

# River diversion and hydropower plants: The unknown Ribeira Valley (states of Paraná and São Paulo)

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## “Ribeira” and its partial and idealized images

THE BASIN of the Ribeira de Iguape River extends from the ridge of the Paranapiacaba Mountain Range to the southern tip of the state of São Paulo (SP) and from the Serra do Mar Mountain Range in Paraná to the east border of this state, including some of the municipalities in the metropolitan region of Curitiba. The Ribeira River, which was one of the first access routes of European settlers into the Brazilian hinterland, houses secular cities along its banks such as Iguape, at the river mouth, and Iporanga, in the middle section. Its banks and tributaries have been mined for gold and precious metals since the 17<sup>th</sup> century and, not by chance, between these two cities lies another one called Eldorado, an iconic name and toponymy of different locations in South America. During the pioneering period, when indigenous people were the only inhabitants, groups of African and Afro-descendent slaves came into the valley or fled there later, giving rise to some of the current rural communities of descendants of runaway slaves (Quilombolas) established between these cities.

Until a few years ago, silver and gold were obtained as a byproduct of lead ore, which for decades was exploited in mines close to the Ribeira River between Cerro Azul and Adrianópolis in the state of Paraná (PR), as well as in the surroundings of the São Paulo side of the Betari River. Even today, mineral resources are highly exploited in some parts of the territory, particularly limestone in the region of Apiaí (SP) (mining and cement plant of the Camargo Correa group) and along the opposite ridge on the Paraná side, in Rio Branco do Sul and Campo Largo, in the metropolitan region of Curitiba, one of the country's largest lime and cement centers (cement plant of the Votorantim group). Phosphate rocks are also mined and processed for manufacturing NPK fertilizers in the region of Cajati (SP), whose brand Serrana belongs to the multinational group Bunge (Bitar, 1990).

The original vegetation cover (Atlantic Forest) of these “Serra do Mar” mountain ranges has not yet been significantly destroyed in the coastal part, what unfortunately has happened in the hinterland part (in the territory of the Sorocaba and Paranapanema river basins). In the early 2010s, Atlantic Forest deforestation fronts were found in the municipality of Taparái (SP) in the Juquiá sub-basin, with the subsequent charcoal production from pau-flor or manacá-da-serra trees and from the eucalyptus plantations. Additionally, eucalyptus and pine trees spread quickly over the highlands of Paranapiacaba, and particularly on the Paraná plateau (e.g. in the municipalities of Tunas do Paraná and Jaguariaíva), to feed the burgeoning wooden product industry and the expansion of pulp production in that state.

In the São Paulo section of the Ribeira Basin and adjacent areas, different state Conservation Units were defined: “Intervales” Park in the interfluvium between the Ribeira and Paranapanema Basins; “Petar” in the cave region between Apiaí and Iporanga; “PEJ”, located further below, around the municipality of Jacupiranga; and an extensive Environmental Protection Area (EPA) of Serra do Mar mountain range, with nearly 5,000 square kilometers, stretching from close to the metropolitan region of São Paulo to near the border with Paraná. The harvest of Juçara palm heart on the lower slopes and piedmont in both states was a major source of income in past decades and, while this practice does not lead to massive deforestation, it is being strongly opposed by environmental enforcement agencies and promptly replaced by palm tree plantations (e.g. close to Juquiá (SP)). Two plant products symbolize the region’s rural economy: banana, with plantations stretching for more than 100 hectares from the foothills of the mountain ranges to the banks of the Juquiá and Ribeira de Iguape rivers (e.g. in Sete Barras and Eldorado), and tea, with the country’s largest production center located in the largest city in the valley, Registro, at the intersection of the Ribeira River and the Regis Bittencourt Highway – though tea has also been planted and processed in the upper part of the municipality of Tapiraí (SP). In other riparian niches and lower hills, tomato, other vegetables and fruits such as passion fruit and orange are also planted for commercial purposes – for example, in the municipality of Cerro Azul (PR), which holds an annual orange festival.

In the lower Ribeira and particularly in the lower Juquiá, sand ports have proliferated since the 1970s and 1980s and are still in operation, supplying the construction industry on the south coast and in the metropolitan region of São Paulo. In the coastal lowlands, a part of the wider estuarine system extends from the Iguape region, where it borders the Jureia-Itatins Ecological Station, all the way southeast to the city of Cananeia, where it edges Ilha do Cardoso State Park, which is still in good natural condition and thus allows for traditional local populations to engage in fish and seafood production. However, several sections of these wide lowlands are covered with banana plantations (e.g. along the São Lourenço River Valley (SP)), while others (e.g. close to the municipality

of Pariquera-Açu) have been deforested and cleared for the production of peat used as fuel in the phosphate industry in Cajati