.

March 2007 was defined as the deadline to start works, taking into account the periods for ANEEL approval and licensing.

Commercial generation is scheduled to occur in May 2009.

The main condition used to specify the milestones was the period required to manufacture and supply the turbines with a minimum deadline of twelve months for the first machine and up to sixteen months, for the third.

The critical path includes construction of the power station, including civil works, designs, production, transport, assembly/supervision, testing and commissioning of the turbo-generating units and the electromechanical equipment. The physical timetable is represented in Exhibit 08.

4. LEGAL AND INSTITUTIONAL ASPECTS

Environmental law provides rules that regulate the interrelation between man and the environment and aims to defend and preserve the latter, ensuring oversight and compliance with these rules.

Environmental licensing is an administrative procedure through which the State or Federal Government requires parties that want to develop potentially or effectively pollutant activities to issue environmental studies and environmental monitoring and control plans and programs.

This chapter is devoted to the introduction and analysis of the main legal provisions within the Federal, State and Local spheres which must be taken into account when planning and operating the Santa Luzia Alto SHS.

4.1. Environmental Licensing

Environmental Licensing is a planning tool, part of National Environment Policy (Law No. 6.938/81 – amended by Laws 7.804/89 and 8.028/90; regulated by Ordinances 89.336/84, 97.632/89 and 99.274/90), to preserve, improve and recover environmental quality and support life, ensuring conditions for socioeconomic development and protection of human dignity.

This means that any construction, installation, extension and operation of any activity or facility using natural resources and which is deemed effectively or potentially pollutant or which may cause environmental degradation is required to apply for advanced licensing.

Although enacted in 1981, some orders included in the National Environment Policy were only regulated in 1986, by Resolution No. 001 issued by the National Environment Council - CONAMA (amended by CONAMA Resolutions 01 1/86 and 237/97), attributing responsibilities and governing the institutional channels to implement the aforementioned regulations.

This was therefore the basis for defining the Environmental Impact project and establishing criteria for preparing the Environmental Impact Assessment (EIA) and the Environmental Impact Report (RIMA), both critical documents when obtaining the Prior Environmental License (LAP).

Environmental Law in the State of Santa Catarina, Decree 14.250, dated June 05, 1981, which regulates Law No. 5.793, dated October 15, 1980, which provide for the protection and improvement of the environmental quality, states, in article 69: *"The construction, the expansion and operation of equipment or industrial, commercial and service activities depends on prior authorization and registration, provided they are included in the list of activities which could possibly cause environmental degradation."*

CONSEMA Resolution of 2006, "Approves the list of Activities Deemed Potential Causes of Environmental Degradation requiring environmental licensing by the Environment Foundation - FATMA and relevant environmental assessment for licensing purposes", in its Exhibit I - Activities

Subject to Environmental Licensing and Respective Prior Studies – classifies energy production with 28.5 MW of nominal output as a medium size project, requiring an Environmental Impact Assessment and respective Environmental Impact Report.

4.2. Licensing Powers

In general terms, the environmental licensing processes are described in CONAMA Resolution No. 237/97.

The State environmental body is responsible for licensing any project or activities with significant environmental impacts located or developed in two or more Municipal Districts, or in State preservation units or where the direct environmental impacts occur within inter-municipal areas or, additionally, when the Municipal District does not have the relevant infrastructure (an Environment Department).

The projects or activities that are located or developed in forests and other areas of natural vegetation subject to permanent preservation, established in article 2 of Law No. 4.771, of 1965 or in those that are designated as such by act of Government or when assigned by the Federal Government, fall under this rule.

Considering this information and the fact that the Federal Government has not delegated this task to the Municipal Districts affected by the project, the environmental licensing process at Santa Luzia Alto SHS is governed by the State environmental body for the State of Santa Catarina, FATMA.

In compliance with CONAMA Resolution No. 237/97, in Art. 10, 1st paragraph, environmental licensing procedures shall provide a Municipal Government certificate, stating that the location and type of project or activity are in compliance with laws applicable to the use and occupancy of the land. In this case, the Local Governments of São Domingos and Ipuaçu were consulted and the certificates were submitted in Exhibit 09.

4.3. Licensing Stages

The Environmental Licensing through FATMA involves three different phases:

Prior Environmental License - LAP: This is the document requested in the preliminary planning phase, corresponding to the studies defining the location of the project. The issuance of the LAP does not authorize any works or activities for the implementation of the project.

LAP is valid for up to two years and establishes the feasibility of the project and/or location of equipment or activities, in terms of the environmental impact and guidelines for land usage.

Environmental Facility License - LAI: This is the document that must be requested before the construction. At this phase, the following documents, and others, are required: copy of the authorization for tree felling issued by FATMA (as applicable), the

licenses from the municipal governments and the Detailed Report of Environmental Programs. The issuance of LAI is a commitment from the interested party to maintain the final project in line with the approved conditions.

LAI is valid for up to three years and it authorizes the construction activity or installation of equipment, based on the final detailed engineering design.

It is the document that must be requested before the starting the project. The issuance of the LAO implies a commitment from the interested party to maintain the pollution control equipment pursuant to approval conditions.

The LAO is valid for up to eight years and authorizes operation of the equipment, activity or service, based on survey, operation test or any technical means of verification.

4.4. Legislation Related to the Project

Below is a list of the legislation related, either directly or indirectly, with the project, representing general and specific rules or regulations in the environmental licensing process.

Federal Legislation

- Federal Constitution of 1988– In article 225, it states that "everyone is entitled to an ecologically balanced environment, which is public property of common use and essential to a healthy quality of life, where the Government and the population are responsible for defending and preserving it for current and future generations.". It also states that the Federal Government, the States, the Federal District and the Municipal Districts are liable for preserving the forests, fauna and flora, prohibiting practices or activities that endanger the survival of these resources, or cause their extinction. With regard to authority, it allows States and Local Governments to create a law on almost all subjects associated with the environment, in accordance with their specific needs. The State environmental agency can stipulate the general requirements and define specific standards of requirements that are more severe but not less detailed or restrictive than those issued by the Federal Government. They must comply with art. 5, item XXIII, which amended the characteristic of the property right stating that property must fulfill its social function, which, in compliance with art. 186, referring to rural property, includes, but is not limited to, environmental preservation.
- Law No. 4.132/1962 – Provides for cases of expropriation based on social interests, making instruments available to the energy industry providing effective measures for the protection of reservoirs and corrections to the impacts caused in the Area of Influence around these projects.
- Law No. 6.513/1977– Requires the electric industry to consider, when selecting its projects, special areas and areas of tourist interest.

- Law No. 6.938/1981 – In article 3 "Provides for the national environmental policy, its purposes and mechanisms of formulation and application and other measures." This Law established an approach involving detailed planning with regard to the preparation of environmental regulations, creating a licensing process in three stages for economic activities that may cause environmental impacts: Prior Licensing, Facility Licensing and Operation Licensing.
- Law No. 7.347/1985 – Regulates the Public Civil Action of liability for damages caused to the environment, consumers, property and rights of artistic, aesthetic, historical, tourist and landscape (cancelled) value and other measures.
- Law No. 7.990/1989 – Provides for a 6% tariff on the value of the power generated to be paid to the States and Municipal districts and bodies within the direct administration of the Federal Government.
- Law No. 8.001/1996 – Provides for the correction of environmental damage caused by the destruction of forests and other ecosystems by projects that cause environmental impacts, including the distribution of "royalties" from the electrical industry.
- Law No. 9.427/1996 – Provides the rules for the electric industry comprising issues related with the energy production and SHS's.
- Law No. 9.433/1 997 – Creates the National Policy of Water Resources and the National Management System of Water Resources, partially amending the water code of 1934.
- Law No. 9.478/1997 – Provides for the national energy policy and other measures.
- Law No. 9.605/1998 – Enacts criminal and administrative penalties resulting from behavior and activities that are harmful to the environment, which were later regulated by Decree no. 3.179 of September 21, 1999. These legal rules define the application of fines and other punitive measures for offences against the environment, specifying, in chapter V, Sections I and II, the crimes and punishments referring to aggression against fauna and flora, respectively.
- Law No. 9.984/2000 - Creates the National Water Agency – ANA, a federal agency for implementing the National Policy of Water Resources and coordination of the National Management System of Water Resources.
- Law No. 9.985/2000 – Regulates article 225, 1st paragraph, items I, II, III and VII of the Federal Constitution, creates the National System of Nature Preservation Units for the Conservation of Nature – SNUC, establishing criteria and standards for the creation, implementation and management of preservation units.
- Law No. 9.993/2000 – Redefines the distribution of the portion referring to the Federal Government's interest in "royalties" based on 6% of electric power generation.

- Law No. 11.428/2006 – Provides for the use and protection of the native vegetation of the Atlantic Forest Biome, and other measures.
- Provisional Measure No. 1.956/1952 - Provides, in article 4, the requirement regarding expropriation or purchase, by developers, of the permanent preservation areas created following the construction of artificial reservoirs, the parameters and usage regime which shall be defined by CONAMA Resolution.
- Decree No. 26.643/1934 – Creates the Water Code and regulates the actions that involve the multiple uses and preservation of waterways.
- Decree-Law No. 852/1938 – Defines the concept of public waters for common use and other related measures.
- Decree-Law No 2.848/1948 (Criminal Code) – In article 271 it states that the concessionaire that uses water will be responsible for its quality.
- Decree No. 40.974-A/1961 – Established mandatory maintenance of the quality of the water and reservoirs in the downstream area, applicable to the electricity industry.
- Decree No. 50.887/1961 – Defines the pollution of waters and characterizes the construction of hydroelectric projects as potentially pollutant, requiring development of corrective or offsetting measures.
- Decree No. 221/1967 – Provides for the protection and incentives for fishing.
- Decree No. 99.274/1990 - Regulates Law 6.902/81 and Law 9.938/81, which respectively provide for the creation of Ecological Stations and Environmental Protection Areas and the National Environment Policy (amended by Decrees 122/91 and 2.120/97; revokes Decree 88.351/83 and others). Provides for the licensing of activities that use environmental resources, deemed effectively or potentially pollutant or able to cause environmental degradation.
- Decree No. 2.612/1998 – Regulates the National Council of Water Resources and provides other measures.
- CONAMA Resolution No. 002/1985 – Includes the construction of dams as potentially pollutant activities.
- CONAMA Resolution No. 001/1986 – Establishes that the licensing of activities that change the environment shall depend on the development of an Environmental Impact Assessment –EIA and respective Environmental Impact Report –RIMA to be submitted for analysis by the relevant environmental bodies.
- CONAMA Resolution No. 006/1986 – Approves the models for licensing requests. Provides instructions for publication of licensing applications, renewal and issuance of licenses in newspapers and official gazettes published by the State or Federal Government.
- CONAMA Resolution No. 006/1987 - Establishes general rules for environmental licensing of large scale works, specially electrical energy generation. States that the power exploration, generation and

distribution concessionaires, upon submitting their projects for environmental licensing shall provide technical information, as provided in environmental law and procedures defined in this Resolution (art. 1).

- CONAMA Resolution No. 009/1987 – Provides for Public Hearings. The Public Hearing referred to in CONAMA Resolution No. 001/86 aims at providing interested parties with information on items analyzed and the related RIMA, answering questions and receiving comments and suggestions from those present.
- CONAMA Resolution No. 002/1996 – States that projects that cause environmental damage related to destruction of forests and other ecosystems shall undertake responsibility for the implementation of new or existing Preservation Units (UC's) to be defined by the environmental licensing body as a means of off-setting environmental damage caused that can not be mitigated.
- CONAMA Resolution No. 237/1 997 – Reviews the procedures and criteria used in the environmental licensing to ensure their use as environmental management instruments as provided for in the National Environmental Policy.
- CONAMA Resolution No. 279/2001 – Establishes the simplified procedure for environmental licensing of electric projects with little potential environmental impact.
- CONAMA Resolution No. 281/2001 – Provides for environmental licensing applications, allowing the possibility of establishing simplified types of license requests and renewal of some types of these licenses.
- CONAMA Resolution No. 303/2002 – Provides parameters, definitions and limits of Permanent Preservation Areas.
- CONAMA Resolution No. 306/2002 - Provides the minimum requirements and the reference period for concluding environmental audits.
- CONAMA Resolution No. 307/2002 – Defines the guidelines, criteria and procedures for the management of waste from civil construction.
- CONAMA Resolution No. 357/2005 – Provides for the classification of bodies of water and environmental guidelines on classification, and establishes the conditions and standards of effluents discharge and other measures.
- CONAMA Resolution No. 369/2006 – Provides for exceptional cases of public utility, social interest or low environmental impact that allows the intervention or suppression of vegetation in a Permanent Preservation Area - APP.
- CONAMA Resolution No. 388/2007 – Provides for the authentication of the Resolutions that define the primary and secondary vegetation at the initial, medium and advanced stages of regeneration of the Atlantic Forest for the purposes of art. 4, 1st paragraph of Law No. 11.428 of December 22, 2006.

- CONAMA Resolution No. 371/2006 – Establishes the guidelines for environmental bodies for the calculation, collection, application, approval and control over expenditure of resources accruing from environmental compensation, in compliance with Law No. 9.985, of July 18, 2000, which creates the National System of Nature Preservation Units - SNUC and other measures.
- ANEEL Resolution No. 394/1998 – States that power generation projects of up to 30 MW with reservoirs of up to 3.000 m2 are deemed Small Hydroelectric Stations (SHS's).
- ANEEL Resolution No. 395/1995 – Establishes the procedures for filing and approving feasibility studies and basic projects for hydroelectric generation and authorization for power generation plants of up to 30 MW.
- ANEEL Resolution No. 652/2003 – Establishes the criteria for rating the hydroelectric use of SHS's (power between 1 MW and 30 MW).
- MME Ordinance No. 1.832/78 (Ministério de Minas e Energia) – Provides for use of public waters.
- SUDEPE Ordinance No. 001/1977 – Provides rules for protection of water fauna for dams builders throughout Brazil.

State Legislation

- State Constitution of 1989 – Chapter VI, related to the environment – provides, in article 181, that "everyone is entitled to an ecologically balanced environment, with government and the population being required to defend it for present and future generations." In Article 182 item V, it states that the State shall require, for the installation of works or activity that potentially causes environmental degradation, prior environmental impact assessments, which it shall publish.
- Law No. 5.793/1980 – Provides for protection and improvement of quality of life. Article 3, 3rd paragraph states that the construction and expansion of public or private business activities depend on consideration and licensing from the relevant State body responsible for the protection and improvement of the environment, to which the projects, together with the environmental impact reports, shall be submitted.
- Decree No. 14.250/1981 – Regulates the provisions of Law No. 5.793, of October 15, 1980, referring to the protection and improvement of environmental quality. Article 65 states that projects for the installation and the expansion of business activities included in the list of activities deemed potential causes of environmental degradation require analysis and approval, with the environmental impact reports and prior licensing for construction and operation. Article 69 states that the construction, expansion and operation of equipment or industrial, commercial and service activities require prior registration, provided they are included in the list of activities considered

potential causes of environmental degradation. Article 70 states that the authorization to which Article 69 refers shall be granted through: I - Prior Environmental License - L.A.P.; II - Environmental Facility License - L.A.I.; III - Environmental Operating License - L.A.O. Articles 71 through 74 establish for how long environmental licensing is valid.

- Law No. 6739/1 985 - Creates the State Council of Water Resources.
- Law No. 9.022/1993 – Provides for the creation, structuring and organization of the State Management System of Water Resources.
- Law No. 9.748/1994 – Provides for the State Policy of Water Resources and other measures.
- FATMA Ordinance No. 078/2004 – Provides the criteria for defining and applying environmental offsetting measures following environmental licensing involving significant environmental impact, environmental assessments and legal uses of the permanent preservation area.
- Ordinance No. 024/1979 – Classifies the water courses of the State of Santa Catarina.
- CONSEMA Resolution No. 001/2006 - Approves the List of the Activities Deemed Potential Causes of Environmental Degradation subject to environmental licensing from the Environment Foundation –FATMA and specifies the proper environmental assessment for licensing purposes.

Municipal Legislation

- Organic Law of the Municipal region of São Domingos (01/2005) – in chapter XII (Environment) provides the main concerns in terms of quality of the environment. In Article 280 states that any person that explores mineral resources and /or other resources shall repair the degraded environment, in accordance with the technical solution required by the relevant body, as specified by law.
- Organic Law of the Municipal region of Ipuaçu

4.5. Protection of Flora and Fauna Fauna

- Law No. 5.197/1967 – Main legal rule that regulates the protection of specific fauna and establishes the protection standards and basic premises of defense of animal life. In Law 5.197/67 it states that all animals that live naturally in the wild are the property of the State, and the same applies to their nests, shelters and natural nurseries and their use, hunting, persecution, destruction or apprehension is prohibited.
- Law No. 7.653/1988 – Alters and complements Law No. 5.197/67 specially in relation to the aquatic environment adding legal instruments regarding ichthyologic fauna and defining penalties for aggressive action affecting fauna as a whole.

- Law No. 9.605/1998 – States that "all species that belong to native, migratory and any other water or earth species whose life cycle occurs within Brazilian territory or Brazilian territorial waters are wildlife species".
- Legislative Decree No. 3/1 948 – Approved the convention to protect the flora, fauna and natural landscapes in Latin America, limiting human intervention in certain areas and requiring the electric sector to consider these areas when defining projects.
- IBAMA Directive 1.522/1989 – Defines the list of species of Brazilian Fauna threatened with extinction (updated in 2003)

Flora

- Law No. 4.771/1965 (Forest Code)–Defines the main instruments to protect and regulate use of the floral resources in the Country, creating the Forest Code. Article 2 defines forests and other forms of natural vegetation for permanent preservation, including those located along rivers or any water course, around ponds, lakes or reservoirs of natural or artificial water, in compliance with specifications provided for herein. Grant Government the prerogative of declaring other permanent preservation areas according to criteria defined in article 3 of this Law, and states that the suppression of these areas for the execution of works, plans, activities or projects of public usefulness or social interest is only possible upon the prior authorization of the Federal Government, represented by IBAMA.
- Law No. 1 1 .428/2006 - governs the use and protection of native vegetation in the Atlantic Forest Biome, and other measures.
- I Federal Decree No. 750/1993 - Provides for the suppression of vegetation at initial, medium, and advanced stages of forest regeneration in the Atlantic Forest Biome.
- CONAMA Resolution no. 01 0/1 993 - establishes basic parameters for analyzing the successive stages of the Atlantic forest.
- CONAMA Resolution no. 004/1 994 - defines the basic parameters for analysis of the successive stages of the Atlantic forest, covering physiognomy, predominant strata, diametric distribution and height, existence, diversity and amount of epiphytes , presence, diversity and amount of creepers, presence, absence and characteristics of vegetation detritus, sub-forest, diversity and prevalence of species and indicative vegetable species. It represents, therefore, a fundamental basis for producing studies in areas within the Atlantic forest defining the classification of the succession forms of this vegetation.
- CONAMA Resolution no.. 388/2007 - provides for the joint validation of Resolutions that define the primary and secondary vegetation in the initial, medium and advanced stages of regeneration of the Atlantic forest for the terms of art. 4, 1st paragraph of Law 11.428 of December 22, 2006.

- IBAMA Ordinance no. 037-N/1 992 - defines the list of species of the Brazilian flora threatened with extinction.
- State Law No. 5.793/1980 considers environmental degradation, among other factors, to be any change caused to the environment capable of causing significant damage to flora, fauna and other natural resources. Decree no. 14.250 that regulates this Law states, in its Art. 42, item V, that the special protection areas are those where there are vegetable formations stopping the erosion of hillsides and environments of great biological diversity. In Art. 45, the same rule bans clear cutting forests on land adjacent to: I state parks; II: ecological stations or biological reserves; III: scenic highways. The same prohibition is mentioned in Art. 47, 48, 50, 52, 57 and 58 for the case of promontories, within an area of 2000 meters, islands, estuaries, springs and nascent, state parks and ecological stations or biological reserves, respectively.
- State Decree no. 14.250/1981 - In the areas of vegetation the help avoid erosion, Art. 49 of Decree no. 14.250/81 bans clearing trees and other forms of natural vegetation along the bank of rivers, around ponds, hillsides, sandbanks and plains.

Suppression of Vegetation

The suppression of the vegetation to build a project and maintain a safety area requires prior issuance of a Cutting License granted by the environmental agencies. For this, a forest inventory of the area of direct influence (AID) is generally required, containing an analysis section and subsequent field inspection.

In the Atlantic forest biome this issue is governed by Law No. 11.428, dated December 22, 2006, which governs the use and protection of the native vegetation in the Atlantic forest Biome. And it establishes the prohibition of cutting, exploration and vegetation suppression and exceptionally admits the vegetation clearing when required for the performance of works, plans, activities or projects of public utility and social interest, upon authorization of the competent state agency with prior approval from IBAMA.

Based on afore-mentioned legal rules, there is the restriction on suppression in the medium and advanced stages of forest regeneration, being forecasted some handling possibilities for the initial stage.

When there is a justified need to suppress vegetation within the Permanent Preservation Area (APP), the procedures are established in Temporary Measure no. 2.166-67, of August 24, 2001, where this is regulated: "(...) it can be authorized in case of public utility or social interest, properly characterized and based on specific own administrative proceedings, when there is no technical or local alternative to the proposed project."

Another legal scenario is presented in CONAMA Resolution 369, of March 28, 2006, which "provides for the exceptional cases of public utility, social interest or low environmental impact, which allows the intervention or suppression of vegetation in the Permanent Preservation Area -APP." Thus, the environmental licensing body

will evaluate the possible impacts defining the compensatory and mitigating measures to be implemented by the developer.

In the specific case for Santa Catarina, FATMA usually has been consulting IBAMA before issuing an opinion for vegetation suppression and execution of projects within the Permanent Preservation Area (APP), requesting their approval. In this case, IBAMA just authorizes the suppression of the vegetation of APP when it is of social interest and public utility of the project, which is the case with small hydroelectric power plants.

Next is a list of the legal rules that are either directly or indirectly related with the project in question, based on standards or general and specific regulations regarding the protection of native forests.

Other legal rules directly related to the issue of vegetation suppression are listed below:

- Law No. 3.824/1 960– requires clearing of the hydraulic basins for dams, dikes and artificial lakes.
- CONAMA Resolution 003/93 - creates the temporary Technical Committee for Atlantic Forest issues, mainly to create and propose standards, aiming at defining primary and secondary vegetation in the advanced, medium and initial regeneration stages, in compliance with art. 6 of Decree 750/93. The definitions of these parameters are included in CONAMA Resolution 010/93.
- CONAMA Resolution 01 0/93 - defines the basic parameters for analysis of the succession stages of the Atlantic forest (amends CONAMA Resolution 004/85; see Decree 750/93).
- CONAMA Resolution 003/96 - defines the remaining vegetation of Atlantic forest (See Decree 750/93). It establishes that the remaining vegetation of the Atlantic forest covers the totality of the primary and secondary vegetation in the initial, medium and advanced regeneration stages (art. 1).
- CONAMA Resolution 009/96 - provides for the corridors among the remaining ones of the Atlantic forest (See Decree 750/93).
- CONAMA Resolution 278/2001 - establishes limitations and special rules for felling endangered species of flora in the Atlantic forest Biome.
- CONAMA Resolution 300/2002 - supplements Resolution 278/2001 on cases of authorization for vegetation suppression of the species threatened with extinction of the Atlantic forest Biome.
- CONAMA Resolution 31 7/2002 - provides for the regulation of Resolution no. 278/2001 establishing state plans for handling species threatened with extinction in the Atlantic forest.
- CONAMA Resolution 369/2006 - provides for cases of the exceptional , public utility, social interest or low environmental impact, which allows intervention or suppression of vegetation within the Permanent Preservation Area - APP.

- CONAMA Resolution 388/2007 - provides for the co-authentication of Resolutions that define primary and secondary vegetation in the initial, medium and advanced regeneration stages of the Atlantic forest for purposes of art. 4, 1st paragraph of Law No. 11.428 of December 22, 2006.
- Ordinance IBAMA 037-N/92, which defines the list of species of the Brazilian flora threatened with extinction.

State Sphere

- Law No. 10.472/97 - This law regulates the preservation, conservation and use of the forest resources in the State of Santa Catarina. Article 2 states that the forests and other forms of native vegetation that are useful for the maintenance and preservation of the lands are properties of common interest to all citizens, use of which is subject to the limitations established by in law.
- Joint Resolution 01/95 (between IBAMA-SC and SEDUMA-SC) - regulates the cutting and exploration of the secondary vegetation at the initial regeneration stage of the Atlantic forest in the State of Santa Catarina.

4.6. Protection of Historic, Artistic and Natural Heritage

Assets of a material and non-material nature incorporating references and identity, involving actions and memory of the different groups forming Brazilian society that include sites with historical references to slave descendants represent Cultural Heritage and are protected by the 1988 Federal Constitution.

The identification and the study of the historical, artistic and natural heritage of a certain area aim to rescue the culture and the way of life of people that lived there in ancient times.

Article 20, item X, of the National Constitution states that the underground natural cavities (caves) and prehistoric archaeological sites are Federal Government property, and the Federal Government, States and Municipal Districts are liable for protecting the documents, the works and other assets of historical, artistic and cultural value, monuments, outstanding landscapes and archaeological sites.

In order to conduct excavations for archaeological purposes, permission or authorization is required in advance from the Instituto do Patrimônio Histórico e Artístico Nacional – IPHAN, regulated by Ordinance MC 07/88. IPHAN will respond to this application within ninety (90) days for this application and, when granted, they are valid for two years, and may be revalidated for an equivalent period of time.

- Federal Constitution (articles 5, 20 and 216) - Defines which assets are subject to protection and rescue, among other provisions.
- Decree-Law No. 25/37 - organizes the protection of the national historical and artistic heritage, establishing mandatory surveys of assets located within the area affected.

Other laws (all issued by the Federal Government):

- Law No. 3.866/44;
- Law No. 3.924/61;
- Law No. 4.845/65
- Law No. 8.029/90;
- Decree Law No. 25/44;
- Decree no. 335/91;
- Decree no. 1.361/95;
- Temporary Measure no. 752/94;
- Ordinance MC no. 07/88 (Ministry of the Culture).

4.7. Colocated Plans and Programs

SHS Santa Laura

The deployment process for the Small Hydroelectric Power Plant Santa Laura, located on the border of the municipal districts of Faxinal dos Guedes and Ouro Verde in the state of Santa Catarina is at an initial stage. This SHS will be built on the river Chapecozinho, an affluent of the river Chapecó.

The flooded area will measure 3,12 Km2. The dams and dikes will be CCR type – roller-compacted concrete, with crest length of 245 meters and maximum height of 21 meters. The diversion will be sluice type, using two units and the flow rate at the site will be 310m 3/s and 23 meters long.

The spillway will be a free-flowing weir type, with flow rate equal to 2,270m3/s and 125 meters long. The adduction channel will be 320 meters, the adduction tunnel 980 meters and the penstock 150 meters.

The water inlet will be a rock-fitted type, with a unit 12.5 high and 5.25 m wide. The floodgate will be wagon type, and 3.25m wide and 3.25m high.

The power station will be internally operated, with three generating units measuring a total of 48.10m. The horizontal Francis type turbines will have a power output of 5,200 kW from the three units. The generators will have unit outputs of 5,600 kWA.

LT SHS Santa Laura–Xanxerê Substation

The transmission line leaves the SHS Santa Laura substation, in the municipal district of São Domingos, latitude 26º45' 36” S, longitude 52° 19' 40”, State of Santa Catarina, passing through the Municipal District of Faxinal dos Guedes up to the substation on the CELESC Electric System in Xanxerê, latitude 26° 51 ' 47” S, longitude 52°23 ' 36” S, located in the City of Xanxerê.

In the area that extends for 13 Km, there is a prevalence of undulating to smooth undulating relief, which facilitates implantation quite a lot. The area presents vegetation predominantly composed of cyclical cultures (corn, soy and wheat) and,

there are also some dispersed fragments of secondary vegetation of Atlantic Rain Forest and Deciduous Seasonal Forest at the initial and medium regeneration stages.

The plan included the implementation of additional vertices to protect the remaining vegetation fragments found along the LT section. Additionally, there was a concern locating the LT, with its respective towers, on better access ways, including locating it along the edge of roads, which are not paved.

SHS Ludesa

Implementation of the Small Hydroelectric Power Station – SHS is being concluded on the border of the municipal districts of São Domingos and Ipuaçu of the State of Santa Catarina. This SHS will be installed on the Chapecó river, 16 Km upstream from the project under analysis.

São Domingos SHS, financed by the private sector, specifically by Indústria de Papel Dall'Asta Ltda will generate 28 MW. Its design complies with a general layout formed pursuant to SHS criteria defined by ANEEL. It has a dam, the axis of which is located about 200m upstream from the fall that exists in the vicinities of the current dam from the plant maintained by the aforementioned company.

That dam will be formed by a rock dam with clay core, at an elevation of 641.5m, rising 28m above the foundations, 543m long and 8m wide, and free-flowing spillway, which will be implemented at the left abutment and 390m long, with a crest at an elevation of 635m and maximum height of 12m above the foundations.

The small reservoir to be formed will cover an estimated area of 6,45 ha and maximum width around 1,000 m.

LT SHS Ludesa–Substation of Clevelândia

The transmission line leaves SHS Ludesa substation, in the municipal district of São Domingos, latitude 26° 34 ' 40" S, longitude 52° 29 ' 46" in the State of Santa Catarina, passing through the municipal district of Abelardo Luz up to the substation of COPEL Electric System in Clevelândia, latitude 26° 23 ' 45" S, longitude 52° 28 ' 15" S, located at Av. Nossa Senhora da Luz, s/nº, Bairro Jardim Brasília, Clevelândia, State of Paraná.

The line reaches the states of Santa Catarina and Paraná, being 89% in Santa Catarina territory and 11% in the State of Paraná. The route covers 22,643 meters mainly comprising average undulating relief with a small variation of up to 20% (twenty percent) for the small nodulations and 5% (five percent) for the large undulations at the exit of SE SHS Ludesa.

UHE Quebra Queixo

UHE Quebra Queixo is implemented downstream from the plant at SHS Santa Luzia Alto. It was originally designed to generate 120 MW. However, after the construction of the project, it was noticed that the volume of water available, in terms of the design characteristics, did not allow the hydroelectric plant to reach full operation capabilities in terms of power generation, generating much less than its nominal capacity.

Today UEH Quebra Queixo produces an average of 35 MW/month, surpassing that value at exceptional times. These issues led to the implementation of the Quebra Queixo reservoir at an elevation 3 (three) meters below the original project, falling from 552 m to 549 m, reducing the reservoir level and volume. Note that this aspect meant there were changes to the engineering designs at SHS Santa Luzia Alto, leading to an energy production gain for this SHS.

5. ALTERNATIVE TECHNOLOGIES AND LOCATIONS

5.1. Technology Alternatives

Man's history is intertwined with the history of energy. In the middle of the 19th Century, new power sources known as oil and electricity appeared. Today's society became extremely dependent on the energy, especially the electricity. Among the main forms of electric power generation the main ones are: wind, sun, nuclear energy, hydroelectric, thermal power and biomass plants.

Currently wind energy is deemed one of the most promising natural sources, mainly because it is renewable, in other words, it does not run out. Although the cost of the wind energy generation is falling quickly, it still does not present an economically feasible method of generating energy. Furthermore, it requires good wind conditions for the construction of the air-generators. a

Solar energy is still being developed and it is not economically viable for large scale power generation, suffering from variations in the energy produced in accordance with the weather (rain, cloud), in addition to the fact that there is no production at night.

The need to import raw material for the operation of gas plants and, indirectly, oil fired plants, also leads to economic problems, as it affects a country's balance of trade.

Thermoelectric coal plants have environmental pollution problems because of the emission of gases into the atmosphere, requiring the implementation of efficient treatment and/or control systems. Coal production still involves problems of soil and water degradation and risks to workers' health in mining.

Power generation through nuclear power plants suffers constant protests because of the risk of accidents and creation of great quantities of long term radioactive waste.

Although hydroelectric generation presents an investment slightly superior in comparison to the thermoelectric coal plants, the latter have an additional operating cost: fuel acquisition. This makes the final generating cost of the hydroelectric plants lower than the alternatives.

Additionally, upon comparing the environmental impact derived from the construction of a thermoelectric coal plant and the construction of a hydroelectric plant, the impacts of the latter are smaller. This is because of the damage caused by coal mining, alongside the gases emitted into the atmosphere and river pollution.

The reason for giving priority to construction of hydroelectric plants is primarily the existent extensive hydroelectric potential in the country and the economic benefits that such power sources present. Pursuant to Table 03, we can see that hydroelectric energy is one of the main, if not the major form of low cost and large scale energy production.

Table 03 – Power source per MW price.

Power Source	Price per MW
Nuclear Energy	US$ 150.00
Solar Energy	US$ 600.00
Wind Energy	US$ 60.00
Hydroelectric energy	US$ 25.00

Source: Gazeta Mercantil, suppl. Grande São Paulo, 16.6.01

The hydraulic or hydro energetic potential in Brazil is 260 GW. Despite its importance in the Brazilian energy matrix, generation from dams and water-falls produced by the medium and large hydroelectric plants and the Small Hydroelectric Stations –SHSs uses just 25% of the national hydraulic potential.

The massive Brazilian hydroelectric potential represents an unquestionable comparative advantage in relation to the models in other countries, which mainly use fossil fuels and/or nuclear plants for electricity. In addition to the abundant, clean and renewable source, the hydroelectric alternative is a technology that Brazil has mastered.

The SHSs present a major advantage in relation to the large hydroelectric plants as they have less of an impact, the maturation time is shorter and there is a greater use of the hydro energetic potential on the rivers.

The Small Hydroelectric Stations (SHSs) represent one of the main priorities at ANEEL for increasing the availability of electricity in Brazil. Because of their characteristics, these plants with an output of over 1 MW and equal or less than 30 MW, better meet the power requirements of small urban centers, rural areas and industrial projects. As of 1998, the construction of these generation units was boosted by series of legal and regulatory mechanisms sponsored by ANEEL.

The project to build the SHS – Santa Luzia Alto, in the region of Santa Catarina, funded by private sector, more specifically by Construtora Gomes Lourenço Ltd., aims to generate 28.5 MW of energy.

This plant will bring, a series of benefits to the west region of Santa Catarina alongside the power it generates, including:

- Support for expansion in the industrial sector;
- Job creation;
- Rise in municipal tax revenues.

Please note that the project area historically does not have any problems from a lack of rain. This fact is important due the enormous criticism leveled at hydroelectric plants is receiving, as they depend on the volume of water in the rivers.

The construction and operation of the Small Hydroelectric Station –Santa Luzia Alto SHS includes the use of modern engineering technologies, avoiding any environmental impacts as far as possible. The SHS will be designed and built in accordance with ANEEL's normal techniques and procedures.

Thus, we have tried to emphasize the environmental issues, using relevant materials and techniques, approaching the environment in a way that affects it as little as possible, strictly following the technical and environmental regulations in force.

5.2. Alternative Locations

Within the context of the basin of the Uruguay river, of which it is one of the affluents of the right bank, the Chapecó river has been studied since 1966, assessing its hydro energetic potential, as described below:

- Assessments performed from 1966 to 1969 by ENERSUL under the technical supervision of CANAMBRA Engineering Consultants Limited, covering the three States of the Southern Region of Brazil;
- Study of the Hydroenergetic Inventory of the Basin of the Uruguay River performed in October 1979 jointly by the companies ELETROSUL and CNEC - National Consortium of Consultant Engineers;
- Study of Head Division of the Chapecó river performed in February, 1996 by ENGEVIX – Engenharia S/C Ltda and INTERTECHNE – Consultores Associados S/C Ltda;
- Study of Head Division of the Chapecó river – Addendum developed in July 1996 by ENGEVIX and INTERTECHNE; and
- Environmental Impact Report of the Hydroelectric Plant of Quebra Queixo on the Chapecó river developed in 1997 by ENGEVIX.

In the studies conducted by ENERSUL the following were accepted: Cutia, Figueira, Golfo, Portela, Quebra Queixo, Toldo Velho, São Domingos, Abelardo Luz and Aparecida, totalizing 622 MW.

Later the studies carried out by ELETROSUL/CNEC showed a new list of possible locations: Aparecida, Abelardo Luz, São Domingos, Quebra Queixo, Foz do Chapecozinho, Nova Erechim, Xanxerê and Voltão Novo, totalizing 418 MW.

In both studies the traditional methodology was adopted (deterministic criteria), based on the concept of available energy associated with an average capacity factor of 55% and the critical hydrological period in the Southern Region (from April, 1944, to November, 1945). The historical series of the available monthly average flow rates correspond to January, 1941, to December, 1976.

The study developed in 1996 by ENGEVIX/INTERTECHNE aimed at assessing the hydro energetic capacity of the Head Division on the Chapecó river, within the course located upstream from the mouth of the Chapecozinho river, focusing on the following assumptions:

- New assessment of division of head for power generation along a section of the Chapecó river between the 430,00 m and 858,00 m elevations. This head division alternative proposed to make the best use of the water resources available at a competitive cost, considering the technical aspects involved and the implications of modifying the environment;

- Definition of the main technical characteristics and estimated costs of the hydroelectric plant at the recommended alternative; and
- Selection of the most favorable uses for continuation of deeper studies for progressive implementation over time.

Within this scenario, the study by ENGEVIX/INTERTECHNE included 5 possible uses associated with 3 basic schemes for dividing the head, comprised of:

Alternative I: Considers the head division proposed in the Study of the Hydroenergetic Inventory for the basin of the Uruguay river performed by ELETROSUL/CNEC in October, 1979.

Alternative II: In addition to the uses proposed in the study performed by ELETROSUL/CNEC, it also considers the use of Santa Luzia Baixo at the original section of Quebra Queixo use (At 589,00 m elevation), with the consequent lowering of Quebra Queixo to. 562 m

Alternative III: In addition to the hydroelectric uses proposed in the study performed by ELETROSUL/CNEC, it also considers the use of Santa Luzia Alto at the original elevation of the Quebra Queixo plant (At 589,00 m) subsequently lowering Quebra Queixo to 552,00 m

Besides the three alternatives referred to above, two variants for Alternatives II (IIA and IIB) and III (IIIA and IIIB) were studied, in which one of them erased the Aparecida plant and another considered eliminating Aparecida and Abelardo Luz.

Of the global analyses of the economical aspects, Alternative IIIB was chosen for the Head Division on the Chapecó river, upstream from its mouth with the Chapecozinho river. This alternative presents a satisfactory economical-energy index (cost / benefit index equal to R$ 32.64 MWh), high profitability (net capitalized benefit /total cost = 1.68) durig the critical period and additionally, smaller initial investment comapred with the other alternatives.

With regard to environmental impacts, they were analyzed in a preliminary manner for each alternative in accordance with certains parameters, the results of which are shown in Table 04.

Table 04 – Environmental Impacts caused by hydroelectric plant alternatives.

Alternative	Flooded area (Km^2)	No. of people affected	Flooding of Vegetation	Fauna Transferral	Reduction in Living Area	Reduction in Density of Threatened Groups
Alternative I	1 01 ,00	1,405	1 .594,06	High	High	High
Alternative II	86,60	1,077	1.474.12	Medium	Medium	Low
Alternative III	88.50	1,056	1.505.02	Medium	Medium	Low
Alternative IIA	31.10	682	374.51	Medium	Medium	Low
Alternative IIB	27.80	622	309.57	Low	Low	Low
Alternative IIIA	33.00	661	405.41	Medium	Medium	Low
Alternative IIIB*	29.70	601	340,47	Low	Low	Low

Source: Water Head Division Study on the Chapecó river - Consultants ENGEVIX/INTERTECHNE, February/96 * Chosen Alternative

It also considered the disappearance of the natural waterfalls of high value to tourism close to the City of Abelardo Luz. Additionally, the layout of the generating structures presents construction problem, represented by the location of the adduction tunnel directly beneath the City.

These environmental repercussions benefitted Alternative IIIB, which because of the fact that it does not include the plants in Abelardo Luz and Aparecida, has fewer impacts on the environment.

In the development of the Basic Project of Santa Luzia Alto, motor studies were carried out on outputs of 24.0 MW, 25.5 MW, 27.0 MW and 28.5 MW, to assess the optimal installation point.

The energy studies allowed us to assess the energetic benefit of each alternative, in terms of the average power generated by the plant. In order to define the output at Santa Luzia Alto SHS, a cost/benefit study was carried out based on an energy/economic analysis, the respective costs and energy benefits, trying to reach the optimal point for the plant according to the available water resources and feasibility.

The alternative selected was defined in order to minimizing the impacts on the environment. The results of the environmental and economic factors resulted in the selection of Santa Luzia Alto SHS. The optimal output at Santa Luzia Alto SHS is 28.5 MW. From an environmental standpoint the increment to a 28.5 MW output is positive, as the size of the lake does not change. The increased output at Santa Luzia Alto SHS would not reduce or increase its negative impacts, however, there would be a considerable increase in positive impacts, mainly in the socioeconomic area, increasing economic activities and electrical power available in the region.

6. PROJECT INFLUENCE AREAS

Influence area is the entire territorial area which might be affected, either directly or indirectly, by the positive and/or negative environmental impacts, caused by the project during the planning, implementation and operational stages.

In view of the regional importance of Santa Luzia Alto SHS, three Areas of Influence were defined: **Directly Affected Area (ADA), Area of Direct Influence – AID and Area of Indirect Influence (AII).**

The physical limits defined for these areas vary in accordance with the physical, biotic and socioeconomic environments surveyed, in order to make adjustments to the requirements in each area. However, in order to set a restricting parameter of these areas, we have defined a limit for each area of influence:

6.1. Directly Affected Area – DAA

It is restricted to the area where the construction works for Santa Luzia Alto SHS are planned to occur, for the physical, biotic and socioeconomic environments, comprising: dam area, power plant, reservoir, access ways, work site, accommodation for the labor and lease and disposal areas.

6.2. Direct Influence Area – DIA

Area subject to the direct impacts of the construction and operation of the plant in the physical and biotic environment, in a radius of 500 meters from the work location at the SHS plant and within an area of 100 meters from the flood area.

In the socioeconomic environment, the Area of Direct Influence is covered by the municipal districts of Ipuaçu and São Domingos.

6.3. Indirect Influence Area – IIA

In project of this nature, it the entire region could be considered an Area of Indirect Influence. However, in order to create a boundary for this area, it was limited to a more specific region.

Therefore, the Area of Indirect Influence is the area actually or potentially affected by the indirect impacts of the construction and operation of the project, resulting from the planned interventions for the construction and operation of Santa Luzia Alto SHS. For the physical and biotic environment, it is limited by the sub hydrographic basin of the Chapecó river, and for the socioeconomic environment, the area covered by the Western region of Santa Catarina.

7. METHODOLOGY

7.1. Introduction

The Environmental Impact Assessment –EIA aims at avoiding any project which is justified from an economic standpoint or is in the immediate interest of the bidder is later shown to be disastrous for the environment, which is why it is a preventive and precautionary tool. Undoubtedly, it is an efficient and reliable instrument to assess environmental impacts.

This statement shows the importance of environmental impact assessments. However, nowadays, there is difficulty adopting a methodological approach able to encompass the many environments and possibilities created by the human construction activities. What we have available is a conceptual basis on which we have built a framework of regulations.

Adoption of the AIA model (Environmental Impact Assessment) as part of environmental studies is widely accepted in the current stage of development of the socio-environmental sciences in Brazil, which addresses three basic areas:

a) description of the area per its physical, biotic, social and economical features before the construction of the project. What is traditionally referred to as "environmental diagnostics"

b) identification, description and assessment of impacts, in each phase of the project - planning, construction and operation – because these different phases have significantly different impacts, specially in terms of time, location and intensity.

c) propose measures to minimize, or even revert any negative impacts, mitigating, compensatory or maximizing measures, the latter when increasing the positive impacts.

7.2. "Diagnosis" Particularities

The environmental diagnosis aims to describe the environmental status of the area affected before project construction, based on the relevant considerations:

a) Physical environment: climate and weather conditions, geology, geomorphology and soils, water resources and quality of the water;

b) biological environment: terrestrial biota; aquatic biota; preservation units;

c) social and economic aspects: History of occupation, population, infrastructure, water supply, sewage disposal, collection of solid waste, electric power, communication means, transportation system, social indexes, education and health, human development index – HDI, economic aspects, land use and occupation, leisure, tourism and culture, historical heritage, cultural and archeological sites.

As the collection of every single aspects is an exaggeration and will harm the study, the diagnosis in this assessment of the environmental impact of the

building of the Small Hydroelectric Station –Santa Luzia Alto SHS was carried out in two interlinked approaches:

a) PROSPECTION, where the study is characterized by vertical information on the environmental variables that best represent the current scenario and that are able to consistently define the impact vectors of the project, which are more important in terms of the risk to sustainability and, therefore, to quality of life within the region. In the this case, the emphasis of the diagnosis that will assess impacts restricted to the area of direct influence (AID), with a horizontal focus on the area of direct influence, involving variables associated with the construction of this project;

b) CONSOLIDATION, where the diagnosis stops being merely a description, adopting an analysis guided by questions on the impacts and the variables that can be most affected by project construction.

Although in the order the studies are presented the diagnosis precedes the assessment of the impacts, the investigation will not be linear and will allow adjustments between one phase and another. Thus, the team that analyzed the current scenario relied on recommendations from the technicians responsible for the design and planning of the project works, initially analyzing their potential impacts, and, then, based on this, outline areas for in-depth diagnosis already established in the reference material for the studies.

7.2.1. Research Techniques and Sources of Information

The EIA of the project in question is being developed, first of all, from the survey and reading of existing information, i.e. from secondary data. From this information, we can highlight the environmental reports for the Ludesa SHS, the Transmission Line at Ludesa SHS up to the substation at Clevelândia, PhD and Master's degree dissertations on the study area, as well as other studies and academic publications, among other texts.

In order to obtain information that identifies the characteristics of the municipal district and the socioeconomic conditions of the populations that reside in the area directly and indirectly affected by the project, the following information was analyzed:

from the public bodies (IBGE, PMSFS, Municipal Secretariats, State Secretariats, Association of Municipal Districts, etc.); we acquired basic data on the economic situation in the Municipal District and the Basic Plan for Ecological-Economic Development; Urban Zoning Law; Organic Laws in the Municipal Districts; municipal data recorded by the IBGE, demographic census of 2000.

As cartographic resources, we use IBGE charts at a scale of 1:50,000 and satellite images.

After the initial survey of the secondary data, the field work started by looking for information more directly related to this project.

The description of the socioeconomic aspects benefitted substantially from the field work, as it provided a clear definition of the interference from the project on the community present in the influence area.

The characteristics of the project were taken from the engineering designs, where the impact-generating technical aspects were identified and analyzed. Both of them were jointly addressed by the entire multidisciplinary technical team.

7.3. Identification and Evaluation of Impacts

Based on a general overview, any type of project includes an aspect that induces economic development, as its area of influence is not restricted solely to the construction site, reaching a larger area, sometimes regional in size, where changes are brought about in a direct and indirect manner in the physical, biotic and socioeconomic environments.

The nature and intensity of the impacts are different in each phase of the project – planning, construction and operation – which implies significant differences, especially with regard to time and location. Therefore, this analysis takes into account the characteristics of the influence area and the activities of each phase and stage of the project.

The current environmental conditions were presented throughout the development of this Environmental Impact Assessment - EIA, which meant we were able to identify and analyze the likely environmental impacts, either positive or negative. This will allow the relevant public authorities to decide on the feasibility of the project.

The execution and analysis of the prognostic and assessment tasks must comply with CONAMA Resolution 001/86, "in the use of the powers granted by article 48 of Decree No. 88.351, of June 1, 1983, for the effective performance of the responsibilities assigned by Art. *18 of the same decree, and also considering the need of establishing the definitions, responsibilities, basic criteria and general guidelines for use and implementation of the Environmental Impact Assessments as one of the instruments of the National Environment Policy, hereby establishes":*

> *Art. 1 – For the purpose of this Resolution, environmental impact is any change in the physical, chemical and biological properties of environment, caused by any form of matter or energy resulting from human activities that, directly or indirectly, affect:*
>
> *"I - Health, safety and the well-being of the population;*
>
> *II - Social and economic activities;*
>
> *III - The BIOTA;*
>
> *IV - The aesthetic and sanitary conditions of the environment;*
>
> *V - The quality of the environmental resources."*

In order to assess the environmental impacts of Santa Luzia Alto SHS, it was associated with some of the methods already used in the Environmental Impact Assessment

(EIA), in compliance with the Environmental Impact Assessment Manual (SEMA PR, 1992).

For impact analysis, the “ad hoc” method was adopted, which uses “brain storming” based on each team technician's specific knowledge, drawn up generically for this type of project, based on the activities developed in each phase– planning, construction and operation.

The evaluation of the environmental impacts in this project will be use two procedures:

- Social and environmental analysis of the project, which includes information on the construction process and plant operation, marking its initial stages, isolating each work in the general layout of the project for analysis;
- Relationship between the actions in the project and socio-environmental elements of the area, using the "Interaction Matrix" technique, created by LEOPOLD et. al. (1971), which views relationships with greater possible impacts;

It must be highlighted that, in order to classify an impact, in terms of an ecosystem, it is important to bear in mind the concepts of resilience and homeostasis.

Resilience is the measurement of the capacity of a system to persist in the presence of a disturbance. Thus, if the magnitude of the impact remains within the resilience limits, the effects can be annulled by a new balance reached within the ecosystem, or when it returns to its original condition. On the other hand, homeostasis is the measurement of the capacity of the ecosystem to maintain a stable internal balance in spite of external disturbances.

The method used as a basis for the interaction matrix from Leopold et al. (1 971) it is the better known technique among the methodologies of impact analysis, representing a matricial analysis of cause and effect.

The input data in this method is organized in a matrix, where the columns represent the impact actions that can change the environment, and the lines are the environmental components (environmental changes) that can measure the intensity of the impact on the environment caused by the actions. By cross-referencing the lines and columns, we can identify the interactions between the tensile impact (actions) and the local environment, as well as the level of harm caused.

In order to overcome the assessment deficiencies of this method, allowing us to define the significance of each environmental impact, the characteristics inherent to each of them were drawn up, establishing a group of classes to measure the weight of the impacts according to Table 05, adapted from CONAMA Resolution 01/86.

The characteristics of the impacts were weighted, with differentiated values according to the relevance of the environment and classification of the impacts. The weights ranged from 0 to 4, incrementally, in terms of

interference into the environment based on the knowledge and environmental awareness of each technician on the team.

The final value can be either positive (+) or negative (-), if the impact is positive or negative, respectively. Furthermore, if that value is null or insignificant, the cell in the matrix is left blank.

From this valuation, the relevance of each impact was defined in relation to each socio-environmental component. To achieve this, the assessment team, using the method developed by Rocha et al. (2001), agreed that the module values, i.e., irrespective of the sign, would represent irrelevant impacts if equal to or loewr than5, relevant impacts, fell between 6 and 10, and very relevant impacts were highly relevant with those above 16 considered extremely relevant.

In EIA–Environmental Impact Assessment of Santa Luzia Alto SHS, each impact was rated according to its likelihood, accumulating the corresponding weights, with the results transferred to the impact matrix in order to quantitatively measure the impact, according to the following rating:

Table 05 – Description and evaluation of the environmental impacts for Santa Luzia Alto SHS.

Característica	Classificação do Impacto			
Característica de valor	Positivo (+)	Negativo (-)		
Característica espacial	Local (1)	Regional (2)	Estratégico (4)	
Característica de magn itude	Desprezível (1)	Pequena (1)	Média (2)	Alta (3)
Característica de importância	Desprezível (1)	Pequena (1)	Média (2)	Alta (3)
Características de intervenção	Evitável (1)	Mitigável (2)	Compensável (3)	Potencializável (4)

Value: corresponds to the value of impacts, which is, whether their effect on the environmental variable is beneficial or adverse to the quality present at the time the impact occurs. Considering:

- a positive or beneficial impact – when an action results in the improvement of the quality of a factor or environmental parameter; and
- negative or adverse impact – when an action results in harm to the quality of an environmental factor or parameter.

Spatial characteristic – refers to impact classification according to its coverage area. Thus, it can have a:

- Local impact–when the action affects only the site and its vicinities;
- Regional impact–when an effect spreads across an area, beyond the site where the action occurs; and
- Strategic impact–when an environmental component of collective or national importance is affected.

Magnitude – Refers to the measurement of the change in an environmental variable in relation to its prior status, irrespective of its importance, be cause of the fact that it affects other environmental elements. In this sense, the impact can be:

- Impact of ignorable magnitude – when the change caused doesn't have any importance;
- Impact of small magnitude – when the change caused has little or no importance;
- Impact of average magnitude – when the extent of the change is at an intermediate level; and
- Impact of high magnitude – when it extensively changes a pre-existing situation.

Importance – contrary to the magnitude, the importance expresses the eff ect of the environmental impact on a component and on the other environmental variables. Based on that characteristic, the impact can be rated as:

- Irrelevant impact – when the impact only affects one environmental variable, in an insignificant way;
- Impact of small importance – when the impact only affects one environmental variable without affecting other components;
- Impact of average importance – when the effect of an impact affects other variables, but it doesn't affect the range of the environmental factors in which it is included or the quality of life of the local population; and
- Impact of great importance – when the impact on the variable risks the survival of the environmental in which it is included or acutely affects the population's quality of life.

Intervention – refers to the possibility of the impact being prevented, minimized, offset, if negative and increased, in if positive. The impact may be rated as:

- Avoidable – preventive solutions are possible;
- Minimized – impact that cannot be avoided, but its effects can be minimized by the adoption of mitigating measures;
- Offset –impact that can neither be avoided nor minimized, only offsetting measures can be established; and
- Incremental – impact that even though positive, may be optimized through appropriate measures.

8. ENVIRONMENTAL

DIAGNOSTIC

8.1. Physical Environment

8.1.1. Weather and Meteorological Conditions

Santa Luzia Alto SHS is located in the humid mesothermal Cfb type climate, according to the Köppen classification, the prevailing characteristics of which are a subtropical climate marked by pleasant summers and harsher winters, a characteristic that is dictated by the latitude and altitude. It also suffers the influence of air masses, which during the winter help to increase the cold in the region, when it is affected by the Polar air mass. It also has an influence on the high level of regional rainfall, associated with relief characteristics.

In the municipal districts surveyed, only Abelardo Luz has a weather station, and as these municipal districts are adjoining, the climatic difference between them is considered small, therefore we can use data from this station.

For about seven years, a Weather Station has been operating in Abelardo Luz, located at latitude 26° 34' 11" South, and a longitude 52º 20' 37" West and an approximate altitude of 770 meters above sea level. This station is responsible for monitoring the data presented below in Tables 06, 07, 08 and 09, also specifying the number of years of observation.

Table 06 – Normal temperature data, municipal region of Abelardo Luz/SC.

Meses	Temperatura (ºC)			Temperatura Média (ºC)	
	Mé dia	Máxima Absoluta	Mínima Absoluta	Má xi ma	Mínima
Janeiro	22,0	33,8	10,4	28,4	16,4
Fevereiro	21,8	34,4	8,2	28,6	16,3
Março	20,9	35,0	5,0	27,8	15,1
Abril	19,0	34,0	5,6	26,4	14,0
Maio	15,9	30,4	-1,8	23,0	11,1
Junho	14,5	28,4	-3,2	20,9	9,9
Julho	13,5	28,4	-6,0	19,8	9,0
Agosto	15,3	32,0	-2,3	22,5	10,2
Setembro	16,3	33,8	-2,1	23,1	11,2
Outubro	18,9	33,4	5,5	25,8	13,4
Novembro	20,5	38,4	2,3	28,6	15,0
Dezembro	21,7	33,3	6,0	28,3	16,6
Anos Observados	**5**	**7**	**6**	**6**	**5**

Source: CLIMERH / EPAGRI – SC

The maximum absolute temperatures are around 38.4ºC. They are high values, however they are not the highest ones in State or the Country, but only occur during the summer. On the other hand, the absolute minimum can reach 6 degrees negative, which can cause frequent frosts in the surrounding municipal districts. Such extreme values in the winter lead to a high absolute thermal range

in the area, and sometimes exceeds 40ºC.

Table 08 – Normal precipitation, humidity and evaporation data, Abelardo Luz/SC.

Meses	Precipitação (mm)		Número de Dias de Chuva	Umidade Relativa (%)	Evaporação Total Piche
	Total	Máxima em 24 horas			
Janeiro	281,0	91,1	15,3	77,8	73,4
Fevereiro	151,4	39,8	12,9	79,8	63,3
Março	164,7	41,2	12,6	79,5	74,2
Abril	169,3	61,2	8,9	81,7	58,5
Maio	190,7	69,2	8,9	82,0	59,9
Junho	207,5	59,3	9,0	82,1	55,1
Julho	137,9	40,1	8,6	82,8	66,2
Agosto	151,8	30,5	8,3	79,7	74,7
Setembro	218,7	52,7	11,9	79,7	75,1
Outubro	232,6	71,4	12,4	79,8	75,9
Novembro	146,3	44,4	10,2	73,0	100,0
Dezembro	201,2	49,9	10,7	78,2	94,3
Anos Observados	**7**	**7**	**7**	**5**	**3**

Source: CLIMERH / EPAGRI – SC

The relief and the air masses that prevail in the area influence the other climatic elements, such as rainfall, atmospheric pressure, temperature and the relative humidity of the air.

Table 08 – Normal meteorology data, Abelardo Luz/SC.

Meses	Nebulosidade (0 / 10)	Insolação (horas)	Radiação Solar Global (cal/cm^2)	Pressão Atmosférica (mb)
Janeiro	5,8	155,1	1.042,9	
Fevereiro	5,6	183,0	969,0	N
Março	5,5	166,1	846,2	Ã
Abril	4,8	172,9	693,1	O
Maio	4,7	168,2	565,3	
Junho	4,9	156,6	502,4	E
Julho	4,9	187,6	529,2	X
Agosto	4,5	196,8	632,7	I
Setembro	5,0	153,3	777,8	S
Outubro	5,7	157,3	914,7	T
Novembro	5,0	244,4	1.014,2	E
Dezembro	5,3	229,9	1.056,5	
Anos Observados	**6**	**1**	**1**	*****

Source: CLIMERH / EPAGRI – SC

The annual relative humidity can be considered continuously humid, with an annual average of 80%. The high relative humidity of the air is explained by the relief, vegetation, water courses and direction of the winds, and, on the plains, the humidity is moved towards the mountain by the winds and in the plain it follows the river course. In this area, as well as in the remaining area in the south of the Country, the weather conditions depend on the behavior of the Atlantic Tropical Mass (ATM) and the Atlantic Polar Mass (APM). The former acts throughout the year, especially in Spring and Summer, while the Atlantic Polar Mass acts more often in Autumn and

Winter. The Atlantic Polar Front, resulting from the contact between the Atlantic Tropical Mass and the Atlantic Polar Mass, is responsible for good rainfall distribution.

Meses	Velocidade do Vento		Direção dos Ventos		Geadas (dias)	Horas de Frio (. 7,2 ºC)
	(m/s)	(Km/h)	1ª Opção	2ª Opção		
Janeiro	2,7	9,72	NE	SW	0	0
Fevereiro	2,4	8,64	NE	SW	0	0
Março	2,5	9,00	NE	SE	0	0
Abril	2,4	8,64	NE	SE	0	0
Maio	2,5	9,00	NE	NW	0,5	81,0
Junho	2,4	8,64	NE	SE	4,0	119,0
Julho	2,8	10,08	NE		3,7	145,0
Agosto	2,6	9,36	NE	SW	1,5	40,0
Setembro	2,7	9,72	NE		1,1	56,0
Outubro	2,8	10,08	NE	NW	0	2,0
Novembro	2,9	10,44	NE		0	1,0
Dezembro	2,6	9,36	NE		0	0
Anos Observados	**5**	**5**	**7**	**7**	**5**	**1**

Source: CLIMERH / EPAGRI – SC

According to the data from the Weather Station in Abelardo Luz, as shown in the map in Figure 02, the total annual average precipitation in the area is 1930 mm, with the following distribution: 26.0% in the Summer (December, January and February), 24.0% in Autumn (March, April and May), 24.0% in Winter (June, July and August) and 26.0% in Spring (September, October and November). Occasionally, there may be dry months causing losses for farmers. In the evaluation of the historical series of rainfall across the area we can see that December is the month with a 42.8% chance of a dry spell.

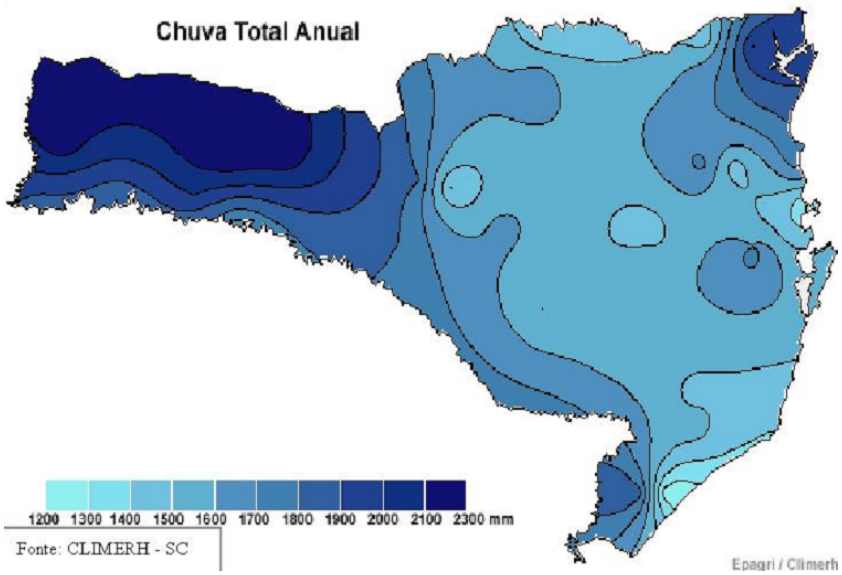


Figure 02 – Rain distribution in Santa Catarina.

8.1.2. Geology, Geomorphology and Soils

The area which Santa Luzia Alto SHS directly and indirectly influences, located in the cities of São Domingos and Ipuaçu, in the state of Santa Catarina, presents lithological aspects connected to the geology of the Southern Brazilian region. The geological and geomorphological characteristics of the state of Santa Catarina will be described in general terms and the West Catarinense geology and geomorphology in detail, for the study area.

Regional Geology

The general geological scenario in the state of Santa Catarina, based on information from DNPM (1986) (National Department of Mineral Production) data, presents a broad lithological diversity with ages that date from Archean to Quaternary.

Horn Filho & Diehl (1994, 2001) and Horn Filho (2003) subdivided Catarinense geology into five large geological provinces positioned by their structural, petrographic, sedimentary and evolutionary characteristics: Escudo Catarinense; Paraná Basin; Planalto da Serra Geral; Alkaline Complex and Coastal Province.

From a chronological standpoint, the archean, proterozoic and cambrian rocks of the Escudo Catarinense represent the State's oldest rocks (± 550 MA AP), followed by Paraná Basin's sedimentary rocks (between 500 MA AP and 180 MA AP), Serra Geral Plateau's basalt (± 130 MA AP), Alkaline Complex (± 65-70 MA AP) and the sedimentary deposits of Coastal Province from the quaternary age (± 2 MA AP to now).

Escudo Catarinense is restricted to the eastern sector of Catarinense territory, bordering the Atlantic Ocean; Paraná Basin is in the State's central sector; Alkaline Complex outcrops are found mainly in the Lajes region; Coastal Province, represented by the submerged sediments of the continental shelf on the coastal plain, it has its deposits mapped next to the current coastline and the Plateaus of the General Mountain range, which occupies about 50% of the area of the state of Santa Catarina, in the central and western sector, represented by a classic sequence of dense plateau spills, predominantly of magmatic origin (Figure 03).

The plateau spill system was fed by intensive intrusive activity, normally represented by dykes and sills which follow the main structural discontinuity of the Paraná Basin, which is sotoposta. These discontinuities, complementary to the Atlantic rift, are responsible for the opening and distribution of gondwanic fragments and separation of the Paraná basin in South America, and Etendeka, in Africa. The fissural volcanism of the Paraná basin represents one of the greatest demonstrations of continental volcanism in the world. It is represented by thick and extensive lava spills, as well as dykes and sills, with small and occasional bodies of associated sedimentary rock.

The dykes are kilometers in length marked by a unique parallelism and density, which reveal old weak features based on the bedrock, through which the magma was expelled to form the basalt slope.

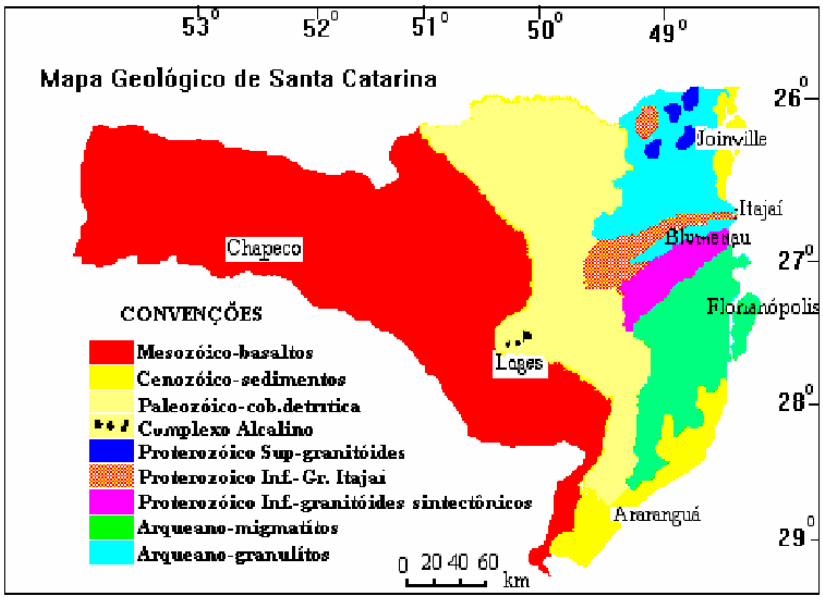


Figure 03 – Lithostratigraphic units of Santa Catarina, according to SCHEIBE (1986).

The continental basaltic province is related to processes which differ from those related to the normal bedrock of the ocean floor. This province represents, after the ocean floor, the greatest igneous event on the planet, representing important temporal, spatial and arrangement relationships between continental and ocean basalts.

The Serra Geral magmatism of the Paraná basin, in the central-eastern portion of South America and Etendeka, Northeast Namibia (Africa), represents a geotectonic unit with approximately 1,700,000 km^2, occupying part of the territories of Brazil, Argentina, Uruguay and Paraguay (South America) and Namibia (Africa).

The rupture and separation of Gondwana, during the inferior Cretaceous, was responsible for the volcanic event which covered the central-south portions of the Paraná basin and Northeast of Etendeka basin with lava, up to a thickness of approximately 1,720m in the basin's depocenter. The cooling of these lavas resulted in rocks with characteristics of bimodal tholeites, being dominantly composed of basalts and andesitic basalts in the lower sequence and riolites and riodacites in the sequence above.

Local Geology

As seen on the map (Exhibit 10), the local geology in the direct influence area at Santa Luzia Alto SHS is directly based on stratigraphic, chronological, lithological and pedological aspects, among others, from the geological province of Planalto da Serra Geral.

The rocks of Planalto da Serra Geral originated from the lavas released from the magmatic chamber, being displaced through various cracks (geoclasses) open on the surface. Lava spills cover various states nationwide, including Santa Catarina, occupying an area of 1,200,000 km^2.

From a stratigraphic standpoint, the geology in the direct influence area is composed of rocks of the São Bento Group, subdivided into formations of Serra Geral at the top of the sequence and Botucatu, at the bottom, which is made from extensive basaltic spills in the form of basic effusive (tholeitic basalts) with eventual interspersion of intertrappean arenites, which cover the aeolic arenites of the Paraná basin.

The Serra Geral Formation, according to DNPM (1984), was defined by White (1906) in the location – same type as Serra Geral of the Meridional Plateau, between Lauro Muller and São Joaquim, in the State of Santa Catarina. The designation of this formation refers to the magmatic province related to the spills and intrusions which cover the central-south region of Brazil and extends through the borders of Paraguay, Uruguay and Argentina (MELFI *et al.*, 1988).

From a geochronological standpoint, rocks from the São Bento Group, are located in the Mesozoic era, more precisely, the lithotypes of the Serra Geral Formation were generated between 119 MA AP and 147 MA AP, in the Jurassic and Cretaceous periods and the arenites of the Botucatu Formation, older, in the Triassic (± 180 Mya). K - Ar and Rb – Sr dating identified maximum intensity of volcanism between 120 Mya and 130 Mya, according to data from Almeida (1986), corresponding, according to Amaral (1966), to the inferior Cretaceous.

The internal characteristic of the spills of Serra Geral Formation reveals four main zones: basal vitreous zone, with horizontal disjunction; intermediate zone, with vertical junctions; upper zone, with vertical and horizontal disjunction; and vesicular basalt, at the top.

According to Pinese (1989), the inferior contact of the Serra Geral Formation with arenites of the Botucatu Formation is discordant and with older units is marked by erosive discordance, in certain locations, directly on the bedrock. Basaltic and riolitic extrusive rocks are found covered in some locations by continental sediments of the Bauru formation, of cretaceous age, according to the stratigraphic column of Mühlmann *et al*. (1974).

The Serra Geral Formation, from a perographic standpoint, presents a full set of litological types, from basalts to acid rocks of the riolitic extreme. Basaltic volcanism is the most extensive, located throughout the area of the Paraná basin and in the adjacent tectonic pools.

Intermediate composition spills present a very broad distribution, being recorded in all quadrants of the Paraná basin, although the extensions and thicknesses are lower than the basalts. Volcanism of acid filiation comprises discontinuous occurrences as well as being deeply cut by erosive processes (PINESE AND NARDY, 2003).
This set of lithologies allows the division of Serra Geral Formation into two distinct sequences: basic sequence and acid sequence. The basic sequence is predominant in area and volume, comprising basalt, andesite and obsidian spills, in addition to volcanic cracks and intertrappean arenites. The acid sequence comprises porphyry dacite, phelsitic dacite, felsitic riolite and felsitive riodacite spills.

Basalts are melanocratic rocks, of dark grey to black color, aphanitic dominant texture, whose minerals are not noticeable to the naked eye, being predominantly composed of calcic pyroxene, amphibolies and plagioclases.

In thicker varieties, such as those encountered in the top zone, minerals form crystals visible to the naked eye, characterizing the geodes, with the presence of subedric to auedric minerals filling the spill's top vesicles.

Basalts when altered, generally in the rock surface, create eluvial sediments which take on brown-reddish colors, turning darker in inner parts, where the chemical decomposition is lower, according to field observation in the layout of the chosen alternative.

Eluvium gradate to coluvial and alluvial deposits, associated with the continental system of slopes and accumulated in a non differential manner during the Quaternary. They occupy the feet of hills, river lowlands, drainages and thalwegs, composed of fine and thick sands, unconsolidated pebbles, as well as flooding lowland clay.

Mineral Resources

Mineral resources of the influence area are light, being represented mainly by occurrence of explored basalts from the outcrops as material for civil construction and aggregate production. Their economic importance is also in the extraction of semi-precious rock from the amygdaloid basalts at the spill's top, whose main minerals are: rock crystal, citrine, amethyst, agate, chalcedony, onyx, calcite, zeolite, malachite, among others.

As verified in on site, no quarry was identified in the direct and indirect influence areas of the project.

The locations intended for the extraction of mineral inputs, lease land location and waste deposits are located near the work site as shown in Exhibit 01.

Pedology

From a pedologic standpoint, according to SANTA CATARINA (1986), the direct and indirect influence area of the Santa Luzia Alto SHS is occupied by soils of the dystrophic RED NITOSOIL; RED LATOSOIL and Eutrophic Ta HAPLIC CAMBISOIL groups. Dystrophic RED NITOSOIL is developed throughout the main rivers and their affluents, involved by RED LATOSOIL and Eutrophic Ta HAPLIC CAMBISOIL.

Dystrophic RED NITOSOIL occurs in undulated and strong undulated relief , being mineral, clayey, non hydromorphic soils, with presence in the B horizon of clay of low capacity cation exchange and derivatives. They represent deep, porous and well drained soils, with sequence of A, B and C type horizons, generally very clayey throughout the profile. Because of small variations of color and texture, transitions between sub-horizons are gradual and diffuse.

RED LATOSOILS are mineral, non hydromorphic soils, characterized through the presence of latosolic B horizon. They derive from basalts and less commonly from acidic effusive rocks of the Serra Geral Formation, and present A, B and C horizon sequence with diffuse and gradual transition. They are also deep and very deep soils with very clayey texture; and they are located in a slightly undulated and undulated relief.

Eutrophic Ta HAPLIC CAMBISOIL comprise mineral, non hydromorphic soils characterized by the occurrence of a incipient B horizon, defined by low textural gradient,

by medium and high silt/clay ratio or by the presence of primary minerals of easy decomposition. Generally, it has A, B and C horizon sequence, finding variations in soil depth, color, texture and structure. When derived from basalts generally they have high activity clay, they are almost always graveled and are located in strong undulated and mountainous reliefs.

Regional Geomorphology

The model of the current surface of the State of Santa Catarina was a result of the integrated action of pluvial, fluvial and tectonic processes, as well as climate influence.

The State of Santa Catarina presents from east to west, in terms of its topographical and geological configuration, five large natural morphological landscapes: 1) Coastal Lowland; 2) Crystalline Mountain Range; 3) Peripherical Depression; 4) Lajes and Serra Geral Plateaus.

Geological provinces of the State of Santa Catarina (Escudo Catarinense; Paraná Basin; Serra Geral Plateau; Alkaline Complex and Coastal Province) are correlated from the geomorphological standpoint, to the following provinces: Crytalline Mountain Range; Peripherical Depression; Basaltic Plateau – Arenitic; Lajes Plateau and Coastal Lowland, respectively.

The Crystalline Mountain Ranges follow the coast line adjacent to the South Atlantic ocean, characterizing a very different relief ranging between acute ridges and deep drainage channels, with altitudes which reach 1,200 m above sea level. In the State of Santa Catarina, they compose the Serra do Mar in the North coast and Mountain Ranges of the east of Santa Catarina, in the center-north coast, central and center-south. In the Peripheral Depression sedimentary rocks appear which originated from the Devonian to the Triassic (Basaltic-Arenitic Plateau), configuring a massive geoenvironmental entity known as intracratonic basin of Paraná, whose relief is represented by hills and valleys at average altitudes of 700 m. The Lajes Plateau comprises a restricted geomorphologic feature associated with alkaline magmatic rocks which reach altitudes of 900m. The Coastal Lowland presents a morphological dominance of lower altitudes when compared to other geomorphologic provinces in the State, presenting types of relief such as alluvial lowlands, marine and lagoon terraces, dunes and coastal paleo-dunes, coastal regressive cords, tide and beach lowlands.

Local Geomorphology

From a geomorphologic standpoint, according to Bortoluzzi (1987), the direct influence area of the Santa Luzia Alto SHS, subordinated to geological lowlands of Serra Geral Plateau and Paraná Basin, is found in the Domain of the Basaltic-Arenitic Plateau of Santa Catarina or Acidic and Intermediate Basaltic Lava Plateau, which at their base involve aeolian arenites from the Botucatu Formation and at the top, the eruptive formations of the Serra Geral Formation, upon which the plateau relief was developed, which meets its eastern boundaries, acclivitous and strongly dissected by a drainage channel subsequent to the Serra Geral.

Monteiro (1958) subdivided the basaltic complex in two geomorphological units,

by altitude: the first, more elevated, with heights of 1,200m and the second, less elevated, with heights of 900m, distributed across extensive areas with spatial discontinuities, presenting on one side, strongly dissected hilly forms, and in the other side, flat surfaces which are almost senile, undulated, cut by valleys of varying depth.

The level surfaces referred to by Monteiro (1958) may be correlated to the Campos Gerais Plateau units (1,200m) and Dissected Plateau of the Iguaçu/Uruguay River (900m), defined by Rosa & Herrmann (1986). These units are different because the Dissected Plateau of the Iguaçu/Uruguay River presents great variations of heights between their maximum points and drainage located in the deeply uneven slopes with steep sides, structurally controlled. The morphologic characteristics of the landscape make the drainage network sinuous, with rocky surfaces, drops, small waterfalls, falls and islands.

The Iguaçu River/Uruguay River Plateau undulates to the east, also presenting a great variation in altitude, resulting from the deepening of the main river's drainage, which presents valleys and deep drops between the top and the bottom of the valley, between 200 m and 300 m.

The relief presents a great number of locations with steep slopes, sometimes in the form of escarpments, characteristic of intense movement. The slopes present steps along their length, frequently representing erosive processes and gullies which act on them, although covered by vegetation.

Drainage is very similar throughout the entire unit, because of being strongly controlled by the structure. This structural control is evident considering the various occurrences of rectilinear and abrupt inflections, as well as because of great quantity of rapids, falls and rocky surfaces. In virtue of morphologic conditions where they are associated with the drainage network, they offer great hydroelectric potential which is starting to be used.

On the other hand, the Campos Gerais Plateau is characterized by the presence of relief blocks isolated by the Dissected Plateau unit of the Iguaçu River/Uruguay River. This compartmentalization is located above circumjacent areas and corresponds to traces of a smoothing surface. The blocks appear fragmented as a consequence of the process developed throughout the main drainage period.

In the study area, tholeitic basaltic lavas from the Serra Geral Plateau reach average altitudes between 750m and 850m, with the relief slightly falling towards the west. A series of structural lines, of predominant Northeast and Southwest direction, occur attached to acidic and basic rocks. SANTA CATARINA (1986) affirmed that the most significant system of faults and fractures of the Serra Geral Formation is in the N50°E, N20°E and N20°W directions.

In the wider area of the Serra Geral Formation, the uniformity and horizontality, or almost horizontality of various spills, was only interrupted in locations where there were seesawing, irregular blocks. In these vaulting locations, spills are centrifugally inclined up to approximately 20º.

The most preserved areas of volcanic spills corresponds to regional tops and belong to the remains of a smoothing surface. Smooth areas generally correspond to areas of occurrence of acidic effusive rocks, being regionally known as Campos Gerais. In areas where acidic effusive rocks occur the characteristics of the outcrops almost always change, are deeply dissected, with deep valleys and layered slopes.

The model of small hills accompanying the drainage axis, associated with fertile soils, drives the development of mechanized agriculture, mainly soybeans, corn and wheat. This has accelerated the erosion processes because of surface erosion, which is shown by furrows on the slopes.

All outcrop rocks are subjected to erosion processes over time, producing sediments that are deposited in restricted sand-banks and sedimentary basins, where deposits of clayey sediments and sand, of predominantly Cenozoic age, occur.

Geomorphologic characteristics of lands adjacent to the project's area characterize a slightly undulated relief to undulated at the top of plateaus and throughout the flood basin of the Chapecó river, resulting from the intense dissection which they have been subjected to.

8.1.3. Water Resources

The project is located on the Dissected Plateau of the Iguaçú/Uruguay river, in the Chapecó river basin, a tributary of the Uruguay River right bank, upstream from the Chapecozinho river in the so-called Integrated System of Interior Watershed (Sistema Integrado da Vertente do Interior), whose waters drain into the Continent, from the divisor created by the Serra Geral, towards the great Hydrologic Complex of the Prata Basin.

As for fluvial regimes, we found that the rivers of Santa Catarina are governed, as a rule, by the pluviometric regime which is characterized by the rain distributed throughout the entire year, assuring in normal supplies for springs throughout the year. The behavior of most of rivers, according to the rainfall distribution is represented by two maximums (occurring in the spring and at the end of summer, respectively) and two minimums (registered at the beginning of summer and fall, extending to winter), characteristics of a subtropical regime.

The project is located in the Hydrographic Region 2 – Mid-West, Figure 04, hydrologic unit formed by the Chapecó and Irani basins, this region has undergone great socio-economic growth in the last two decades. The rural populations represent 47% of the total population, which reveals the social importance of this sector in the region. It is among the areas that represent the greatest number of cities in the State, which is why three associations exist - AMEROS, AMOSC, and AMAI – that are responsible for local political-administrative regionally.

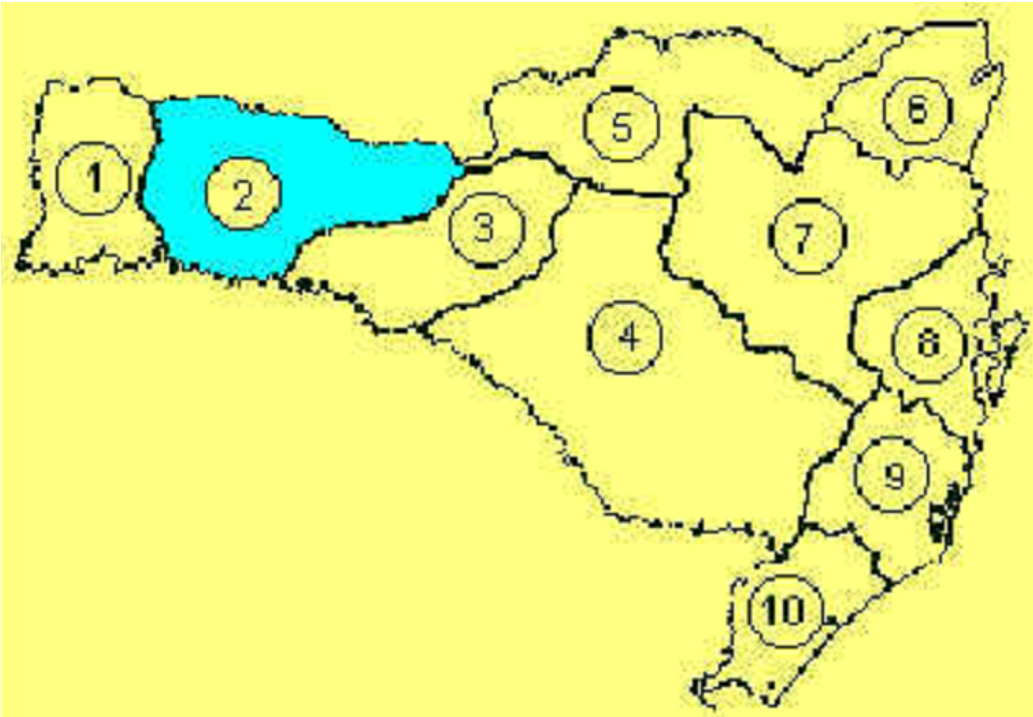


Figure 04 – Hydrographic region of Santa Catarina.

The Mid-west Hydrographic Region (HR – 2) forms the Uruguay river basin and has as major water course that bring water to the region, the hydrographic basins of the Chapecó River and Irani River. The Chapecó River, with an average flow of 263 m^3/s in the estuary, a drainage area of 8,190 Km^2 and a drain density of 1.55 Km/Km^2, represents the main water course in this hydrographic region, draining the areas of 30 cities, including São Domingos and Ipuaçu.

The rivers of this watershed present, as a rule, a longitudinal profile with a long course and a number of waterfalls, which represent significant hydroelectric potential for the region. The Chapecó River, the biggest tributary of the Uruguay River in Santa Catarina, is very sinuous, as a water source it serves the cities included in this study, among others along its course.

The relief is mostly steep, which contributes to erosion. In the same way, the regional vegetation coverage is degraded, with only 17% of primary and secondary vegetation, and 15 of reforested area. The agricultural capacity of most of the soils is in classes 3 and 4 (restricted usage), which does not prevent it from coming first in grain production and among the first in hog, fowl and milk production in the State.

As a consequence of the intense farming and breeding activity, we found aggravated soil erosion and the silting up of rivers, in addition to large scale contamination of springs from hog excrement and pesticides. When the availability of water is compared with its various usages we find that there is a relative normal situation in the most of the sub-basins in the region. However, in some of them there is lack of water, as is the case in the estuary of the Chalana river, near Chapecó, where the situation can be considered critical because during dry weather, more than 70% of the water is consumed by current users.

The most serious problem is related to water contamination by hog excrement. According to surveys done by Epagri 84% of sources and small springs in the area studied are contaminated by fecal coliforms.

In this context, the drilling of deep wells in the region has increased, without the proper registration and without the required assessment of aquifers and potential groundwater in the region.

West Santa Catarina was not included in conservation areas because there are almost no expressive forests in that region, because of the degrading action of agricultural, rural and industrial activities. IN addition to the Forest District that, in a way, discourages aggression to forests, other preservation units were also created in order to protect either the flora, fauna, water resources or soil. The parks, biological reserves, and ecological stations are approaches adopted according to the ecological conditions of each area. The most important preservation unit nearest the region studied is the Xanxerê Indigenous Reserve, a National Preservation unit since 1985.

The cities of São Domingos and Ipuaçu are bathed by the hydrographic Basin of the Chapecó river, which is its main river and whose main tributaries are the rivers Bonito, Saudades, Feliciano, Martins, Emigra, Lajeado Jacutinga, Lajeado Baitaca, Martins, and Lajeado Santo Antônio.

The Chapecó river is the main tributary of Uruguay river, draining an area of 8,180-km^2 . Its springs are located in the Chapecó Ridge, near Capão Doce Hill (1,340 m elevation), which borders the Iguaçu river basin, the main water course in Paraná state. Even with this unevenness, the river's erosive power is not very strong throughout its course (Figure 05 and Figure 06). Its average depth in the dam location and in the longest part of the lake to be formed is 1 to 2 m.

Chapecó river main tributaries on the right bank are Ouro and Burro Branco rivers, and on the left bank only the Chapecozinho river is highlighted.

The hydrographic basin of the Chapecó river runs mostly east-west, up to Abeardo Luz, where it flows northeast-southwest thus it discharges into the Uruguay river, near São Carlos.

In the North, the Chapecó basin borders the Chopim river basin, a tributary on the Iguaçu river left bank. Then in the south, it borders the Irani river basin, which is also a tributary of the Uruguay river.

The drainage density, as a good indicator of the hydrographic network development level, is obtained by the relationship of the sum of all tributaries' lengths, including the main course, and the basin area. The drainage density ranges from 0.5 km/km^2 in basins with poor drainage, to 3.5 km/km^2 or more for basins exceptionally well drained (Villela & Matos, 1975).

Chapecó river basin has 12,716 Km of water courses, resulting in a drainage density of 1.55 km/km^2. This result indicates thon the Chapecó river basin is in the average range of drainage density.

Figure 05 – View of the Chapecó River in the planned location of the power station.

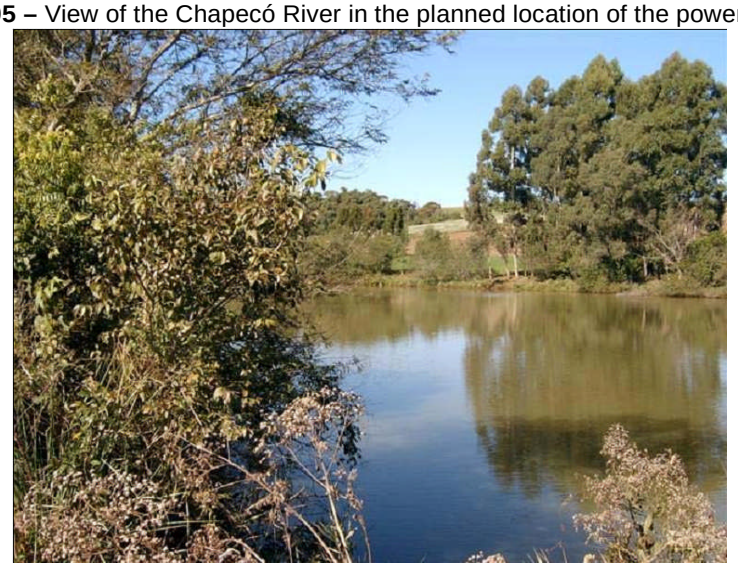


Figure 06 – View of the Chapecó River between the power station and dam.

Its basin is located in one of the regions of Santa Catarina with the highest pluviometric indexes, and its drainage density is 1.55 km/km^2. The basin's typical drainage pattern is dendritic, tending to Angular-subparallel. The average flow through the period at the dam (Figure 07) is

about 64 m^3/s which, after the completion of Ludesa SHS to the upstream, will change to approximately 33 and 35 m^3/s.

Figure 07 – View of the Chapecó River in the planned location of the dam.

The drainage system that constitutes the Chapecó river basin covers 8,190 km^2 and its tributaries have strong structural control, shown by the shape of river beds that run straight and then form sharp bends and curves, and frequent rapids, waterfalls, falls, and rocky surfaces.

Points of use and employment of waters from the Chapecó river as a public supply or for other applications are unknown and were not identified, either upstream or downstream of the current dam.

Five micro hydrographic basins are going to be directly affected by the project, Appendix 11, three on the Chapecó river's right bank and two on the left bank, in Ipuaçu. On the Chapecó river's right bank, in the area where the power station will be built, the dam and the work site have Córrego Azul and Córrego São Lourenço micro basin specifically drained by Córrego Azul, Córrego São Lourenço, and Arroio Santa Luzia rivers, but the Córrego Azul will not be directly affected by the project because it is upstream. Also on the right bank, there are the Bonito River Right Bank and Left Bank micro basins, between these micro basins, there is the Bonito river, a main tributary of the Chapecó river affected by the SHS. In this section, there are some streams that drain their water to the Bonito river, they are not directly affected, and a small river directly drained to the Chapecó river.

In Ipuaçu, the Chapecó river left bank, there is the Toldo Velho river and Lajeado Ipuaçu micro basin located in the section that will shelter the other end of the dam. Toldo Velho river as well as Lajeado Ipuaçu river are located between the

dam and the power station, decreasing the impact caused by the lower flow in this section.

Downstream, there is the Lajeado Grande and Salomão river micro basin. In this micro basin, there are the Lajeado Grande and Sanga União rivers inside the flooding area and upstream of the Salomão river flood plain.

São Domingos is supplied with water from the Bonito river, the main tributary of the Chapecó river in the influence area, rising on the border with Paraná and crossing the city to drain into the Chapecó river.

Bonito river discharges approximately 6.5 km downstream of the future dam at the Santa Luzia SHS, on the Chapecó river. Note that the Bonito river will have part of its course flooded by the reservoir, Figure 08.

The most important hydro geological feature in regional terms is Guarani Aquifer, the current name for the Botucatu Formation. This geological Formation, from the São Bento Group, is made of aeolic sandstone from a desert environment, reddish, thin to average, with cross-stratification of average to large capacity; lacustrine sediments locally represented by argillaceous sandstone , mis-selected, more frequent on the formation base.

Figure 08 – Bonito and Chapecó rivers combining.

Average Monthly Flow

For the assessment of monthly average flows of Santa Luzia Alto SHS utilization, using data from the following stations:

Table 10 – Monitoring Posts.

Código	Posto	Rio	AD (Km^2)	Disponibilidade de Dados Consistidos
73760000	Abelardo Luz	Chapecó	1 .850	Abr/53 a Dez/99
73850000	Passo Nova Erechim	Chapecó	7.535	Jun/59 a Dez/86

Notes: The Passo Nova Erechim post was decomissioned in Sep/90.
The period from Jan/87 to Sep/90 of the Passo Nova Erechim post was not subject to consistency analysis by ANEEL.

Note that only data already consolidated by ANEEL was used, not analyzing the raw data available.

When defining the monthly average flow series at the Santa Luzia Alto SHS plant, the series from the Abelardo Luz and Passo Nova Erechim stations were basically used.

Initially, series from 2 stations were compared to the series used in previous studies. It was found that because of the consistency analysis performed by ANEEL, the series of data from Abelardo Luz station (code 73760000) had changed.

Assuming Abelardo Luz station as the base point for the series of monthly average flows of Santa Luzia Alto SHS plant, initially it was attempted to fill in the gaps existing in the station series (Oct. and Dec/56, Jan./66 to Jul./87, and Feb., Mar. and Dec./79). For that, a co-relation of monthly average flows among the data from Abelardo Luz and Passo Nova Erechim was performed, resulting in the following transfer equation:

$Q_{A.L.} = (0,27 \times {}_{QNE}) + 3,861$
Where:
$Q_{A.L.}$ = average monthly output of Abelardo Luz, in m^3/s
$Q_{N.E.}$ = average monthly output of Passo Nova Erechim, in $m^3/s$$Q_{SL} = 1.373 \times Q_{A.L.}$

Since the gaps are filled in, a series of Abelardo Luz station for the period between May/53 to Dec/99 was made, as presented in Table 11.

A series of monthly average flows at the site of the Santa Luzia Alto SHS plant (AD=2,540 km^2) was obtained applying factors resulting from the ratio of Drainage Areas between Abelardo Luz station and the plant:

$Q_{SL} = 1.373 \times Q_{A.L.}$

Note that the period before Apr/53 was preserved in the series for the plant, changing only the period from May/53 to Dec/99, following the consistency analysis that the Abelardo Luz series underwent.

In Table 12, the series of monthly average flows of Santa Luzia Alto SHS plant may be seen.

Table 11 – Series of average monthly flows (m^3/s).

Ano	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	Média
1953					23	31.1	33.8	32.6	90	111	76.3	44.4	55.3
1954	46	33.3	52.3	44.4	83	175	140	47.3	174	201	37	33.8	88.9
1955	16	17.7	13.8	68	96.2	142	127	62.4	37.4	22.6	12.8	11.4	52.3
1956	29.8	24.8	10.2	57.1	67.3	34.2	44.3	36.2	117	35.9	9.8	12.6	39.9
1957	12.8	36.6	24.3	14	14.4	43.8	129	263	160	37.9	21.8	19.2	64.7
1958	13.2	9.5	46.5	20.9	8.9	26.2	19.6	55	114	70.1	71	91.1	45.5
1959	49.6	33.1	18.1	29	37.1	34.1	24.3	39.7	47.5	31	22.1	16.1	31.8
1960	10.8	14.2	9	10	14.8	32.1	15.8	80.5	69	99.9	73.2	24.2	37.8
1961	19.8	24.3	149	48.1	58.3	35.1	16	12.1	132	141	77.4	34.3	62.3
1962	22.5	52.3	28.2	16.1	57.1	39.7	39.5	25.6	73.8	80	44.1	20.2	41.6
1963	28.2	47.9	59.6	32.1	31	17.3	12.5	14.1	27.9	118	128	48.4	47.1
1964	19.7	30.8	25.8	41.3	65	25.6	36.7	65.7	49.3	30.3	24.9	17.5	36.1
1965	14.6	17.2	10.7	15.1	63.4	43.4	102	85.5	108	173	84.5	124	70.1
1966	66.0	175.0	83.2	33.6	18.1	50.8	58.1	53.0	96.2	135.0	57.9	73.2	75.0
1967	36.8	51.9	75.4	20.6	18.0	23.5	29.4	71.4	76.4	46.1	52.7	48.7	45.9
1968	18.1	10.1	9.6	17.2	19.3	18.9	29.7	16	16.8	29.8	48	35.5	22.4
1969	81.6	49.2	42.2	72.8	68.1	122	68.8	41.2	60.1	73.3	72.5	28.8	65.1
1970	37.8	32.3	30.6	23.1	42.1	87.6	102	40.1	50.7	72	26.7	140	57.1
1971	130	58.3	56.5	108	102	147	118	54.1	40.3	54.2	17	15.7	75.1
1972	32.1	46.4	48	46.9	20.9	93.3	46.4	181	179	85.3	39.3	42.2	71.7
1973	65.5	108	69.2	32.5	101	114	83.5	144	135	96.1	70.2	33.1	87.7
1974	50.5	51.2	43.2	37	43.5	73.5	41.4	29	66.2	29.1	52.1	34.5	45.9
1975	59	58	31.7	19.9	16.9	37.6	40	57	107	137	71.2	102	61.4
1976	70.2	39	26.9	26.3	53.2	79	44.8	66.2	51.9	54.5	75.9	27.6	51.3
1977	23.8	27	60.6	33	14.5	39.5	34.4	67.3	47.1	72.1	72.1	30.8	43.5
1978	14.4	9.1	10.9	4.7	4.7	8.6	61.3	28.3	45.2	23.4	55	36.3	25.2
1979	16.9	13.2	15	42.7	179	52.6	55.2	61.2	49.8	180	104	65.4	69.6
1980	41	28.5	60.4	25.9	41.1	23.8	64.9	84.5	78.9	42.9	54.8	72.8	51.6
1981	50.3	53.3	34.7	28.5	26.6	38.7	20.5	18.3	23.1	41.6	72.2	102	42.5
1982	30.5	38.6	26.8	12.7	16.7	93.5	173	65.1	40.9	131	282	78	82.4
1983	70.7	77.7	165	100	263	148	448	105	89.1	78.3	75.8	29.9	137.5
1984	31	38.2	27.3	38.4	46.3	107	40.3	133	75.8	52	55	26.5	55.9
1985	18.1	51.6	25.1	40.9	33	20.3	31.1	21.1	45.2	34.1	46.4	17.9	32.1
1986	21.6	42	26.8	57	61.7	58.2	23.8	31.1	53.7	63.4	35.2	25.9	41.7
1987	38.9	46.7	17.3	28.1	223	87.4	51.1	51.4	36	80	39	20.1	59.9
1988	16.9	17	11.3	28.5	188	106	42.1	19.4	17.4	51	30.8	26.8	46.3
1989	59	100	58.3	51.1	71.9	37.8	66.7	66.6	205	98.6	52.6	32.5	75.0
1990	119	58.2	44.5	117	105	282	94.3	113	126	114	88.3	91.1	112.7
1991	50.9	50.1	35.3	39.3	36.3	120	75	86.7	48.6	98.7	69	62.2	64.3
1992	61.3	71.4	81.9	73.2	221	153	185	130	107	93.3	88.9	55.2	110.1
1993	66.2	53.5	43.7	36.7	103	90.9	68.4	48	73.2	141	44.6	46.7	68.0
1994	21.8	62.5	36.3	38.1	82.2	113	130	50.4	50.3	77.9	135	91	74.0
1995	145	56	44.7	55.1	35.1	53.3	62.1	31.8	58.7	88.3	31.3	20.7	56.8

1996	35.9	81.2	78.3	56.4	20.5	69	110	74.5	116	191	68.1	70.9	81.0
1997	45.4	161	69.4	30.5	42.9	117	111	136	59.5	252	243	57.8	110.5
1998	97.9	151	111	257	121	46.8	90.4	213	155	130	43.5	35.1	121.0
1999	39.3	46.3	24.9	52.8	22.8	64.6	97.9	21.9	28.6	143	31.7	21.2	49.6
Média	44.5	51.2	45.1	45.3	65.6	73.6	75.3	68.7	78.9	90.2	65.6	46.7	**62.6**
Máxima	145	175	165	257	263	282	448	263	205	252	282	140	137.5
Mínima	10.8	9.1	9	4.7	4.7	8.6	12.5	12.1	16.8	22.6	9.8	11.4	22.4

Station: Abelardo Luz - AD = 1.850 Km

Table 12 – Series of average monthly flow (m^3/s).

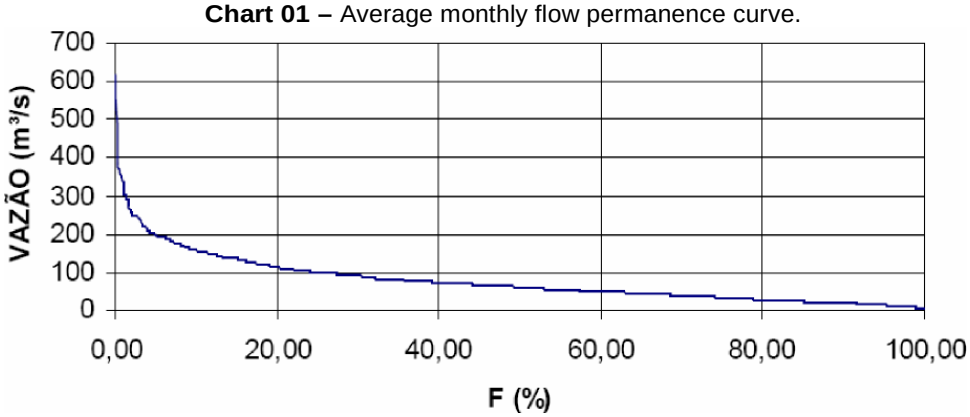
Ano	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	Média
1931	49.2	28.3	26.3	23.5	172.9	120.1	135.9	104.3	152.4	65.2	53.0	68.9	83.3
1932	49.0	66.2	61.8	149.0	140.0	101.7	80.9	80.6	138.0	102.3	62.3	67.4	91.6
1933	28.1	33.9	24.8	20.0	29.9	29.3	44.4	61.8	82.7	140.2	55.1	25.8	48.0
1934	38.4	103.3	66.9	91.1	68.4	67.6	70.4	70.9	75.3	84.1	47.5	40.3	68.7
1935	29.1	25.0	21.1	18.7	12.1	25.4	78.4	109.4	146.2	194.0	82.0	114.7	71.3
1936	77.0	41.2	28.6	20.4	27.6	192.3	123.3	164.7	131.0	122.2	73.2	48.4	87.5
1937	36.6	40.3	57.5	53.2	20.4	13.6	28.4	69.3	64.2	77.8	70.9	43.1	47.9
1938	75.4	69.0	62.1	79.6	95.6	118.7	94.1	46.8	26.4	23.7	35.6	19.5	62.2
1939	28.3	46.5	64.3	51.4	81.0	79.3	33.7	50.2	63.6	54.1	111.0	152.8	68.0
1940	73.1	53.9	27.1	136.3	95.6	41.0	47.1	75.0	40.0	58.6	34.7	45.8	60.7
1941	36.4	64.2	54.7	72.4	117.1	120.0	192.9	155.1	160.3	76.3	101.2	206.4	113.1
1942	30.3	83.1	38.3	97.2	97.4	37.3	72.9	118.7	88.1	173.3	24.0	16.1	73.0
1943	10.0	8.3	13.0	10.4	82.0	290.2	103.3	194.3	161.5	70.3	28.8	17.2	82.4
1944	46.6	17.2	16.2	16.1	9.5	21.4	20.2	8.0	11.1	15.1	15.3	6.9	17.0
1945	4.5	18.5	9.2	5.1	7.3	9.2	11.6	15.5	23.3	20.2	16.9	19.9	13.4
1946	99.7	257.7	49.0	33.8	82.9	108.4	128.8	37.0	26.5	96.7	30.1	33.3	82.0
1947	30.5	45.0	19.3	10.2	37.3	129.7	33.6	66.1	140.8	47.8	25.8	35.6	51.8
1948	10.6	51.4	48.6	31.6	51.6	48.8	32.2	64.3	35.9	57.5	82.0	18.5	44.4
1949	10.6	8.5	25.1	28.4	49.2	80.7	46.9	44.8	61.2	63.0	19.9	13.2	37.6
1950	20.2	16.2	37.6	23.5	43.8	25.1	43.7	35.6	46.6	205.4	96.5	39.7	52.8
1951	51.4	68.1	110.7	22.7	13.2	13.4	22.3	7.9	11.6	88.1	132.0	46.6	49.0
1952	15.8	22.6	10.4	9.5	6.2	70.3	117.1	31.6	64.7	221.2	93.9	24.6	57.3
1953	20.3	64.4	9.7	36.8	31.6	42.7	46.4	44.8	123.6	152.4	104.8	61.0	61.6
1954	63.1	45.7	71.8	61.0	114.0	240.4	192.2	65.0	238.9	276.0	50.8	46.4	122.1
1955	22.2	24.5	19.1	93.4	132.1	195.0	174.4	85.7	51.4	31.1	17.5	15.6	71.9
1956	40.9	34.1	14.0	78.4	92.4	46.9	60.8	49.7	160.6	49.8	13.4	17.3	54.9
1957	17.5	50.2	33.4	19.2	19.7	60.1	177.1	361.2	219.7	52.0	29.9	26.4	88.8
1958	18.1	13.1	63.9	28.7	12.2	35.9	27.0	75.5	156.5	96.3	97.5	125.1	62.4
1959	68.1	45.5	24.8	39.8	50.9	46.8	33.4	54.5	65.2	42.6	30.4	22.1	43.7
1960	14.9	19.5	12.3	13.8	20.3	44.0	21.7	110.6	94.7	137.2	100.5	33.3	51.9
1961	27.2	33.4	204.6	66.0	80.1	48.3	22.0	16.6	181.2	193.7	106.3	47.1	85.5
1962	30.9	71.8	38.7	22.1	78.4	54.5	54.2	35.2	101.4	109.8	60.6	27.7	57.1

1963	38.7	65.8	81.9	44.0	42.6	23.7	17.2	19.4	38.3	162.1	175.8	66.4	64.7
1964	27.1	42.3	35.4	56.7	89.3	35.2	50.4	90.2	67.7	41.6	34.2	24.1	49.5
1965	20.1	23.6	14.6	20.7	87.1	59.6	140.1	117.4	148.3	237.6	116.0	170.3	96.3
1966	90.6	240.4	114.2	46.1	24.8	69.8	79.8	72.8	132.1	185.3	79.5	100.5	103.0
1967	50.6	71.3	103.5	28.3	24.7	32.3	40.4	98.1	104.9	63.3	72.3	66.9	63.0
1968	24.8	13.9	13.2	23.6	26.5	26.0	40.8	22.0	23.1	40.9	65.9	48.7	30.8
1969	112.0	67.6	57.9	99.9	93.5	167.5	94.5	56.6	82.5	100.6	99.6	39.6	89.3
1970	51.9	44.4	42.0	31.7	57.8	120.2	140.1	55.0	69.7	98.8	36.7	192.2	78.4
1971	178.5	80.1	77.5	148.3	140.1	201.9	162.1	74.3	55.3	74.4	23.3	21.5	103.2
1972	44.0	63.7	65.9	64.4	28.7	128.1	63.7	248.6	245.8	117.1	54.0	57.9	98.5
1973	90.0	148.3	95.1	44.6	138.7	156.5	114.7	197.8	185.3	132.0	96.4	45.5	120.3
1974	69.3	70.3	59.3	50.8	59.8	100.9	56.9	39.8	91.0	39.9	71.5	47.4	63.1
1975	81.0	79.6	43.5	27.3	23.2	51.6	54.9	78.3	147.0	188.1	97.7	140.1	84.4
1976	96.4	53.6	36.9	36.2	73.1	108.5	61.6	91.0	71.3	74.9	104.3	37.9	70.4
1977	32.7	37.0	83.2	45.4	20.0	54.2	47.3	92.4	64.7	99.1	99.1	42.3	59.8
1978	19.7	12.5	15.0	6.4	6.4	11.8	84.2	38.8	62.1	32.2	75.5	49.8	34.5
1979	23.2	18.1	20.6	58.7	245.8	72.2	75.8	84.1	68.4	247.1	142.9	89.8	95.5
1980	56.3	39.2	83.0	35.6	56.5	32.7	89.1	116.0	108.4	58.9	75.2	99.9	70.9
1981	69.1	73.2	47.7	39.2	36.5	53.1	28.2	25.2	31.7	57.1	99.2	140.1	58.3
1982	41.9	53.0	36.8	17.4	23.0	128.4	237.6	89.4	56.1	179.9	387.2	107.1	113.1
1983	97.1	106.7	226.6	137.3	361.2	203.2	615.2	144.2	122.3	107.5	104.0	41.0	188.9
1984	42.6	52.5	37.5	52.7	63.6	147.0	55.3	182.7	104.0	71.4	75.5	36.4	76.8
1985	24.8	70.9	34.5	56.1	45.4	27.8	42.7	29.0	62.1	46.8	63.7	24.6	44.0
1986	29.6	57.7	36.8	78.3	84.7	80.0	32.7	42.7	73.8	87.1	48.4	35.6	57.2
1987	53.5	64.1	23.7	38.6	306.3	120.0	70.2	70.5	49.5	109.8	53.6	27.6	82.3
1988	23.2	23.3	15.5	39.2	258.1	145.5	57.8	26.6	23.8	70.0	42.3	36.8	63.6
1989	81.0	137.3	80.1	70.2	98.7	51.9	91.6	91.5	281.5	135.4	72.2	44.6	103.0
1990	163.4	80.0	61.1	160.6	144.2	387.2	129.4	155.2	173.0	156.5	121.2	125.1	154.7
1991	69.9	68.8	48.5	54.0	49.8	164.8	103.0	119.0	66.8	135.5	94.7	85.4	88.4
1992	84.2	98.1	112.5	100.5	303.5	210.1	254.0	178.5	147.0	128.1	122.1	75.8	151.2
1993	91.0	73.4	60.0	50.4	141.4	124.8	93.9	65.9	100.5	193.7	61.2	64.1	93.4
1994	29.9	85.9	49.8	52.4	112.9	155.2	178.5	69.2	69.1	106.9	185.3	125.0	101.7
1995	199.1	76.9	61.3	75.6	48.3	73.2	85.3	43.7	80.6	121.2	42.9	28.4	78.1
1996	49.2	111.5	107.5	77.4	28.2	94.7	151.1	102.3	159.3	262.3	93.5	97.4	111.3
1997	62.3	221.1	95.3	41.9	58.9	160.6	152.4	186.8	81.7	346.1	333.6	79.4	151.6
1998	134.4	207.3	152.4	352.9	166.2	64.2	124.1	292.5	212.9	178.5	59.8	48.3	166.2
1999	54.0	63.6	34.2	72.5	31.3	88.7	134.4	30.1	39.3	196.3	43.5	29.1	68.1
Média	53.4	64.8	54.0	56.6	80.7	94.1	93.1	87.6	99.2	114.2	80.1	59.7	**78.1**
Máxima	199.1	257.7	226.6	352.9	361.2	387.2	615.2	361.2	281.5	346.1	387.2	206.4	188.9
Mínima	4.5	8.3	9.2	5.1	6.2	9.2	11.6	7.9	11.1	15.1	13.4	6.9	13.4

Santa Luzia Alto AD = 2,540km

Based on the series of outputs of the location defined the permanence curve, as presented in Chart 01.

Chart 01 – Average monthly flow permanence curve.



Flood Outputs a)

Wet Period

For evaluation of flood outputs at the plant at the Santa Luzia Alto SHS, the following posts' data wasused:

Table 13 – Posts analyzed for flood outputs.

Código ANEEL	Posto	Área de Drenagem (km^2)	Cheia Média (m^3/s)
73 600 000	Abelardo Luz	1850	590
73 730 000	Porto Elvino	5239	1564
73 750 000	Porto Fae	5528	1526
73 850 000	Passo Nova Erechim	7535	2144

Notes: The Porto Elvino post was decomissioned in Dec/78.
The Porto Fae post was decomissioned in Jan/78.
The Passo Nova Erechim post was decomissioned in Sep/90.
The period from Jan/87 to Sep/90 of the Passo Nova Erechim post was not subject to consistency analysis by ANEEL.

Based on the average flood levels and drainage area at each station, we were able to define a regional equation to obtain the average overflow at any point of the Chapecó river. The function is:

$$Q_{average} = 0.6216 \times AD^{0.911}$$

For the Santa Luzia Alto SHS plant: $Q_{average} = 786\ m^3/s$

The ratio between the average flood levels at Santa Luzia Alto SHS plant and Abelardo Luz station was 1.332, which allowed us to define the ratio for the maximum flood level transfer, given by:

$$Q_{max.S.L.} = 1,332 \times Q_{max.A.L.}$$

The following step was to submit a series of annual maximum flows from Abelardo Luz station to a flood frequency analysis, considering the following probability distribution: Normal, Log-Normal, Gumbel, Gumbel Chow, Exponential, Pearson and Log-Pearson. From the distribution adjustment, it was observed from the plot-position and assimetry coefficient (1.012) that the distribution of best adjustment is Gumbel-Chow, as announced by Eletrobrás in its "Guide for overflow calculation of Spillways Project", March/87. Applying the 1.332 coefficient defined above, to the series of Abelardo Luz station, adjusted by Gumbel-Chow distribution, the values of overflow for different periods of return to Santa Luzia Alto SHS are defined.

For the instant peak calculation, the Füller coefficient given by the following ratio was applied to the values that we obtained.

$Q_{pico} = 1 + 2.66\ AD^{-0,3}$ which results in $Q_{pico} = 1.253$

The final flood level values at the Santa Luzia Alto SHS plant are presented in the Table 14, as follows:

Table 14 – Flood Flood flows for Different Periods of Return on Investment

Tr (anos)	Vazão de Cheia (m3/s)
5	1.419
10	1.761
25	2.191
50	2.510
100	2.829
500	3.562
1.000	3.877
10.000	4.924

b) Dry Weather Period

For the estimate 10 and 25 years of return period flood levels in dry months, new statistical inferences were performed with data from Abelardo Luz fluviometric station, using the series of maximum flows in January, February, March, and April of each year. The probabilistic distribution employed was, once again, the Gumbel-Chow distribution.

Table 15 - Flood flows for January to April.

Tr (anos)	Vazão de Cheia (m^3/s)
10	651
25	843

Sanitary Output

For the minimum flow assessment for 7 successive days associated with 10 year return period, in the Chapecó river basin next to Abelardo Luz station (code ANA 73600000), we used a series of daily average flows for the station covering the period from April/1953 to January/2006, with a few gaps in certain years: 1953 and 1956, inconsistent values for 1990 and 1991, and more extensive periods with the absence of years 1996 and 1997.

Based on the series of daily average flows, the moving averages of 7 successive days were calculated, which allowed us to define a minimum 7 day flow for each year, creating a 47-value series, as presented in Table 16.

Comment [NP1]: here

Table 16 – Minimum weekly output.

Ano	Vazão Mínima de 7 dias (m^3/s)
1953	----
1954	9.8
1955	4.9
1956	4.2
1957	4.6
1958	3.9
1959	9.8
1960	4.9
1961	7.3
1962	7.3
1963	8.0
1964	9.8
1965	7.3
1966	----
1967	----
1968	6.1
1969	16.8
1970	11.0
1971	10.4
1972	11.0
1973	16.8
1974	11.0
1975	11.0
1976	12.0
1977	6.7
1978	2.9
1979	4.6
1980	12.0
1981	9.8
1982	8.0
1983	17.8
1984	11.0
1985	10.8
1986	8.1
1987	9.4
1988	6.8
1989	22.6
1990	32.0
1991	23.8
1992	22.6
1993	18.0
1994	18.0
1995	10.1
1996	13.8
1997	13.8

1998	18.0
1999	13.1
2000	13.1
2001	18.0
2002	7.8
2003	9.4
2004	10.5
2005	11.6
Média (m^3/s)	**11.44**
D. Padrão (m^3/s)	**5.84**

First we defined a reduced variant given by the expression (Gumbel line): y = $_a$ * (x - $_3$) , being $_a$ and $_3$ the parameters:

$$_a = - _y / _x \text{ e } _3 = \mu_x – (\mu_y / _a)$$

Based on the sample size (50 values), we obtained the following table values: $_y$ = 1.1607 (function of sample size); and

$_x$ = 5,84 (standard sample diversion) which provides = 0.1988

μ_x = 1 1 ,44 (sample average); and

μ_y = 0,5485 (function of sample size) which provides $_3$= 8.68 Finally, utilizing the Gumbel distribution expression: -0,1988 * ($Q_{7,T}$ – 8,68) = - ln * (-ln (1 – 1/T) , for T = 10 years with:

$Q_{7,10}$ = 5,03 * ln (- ln (1 – 1/10) + 8,68 , we obtained:
$Q_{7,10}$ = 2,624 m^3/s which corresponds to a week's output and 10 year return period.

Based on the equations defined by Tucci (1991) for the 18 homogenous regions of Rio Grande do Sul, an assessment based on Abelardo Luz station data was performed.

In the regions defined by Tucci, the course of the Chapecó river corresponds to region 5 supplying for T_R= 1 0 years, a minimum adimensional flow of 0.50.
Using the proposed methodology, a minimum flow $Q_{7,10}$ = 2.68 m^3/s was obtained, a value that is consistent with the one defined by the Gumbel equation (2.624 m^3/s) as this as the latest presumed value.

For the definition of a 7-day flow and 10 year return period at Santa Luzia Alto, a transfer of the flow obtained at Abelardo Luz was performed by applying the factor defined by the relatiration between the drainage areas in both places, reaching:

$AD_{Sta\ Luzia}$ / $AD_{A\ Luz}$ = 2.540/1 850 = 1 ,3730

Applying this factor to the Abelardo Luz minimum flow, the following flow for the SHS axis was reached:

Q 7.10 = 1.3730 * 2.624 = 3.60 m^3/s

8.1 .4. Water Quality

It can be even said that Santa Catarina water pollution is completely the result of local activity, since its hydrographic basins are only under the influence of other states or countries' activities in border regions.

The land pollution problems will end up almost entirely in bodies of water located in Santa Catarina. The water pollution in the state is caused by: deforestation, aggressive agricultural practices, discharge of liquid effluents from homes or industry.

The sanitary sewage, for example, reveals that only 6.85% of the urban population have access to sewage systems. Only part of the sewage is gathered for treatment. The investment in sewage should be 0.37 of Santa Catarina GDP to provide this service to 41% of the urban population within 10 years.

The most serious problem is related to water contamination from hog excrement. According to surveys by Epagri, 84% of sources and small springs in the area studied are contaminated by fecal coliforms.

The opening of channels and the dam construction are intended to change the river flow regime, both downstream and upstream. During the filling of the reservoir, the water course will have its flow reduced downstream, until the total formation of the reservoir, when the normal fow will be re-established, except in the area between the dam and the water channel outelt.

On the other hand, the dam changes the ecosystem characteristics from lotic to lentic. In this situation, the water quality may change by nutrient retention, from the vegetation decomposing in the flooded area or by the release of waste waters, fertilizers, and animal excrement into the reservoir downstream.

Especially in hot weather, which encourages faster growth of algae and taller water plants that consume the oxygen dissolved in water, there may be great biochemical oxygen demand, generating undesirable impacts. The nutrient retention deprives downstream water of the required qualities for irrigation.

The impacts on the aquatic fauna may be casued by the flow reduction downstream, specifically between the dam and the power station, and by the loss of water quality, as nutrient levels increase during SHS operation, as well as the rising turbidity during construction.

To perform the water quality analysis in the water complex of the project's direct influence area, we conducted sampling and analysis campaigns to check the quality of the water from this area. The main goal of that campaign is to assess the water quality in the project area.

The monitoring of physico-chemical parameters on the Chapecó river considers the main impact on the water quality caused by SHS construction and operation as mentioned above.

Chapecó river water monitoring points were selected for comparison after project construction. Samples from three points on the Chapecó river were collected and analysed, points 01, 02, and 03. Point 01 is located upstream of the intended reservoir or flooding area, and this point is considered to be a control point, since is quality will not change after SHS construction. Point 02 is located in the dam upstream area, specifically between the dam and the power station, where the river flow will be decreased. The last point, point 03, is located between the previous two points, where the flooding reservoir will be formed, Appendix 12.

To perform the surface water quality analysis in the area directly affected by the project, sampling campaigns and analyses were performed by the Beckhauser & Barros lab in July, 2006 and July 2007, as show in appendix 13. The methods that were used were *Standard Methods for the Examination of Water and Wastewater - 20th edition*.

The results can be viewed in Tables 17 and 18, for sampling performed on 07/08/2006 and in 07/25/2007 respectively, and can be compared to 2005 CONAMA Resolution 357 that governs ranking and environmental guidelines for classifying boieds of water and establishes the conditions and patterns of effluent release, and other measures.

The criteria used for the comparison with CONAMA Resolution 357/05 was fresh water class 2 for the surface water that is used for: supply for human consumption after conventional treatment; protection of aquatic communities; primary contact recreation, including swimming, water skiing, and diving, pursuant to CONAMA Resolution 274 of 2000; irrigation of vegetation, fruit, plants and parks, gardens, sports and amusement fields, with which individuals may have direct contact; and acquiculture and fishing.

Table 17 – Results of surface water sample analysis for 08/07/2006.

Parâmetros Analisados	Unidade	01	02	03	Legislação
Amônia (NH_3)	mg/L	<0.01	<0.01	<0.01	< 3.7
Cor	mg/L Pt-Co	36.7	26.4	31.9	< 75
DBO	mg/L O_2	**7.0**	5.0	3.6	< 5
DQO	mg/L O_2	30	28	22	-
Fósforo Total	mg/L P	< 0.1	< 0.1	0.1	< 0.1
Nitrato	mg/L N	0.06	0.04	0.02	< 10.0
Nitrito	mg/L N	0.004	0.003	0.001	< 1.0
Nitrogênio Total	mg/L N	0.068	0.043	0.029	> 3.7
Nitrogênio Orgânico	mg/L N	< 0.01	<0.01	<0.01	-
Oxigênio D issolvido	mg/L O_2	7.69	7.84	7.92	> 6
Óleos e graxas	mg/L	< 0.20	<0.20	<0.20	Virtualmente Ausentes
Sólidos Suspensos	mg/L	10	7	6	-
Sólidos Sedimentáveis	mg/L	<0.10	<0.10	<0.10	< 1.0

Sólidos Totais Dissolvidos	mg/L	26.5	23.3	20.07	500
Turbidez	UNT	5.75	4.17	3.62	100
Temperatura	°C	22.2	22.1	22.3	-
pH	----	6.20	5.92	6.14	6 a 9
Coliforme totais	NMP/100 mL	**170000**	**110000**	**140000**	5.000
Col iformes termotolerantes	NMP/100 mL	**27000**	**16000**	**13000**	1.000

* Values in red are outside of the CONAMA Resolution standards 357/05.

Table 18 – Results of surface water sample analysis for 25/07/2007.

Parâmetros Analisados	Unidade	P1	P2	P3	Legislação
Amônia (NH_3)	mg/L	0.19	0.11	0.10	< 3.7
Cor	mg/L Pt-Co	30.3	23.2	17.6	< 75
DBO	mg/L O_2	**27.0**	4.0	3.0	< 5
DQO	mg/L O_2	97	13	10	-
Fósforo Total	mg/L P	0.04	0.02	0.04	< 0.1
Nitrato	mg/L N	0.8	0.7	0.7	< 10.0
Nitrito	mg/L N	0.005	0.005	0.006	< 1.0
Oxigênio D issolvido	mg/L O_2	9.70	9.74	9.57	> 5
Óleos e graxas	mg/L	7.3	2.1	1.7	Virtualmente Ausentes
Sólidos Suspensos	mg/L	12.40	12.00	9.00	-
Sólidos Sedimentáveis	mg/L	< 0.10	0.1	< 0.10	< 1.0
Sólidos Totais Dissolvidos	mg/L	14.00	17.00	13.20	500
Turbidez	UNT	21.5	16.4	13.3	100
pH	----	6.73	6.96	6.90	6 a 9
Coliforme totais	NMP/100 mL	210	330	220	5000
Col iformes termotolerantes	NMP/100 mL	80	140	70	1000

* Values in red are outside of the CONAMA Resolution standar ds 357/05.

The analysis of the samples shows good quality in relation to the parameters analyzed, especially nitrogen, phosphorus, dissolved oxygen, solids and pH, however, it in the first sample we found a large quantity of contamination by coliforms at the three points of analysis, which was not observed in the second sample, which shows a low concentration of coliforms, within the range permitted by law. During both sample periods, Point 01 presented values out of the permitted range in Biological Oxygen Demand (BOD), specially in the second sampling period.

According to CONAMA Resolution 274 of 2000, which proposes the assessment of fresh, brine and salt water for bathing purposes, classifying its condition as suitable and unsuitable, the Chapecó river section that was analyzed has water unsuitable for bathing in the first sample and suitable for bathing in the second sample.

8.2. Biotic Environment

The objective of the diagnosis is to describe the ecosystems in the areas covered by the development. Also, vegetation cover mapping and description, state of upkeep, and description of associated fauna. Special attention was given to the aquatic biotic in the River Chapecó hydrographic basin. Additionally, possible conservation units in the area covered by the project were surveyed.

The data herein regarding the indirect area of influence was based on the secondary survey data and observations in the municipal regions São Domingos and Ipuaçu. The diagnostic methodology in the area of direct influence was based on satellite imagery of the river Chapecó stretch, which covers the entire area previously defined as the project's area of direct influence.

In this image, verification points were selected on site, especially considering the density of vegetation. During the on site verification, the vegetation was described in terms of the size and state of regeneration according to CONAMA Resolution No. 04/1994 (Brasil, 1994). The identification of some tree specimens involved on site observation and research in the work of Lorenzi (2002).

For the description of fauna, secondary data was collected and on site we observed mastofauna, avifauna and herpofaun. In view of the difficulty obtaining visual material, especially of mastofauna animals, we looked for tracks, feces and dens which revealed the presence of certain species.

The river Chapecó's aquatic biotic was characterized based on secondary data and on interviews with residents along the river bank.

8.2.1. Terrestrial Biota

8.2.1.1. Flora

Indirect Influence Area

Originally, Chapecó River basin had a diverse phytogeography, with the following vegetation formations:

Mixed Ombrophile (Brasil, 1973), also called Araucaria Forest (Klein, 1 978; SUDESUL, 1978) or Mata de Pinhais (Lorenzi, 2002);

*Seasonal Deciduous Forest (*Brasil, 1 973), also called Subtropical forest (Klein, 1978), Uruguay Basin Forest (SUDESUL,1978) or Broadleaf Forest of Uruguay and Paraná river basins (Lorenzi, 2002), and;

Savannah, called fields (Klein, 1978; Lorenzi, 2002) or natural fields (SUDESUL, 1978).

The Mixed Rain Forest is located in the plateau that extends from Rio Grande do Sul to Paraná and in regions over 1,400 m in the other states (Lorenzi, 2002). It is limited to altitudes above 400 m (SUDESUL, 1978). It is located in places that are always wet, with 4 to 6 cold months and up to 6 hot months, whose annual average temperature reaches 20ºC.

Originally, a large part of the Santa Catarina plateau was covered by this vegetation formation. On the Chapecó river basin, it occupied mainly the North portion (Klein, 1978, SUDESUL, 1978).

In the Mixed Rain Forest, the superior stratus is dominated by Araucaria (*Araucaria angustifolia*), and in the sub-forest we can find the cinnamons (*Cryptocarya aschersoniana*, *Nectandra* sp., *Ocotea* sp.), pau-andrade (*Persea major*), cherry (*Eugenia involucrata*), araçazeiro (*Myrcianthes gigantea*), myrtle (*Blepharocalyx longipes*), camboatá-branco (*Piptocarpha augustifolia*), bracatinga (*Mimosa scabrella*), angico vermelho (*Parapiptadenia rigida*), cedar (*Cedrela fissilis*), tarumã (*Vitez megapotamica*), pessegueiro-brabo (*Prunus sellowi*), mate (*Ilex paraguariensis*), açoita-cavalo (*Luehea divaricata*), among others (Klein, 1 978).

The Seasonal Deciduous Forest follows the Uruguay river and its multiple tributaries, up to an altitude of 600 to 800 m (Klein, 1978). Xanxerê Indigenous Reserve holds the greatest remaining portion of the forest.

This vegetation formation presents three strata:

- Superior stratum, where the crowns of high trees are predominant (bigger than 25 m), emergent and discontinuous, and do not have winter leaves. They are grápia (*Apuleia leiocarpa)*, laurel (*cordia trichotoma*), canafístula (*Cássia multijuga*), angico vermelho (*Parapiptadenia rígida*), cedar (*Cedrela fissilis)*, among others;
- Second stratum: it is the densest part of the woods, with trees 20 to 25m, with perennial leaves. Cinammons basically forms this stratum;
- Small tree stratum, where trees between 6 and 15 m are predominant, such as laranjeirado-mato (*Actinostemon concolor*) and falsa-espinheira-santa (*Sorocea bonplandii*).

Savannah vegetation, locally called fields, grows at the border region between Santa Catarina and Paraná and at the springs of Chapecó and Chapecozinho rivers, in the shape of discontinued spots that spread into the Mixed Rain Forest formations. This vegetation is associated with the presence of flatlands (Cambisoils), generally at altitudes over 800m. According to Klein (1978), herbaceous groups formed by Grass, Cyperaceae, Composed, Leguminous, and Verbenaceae in “clean” fields are predominant. The presence of carqueja-do-campo and samambaias-das-taperas may also exist, which, among other species, will look like “dirty” fields.

In areas where the vegetation occurs, we find copses and riparian forests, which are respectively develop near the depressions (thalwegs) and on the river banks, resulting from more favorable water and pedologic conditions.

Currently, this original finding has been greatly modified. According to Klein (1978), the intense farming and stockbreeding in Santa Catarina, specially in the 60s has modified the State’s primary vegetation substantially. According to the same author, the Seasonal Deciduous Forest occupies lands resulting from the degradation and decomposition of basalt and melaphyre, which are well suited for agriculture. Because of this, since the beginning of the 20th Century, this woodland is being cut down in the rush to exploit the wood, especially to

to open up new lands for agriculture. The fields were changed because of rural activities and periodical fires.

In São Domingos there are vegetation area, isolated among farming areas where soy, beans and corn crops are predominant. The remaining areas are mostly in thalwegs or in other areas where the agricultural is not possible. This typical landscape can be observed in Figures 09 and 10.

Figure 09 – Typical landscape of forest remnants in the municipal region of São Domingos.

Figure 10 – Typical landscape of forest remnants in the municipal region of São Domingos.

Area of Direct Influence

Throughout the direct influence area, the soil is predominantly used for agriculture and reforestation. The most common crops are soybeans (*Glycine max*), corn (*Zea mays*) and beans (*Phaseolus vulgaris*). In the monocultures of reforestation, there are exotic species such as pines (*Pinus sp.*) and eucalyptus (*Eucalyptus sp.*), alongside the native araucaria (*Araucaria angustifolia*).

The original vegetation has changed and the environment is highly anthropized.

We only find remaining fragments of this type of vegetations when farming areas are interrupted by areas unsuitable for crops, like the sinuous line of a valley. In this situation, we can find coppices of vegetation isolated by the farmed areas that surround them. Another situation where a minimum of native vegetation was spared is on the banks of the Chapecó river, in the riparian forest. We can see that in the area of direct influence related to the development, a riparian forest that varies from two to, at most, 5m wide practically all along the river. This narrow riparian forest is at a mostly average stage of regeneration according to Brazil (1994).

Following this diagnosis, we can say that in the direct influence area there are at least four species which are on the Official List of Endangered Species of Brazilian Flora. They are: the xaxim (*Dicsonia sellowiana*); the araucaria (*Araucaria angustifolia*), classified as vulnerable; the cinnamon imbuia (*Ocotea porosa*), also classified as vulnerable; and the sassafras-cinnamon (*Ocotea pretiosa*), classified as endangered.

However, it is worth pointing out that in the locations where these species were found, the formations are secondary. Still, the araucarias are young individuals, presenting reduced DAPs and heights compared with the normal potential of the species.

Because of the great environmental diversity found in the direct influence area, we chose to describe each significant stretch separately. They are identified by letters and can be seen in Exhibit 14.

Stretch A

As we can see in Exhibit 14, Section A is an area widely used for agriculture. The native vegetation is the spared but narrow riparian forest and the small fragments where agriculture is not possible. However, in these locations we can still find exotic species.

The riparian vegetation in section A is 1m to, at most, 5m in width. It is secondary vegetation and the maximum height of the trees is of 20m, with eventual outlying individuals. The vegetation formation of this section is at a stage of regeneration between initial and average (Brazil, 1994). In Figure 11 we can see this structure.

Figure 1 1 – Vegetation structure in section A.

Arboreal examples of two vegetation formations characteristic of the mixed Ombrophila region and Decidual Seasonal Forest were found. The most common examples of trees found in section A are listed in Table 19.

Table 19 – Common vegetation species in section A.

Scientific name	Nome popular
Luehea divaricata	Açoita cavalo
Parapiptadenia rigida	Angico
Schinus sp.	Aroeira
Sebastiana commersoniana	Branquil ho
Cupania vernalis	Camboatá vermel ho
Casearia silvestris	Chá de Bugre
Solanum erianthum	Fumeiro bravo
Syagrus romanzoffiana	Gerivá
Trema micratha	Grandiuva
Fagara sp.	Mamica de cadela
Mimosa bimucronata	Maricá
Allophylus edulis	Olho de pomba

Not in the riparian forest, but in the surroundings, there are some araucarias (*Araucaria angustifolia*) planted in the properties adjacent to the river.

Throughout all the riparian forest there was presence of a bamboo species, popularly known as “taquara índia”. It’s a species from the Gramineae Family, with yellowish leaves. The origin of this species is in Asia and in the western region they have been planted by farmers in the riparian forests so that their roots would help hold up river banks. We also found *Swiss Cheese Plant* (*Monstera deliciosa*).

Some eucalyptus (*Eucalyptus sp.*) are also planted along the banks of the Chapecó river, as seen in Figure 12.

Figure 12 – Presence of eucalyptus exotic species (*Eucalyptus* sp.)

The flame vine (*Pyrostegia venusta)* was frequently found, conspicuous because of its blossom.

There has been interference in the riparian forest, probably carried out by the farmers, trying to prevent the forest from widening. In various spots there has trees adjacent to the crops have been pruned.

Section B

In Exhibit 14 you can see that section B is also highly agricultural and that the native vegetation is present in the remaining riparian forest and in fragments where agriculture is not possible, especially in thalwegs.

The riparian vegetation in section B is denser than in section A and also wider, varying from 3m to 5m in width, with some parts even wider. It is secondary vegetation and the maximum height of the trees is 20m, with eventual outlying individuals. The vegetation formation in this section presents characteristics of coverage regeneration (Brazil, 1994). In Figure 1 3 we can observe this structure. Note the presence of araucarias in this forest.

Figure 13 – Structure of section B. Extensive farming areas and riparian forest on the bank of the Chapecó river. In the background the denser vegetation characterizes section C.

The fragments of vegetation present in section B are dense, but not extensive (Figure 14). Some were visited and the arboreal specimens found don't characterize the vegetation formations in the region, there is a mixture of individuals from the Mixed Ombrophila and the Deciduous Seasonal Forest. The regeneration stage could be classified from initial to medium. The frequent arboreal individuals in the vegetation areas visited are listed on Chart 20.

Table 20 – Vegetation species common in section B, present in different fragments.

Scientific name	**Nome popular**
Luehea divaricata	Açoita cavalo
Parapiptadenia rigida	Angico
Araucaria angustifolia	Araucária
Schinus sp.	Aroeira
Cupania vernalis	Camboatá vermel ho
Ocotea sp.	Canela
Nectandra sp.	Canela
Sorocea bonplandii	Cincho
Syagrus romanzoffiana	Gerivá
Campomanesia xanthocarpa	Guabiroba
Actinostemon concolor	Laranjeira do mato
Fagara sp.	Mamica de cadela
Mimosa bimucronata	Maricá
Allophylus edulis	Olho de pomba
Podocarpus lamberti	Pinheiro-bravo
Eugenia uniflora	Pitangueira

Because of their position in the geography of the terrain, some fragments present a higher relative humidity, being able to present more characteristics of a Mixed Ombrophila formation, with the presence of *epiphytic bromeliads* (Figure 15).

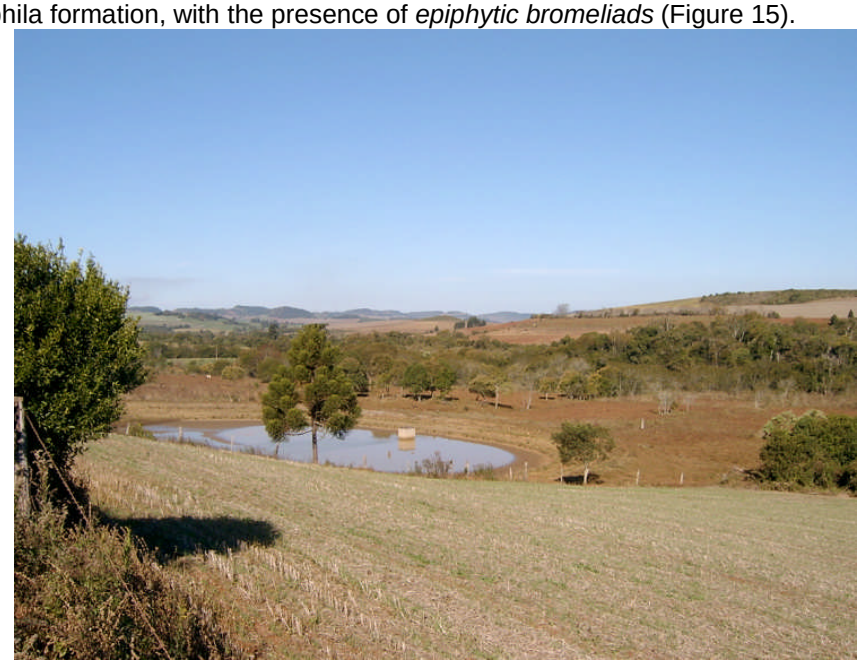


Figure 14 – Structure of vegetation areas present in section B.

Figure 15 – Fragment of vegetation in locations where there is greater humidity and vegetation has typical characteristics of Mixed Ombrophila. In the interior eventual presence of epiphytic bromeliads.

On the other hand, some fragments are totally decharacterized, presenting exotic species like the “taquara índia” (Graminae), as you can see on Figure 16.

Figure 16 – Fragment of vegetation decharacterized because of presence of exotic “taquara índia” species.

Section **C**

Based on the information from the satellite picture in Exhibit 14, and through on site verification, you can see that the left bank of section C maintains the same vegetation pattern as the description of section B: wide areas covered by crops and native vegetation present only in small fragments and in the riparian forest.

However, on the right bank of the Chapecó river, in section C, we can find an large remnant of the Mixed Ombrophila. It's secondary vegetation in an advanced stage of regeneration (Brazil, 1994), with trees of primary vegetation. The arboreal physiognomy is dominant, forming a closed canopy and relatively uniform in size, with outlying trees. In Figure 17 we get an idea of the size of the area as well as its physiognomy, from a picture taken at a distance.

Figure 17 – Physionomy of strecth C on the right bank of the Chapecó river. Presence of large remnantsof Mixed Ombrophila.

In this forest we find a great diversity of arboreal species, among them we can include those in Table 21.

Table 21 – Arboreal vegetation present in section C.

Scientific name	Nome popular
Luehea divaricata	Açoita cavalo
Parapiptadenia rigida	Angico
Psidium cattleianum.	Araçá
Araucaria angustifolia	Araucária
Schinus sp.	Aroeira
Mimosa scabrella	Bracatinga

Cupania vernalis	Camboatá vermelho
Ocotea sp.	Canela
Nectandra sp.	Canela
Cedrela fisslis	Cedro
Sorocea bonplandii	Cincho
Syagrus romanzoffiana	Gerivá
Apuleia leiocarpa	Grápia
Campomanesia xanthocarpa	Guabiroba
Myrciaria cauliflora	Jaboticabeira
Actinostemon concolor	Laranjeira do mato
Fagara sp.	Mamica de cadela
Mimosa bimucronata	Maricá
Allophylus edulis	Olho de pomba
Prunus sellowii	Pessegueiro-do-mato
Podocarpus lamberti	Pinheiro-bravo
Eugenia uniflora	Pitangueira
Miconia sp.	Pixiricão
Vitex megapotamica	Tarumã
Ateleia glazioveana	Timbó

However, we need to register the species like the xaxins (*Dicksonia sellowiana*) and (*Cyathea sp.*), wild mulberry (*Rubus rosae*), the presence of native bamboo groves and various ferns in the sub-woods as well as some epiphyte pteridophyt (*Microgramma sp*.)

In Figure 18, we sought to illustrate a little of the inside of the forest, the environments that exist in them, as well as a view of the typical stratification of the Mixed Ombrophila. Part 'A' of Figure 18 shows the estuary of the Bonito river that passes through the remains of the forest, flowing into the Chapecó river. Part 'B' shows the size of the araucaria present in the remnants. In part 'C' you can see the xaxins found in various parts of the forest. And, finally, in part 'D', you can see in the right corner of the picture, a section of the forest in section C, being seen from a meander upstream on the Chapecó river. We can clearly see the presence of araucarias in the upper canopies.

In spite of being well preserved, the remnants suffer from human intervention in various ways. There are trails in the forest, some of which are used by motorcycles. There are marks of bonfires and camping, including the presence of solid waste on the ground. Additionally, there are araucarias cut down and xaxins knocked down (Figure 19).

Figure 18 – Large fragment of forest in section C.

Figure 19 – Anthropic presence in forest remnants. Felled xaxins and cut araucaria.

Section **D**

Accompanying Exhibit 14, on the right bank of section D there is a big reforestation area of pines (*Pinus sp*.), as you can see in Figure 20. This image was obtained from the left-bank of the Chapecó river.

Figure 20 – Reforestation in Section D.

However, there is a preservation of a native forest along the banks of the Chapecó river, throughout the reforestation area. This riparian forest is narrow (5m at most) and presents vegetation at a a medium stage of regeneration. There is the presence of a few eucalyptus among the planted pines. Also, we registered the presence of native maritime pine (*Podocarpus lamberti*) growing within the reforested pines (Figure 21).

Figura 21 - Pinheiro-bravo (*Podocarpus lamberti*) no interior do reflorestamento de *Pinus* sp..

This area of reforestation, near the mouth of the Bonito river, is used for get-togethers, using the area for leisure. However, we found no evidence of environmental maintenance by those who uses the area. There is garbage on the ground, a barbecue and a cesspit.

On the left bank, there is a riparian forest not well preserved, without sub-woods, especially because there is also intensive use of the area for leisure (fishing and spa). However, you can still find relevant arboreal species. The list of species found in the left bank of section D is in Table 22.

Table 22 – List of arboreal species found on the left bank of section D.

Scientific name	Nome popular
Luehea divaricata	Açoita cavalo
Schinus sp.	Aroeira
Ocotea sp.	Canela
Nectandra sp.	Canela
Cedrela fisslis	Cedro
Syagrus romanzoffiana	Gerivá
Mimosa bimucronata	Maricá
Podocarpus lamberti	Pinheiro-bravo
Ateleia glazioveana	Timbó

In this area, there are some epiphyte plants like cactus (*Ripsalis* sp.) and bromelias (*Tilandsia* sp.). In Figure 22 you can see the structure on site, with the presence of ranches. You can notice the absence of sub-woods and substantial anthropization.

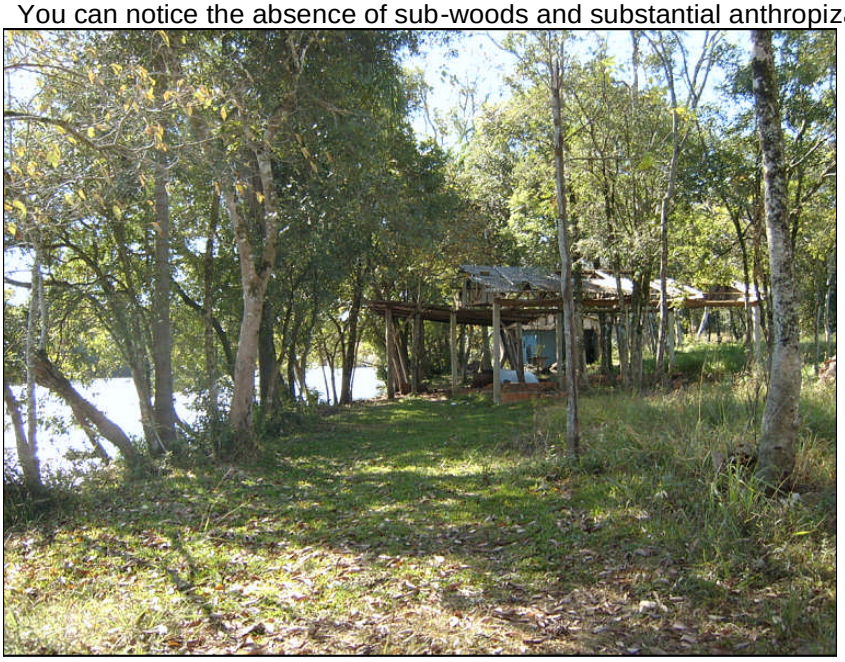


Figure 22 – View of the left bank of the Chapecó river in section D.

Section **E**

This region in the direct influence area has three important regions of reforestation. The region in Exhibit 14 identified as 'E.a' is reforestation of araucaria (*Araucaria angustifaliaI),* probably with the proper registrations subsequent wood-cutting. As for the area identified as 'E.b', this is reforestation with pines (*Pinus* sp.) and, finally, the area identified as 'E.c' is reforestation with eucalyptus (*Eucalyptus* sp.).

The other areas of section E make up a mixed zone, where there are properties, small areas of reforestation, intense presence of exotic trees, which are there because of their proximity to the reforestation areas. The existing native vegetation again is limited to isolated areas and to vegetation from the riparian forest. This structure can be observed in Figure 23, noting that sometimes there is no riparian forest.

Figure 23 – Structure of vegetation in mixed zone of section E.

The existing species in the copses can reach a height of up to 20m. However, there are no sub-woods and the existing species seem to have been spared from deforestation. The species that were found in these structures are listed in Table 23.

Table 23 – List of species found in section E, in clumps and riparian forest.

Scientific name	Nome popular
Luehea divaricata	Açoita cavalo
Psidium cattleianum.	Araçá
Araucaria angustifolia	Araucária
Cedrela fisslis	Cedro
Casearia silvestris	Chá de bugre
Sorocea bonplandii	Cincho
Syagrus romanzoffiana	Gerivá
Myrciaria cauliflora	Jaboticabeira
Actinostemon concolor	Laranjeira do mato
Fagara sp.	Mamica de cadela
Mimosa bimucronata	Maricá
Eugenia uniflora	Pitangueira
Ateleia glazioveana	Timbó

Of all the sections analyzed, this is the one that is most anthropized because of the monocultures for reforestation and the family properties near the river.

Section **F**

As you can see in Exhibit 14, section 'F' presents two important fragments of vegetation, identified as 'F.a' and 'F.b'. However, these fragments were not described in much detail, despite being in a direct influence area,

and will suffer reduced impact for being further upstream from the SHS dam.

The fragment identified as 'F.a' is dense, the trees present heights of over 20m. The arboreal physiognomy is dominant, forming a closed canopy and relatively uniform size. The structure presents an advanced stage of regeneration (Brazil, 1994), with a physiognomy similar to primary vegetation. The structure described as Deciduous Seasonal Forest, contains grapia (*Apuleia leiocarpa*), angico vermelho (*Parapiptadenia rigida*) and cedar (*Cedrela fissilis*) (Figure 24).

Figure 24 - View of fragment 'F.a' in advanced regeneration stage.

The fragment identified as 'F.b' is also dense, the trees present heights of about 15m and there are some emergent individuals, such as the araucarias (*Araucaria angustifolia*). The structure presents an advanced stage of regeneration (Brazil, 1994), with a physiognomy similar to primary vegetation as the arboreal species are dominant, forming a closed and relatively uniform canopy and size. The structure is described as Mixed Ombrophila (Figure 25) in general terms. However, this fragment contains an affluent of the Chapecó river. In the valley where it is located, the abiotic conditions are beneficial for a typical formation of riparian forest, with the intense presence of maricas (*Mimosa bimucronata*).

Figure 25 – Aspect of fragment 'F.b' at an advanced regeneration stage.

The other zones of section F are family properties, with homes and small farms. Again there are isolated copses and a narrow riparian forest.

2.1.1.2. Fauna

Area of Indirect Influence

Mastofauna

Regarding the associated fauna, the Mixed Ombrophila formations and the Seasonal Deciduous Forest, Cherem's (2005) work presents the results of the survey of non-flying **mammals** in seven environmental studies carried out in the south of Brazil, two of which were in areas whose the original formation is Mixed Ombrophila and other two whose original formation is Seasonal Deciduous Forest and Mixed Ombrophila. One of the areas in this study is located in the city of Chapecó.

The results revealed the presence of 46 species of non-flying mammals, which are listed below by family, scientific and popular name.

Table 24 – Mammals species in the area of indirect influence.

Family - Species	Popular name
Didelphidae	
Didelphis albiventris	gambá
Didelphis aurita	gambá
Didelphis sp.	gambá
Micoureus paraguayanus	cuíca
Monodelphis sp.	cuíca
Philander frenata	cu íca-verdadeira
Dasypodidae	

Cabassous tatouay	tatu-de-rabo-mole
Euphractus sexcinctus	tatu-de-dente
Dasypus novemcinctus	tatu-gal inha
Dasypus sp.	tatu
Euphractus sexcinctus	tatu-peba
Myrmecophagidae	
Tamandua tetradactyla	tamaduá
Cebidae	
Alouatta guariba	bugio
Cebus nigritus	macaco-prego
Canidae	
Cerdocyon thous	graxaim
Fel idae	
Leopardus tigrinus	jaguatirica
Herpailurus yagouaroundi	gato-mourisco
Leopardus pardalis	jaguatiricona
Puma concolor	puma, leão, leão-baio
Mustelidae	
Lontra longicaudis	lontra
Conepatus chinga	zorrilho
Eira barbara	i rara
Galictis sp.	furão
Pteronura brasiliensis	ariranha
Procyonidae	
Procyon cancrivorus	mão pelada
Nasua nasua	quati
Cervidae	
Mazama sp.	veado-mateiro
Leporidae	
Lepus europaeus	lebre
Sciuridae	
Sciurus aestuans	caxinguelê
Muridae	
Akodon sp.	ratos, ratazanas, camundongos
Delomys dorsalis	
Juliomys sp.	
Nectomys squamipes	
Oligoryzomys sp.	
Oryzomys angouya	
Oryzomys russatus	
Oxymycterus judex	
Erethizontidae	
Sphiggurus villosus	ou riço-cacheiro
Cavi idae	
Cavia aperea	preá
Cavia fulgida	preá
Cavia magna	preá
Cavia sp.	preá
Hydrochoeridae	
Hydrochaeris hydrochaeris	capivara
Dasyproctidae	

Dasyprocta azarae	cutia
Myocastoridae	
Myocastor coypus	ratão-do-banhado

The Chiroptera Order, not included in this study, is certainly present in the influence area of the project, with representatives of the Noctilionidae, Phyllostomidae, Vespertilionidae and Molossidae Families. They are bats, mammals that have acquired the capacity to fly. They have nocturnal or twilight habits. They can be at different levels of the food chain, because their feeding habits place them as: frugivores, nectivores, piscivores, omnivores and insectivores.

Furthermore, Rocha-Mendes *et al.* (2005), in another survey in an area of Seasonal Forest, mention the occurrence of the tamandua-bandeira (*Tamandua tridactyla*), bugio (*Alouatta guariba*), cuíca (*Chironectes minimus*) and tapir (*Tapirus terrestris*).

Works like that of Rocha-Mendes *et al.* (2005) and Cherem (2005) prove that inspite of the strong anthropization, remaining populations of mastofauna are still present in Santa Catarina and they sample the fauna that existed in the past on the vegetation formations of Mixed Ombrophila and Deciduous Seasonal Forest.

In observation of the area of indirect influence, we found three graxains (*Cerdocyon thous*) which had been run over a few meters from one another (Figure 26) and of two skunks (*Didelphis* sp.).

Figure 26 – Crab Eating Fox (*Cerdocyon thous*) found run over on the road of SãoDomingos/SC.

Despite these observations that indicate the presence of mastofauna, today, big mammals are rare in the hydrographic bay of the Chapecó river or are extinct in this region.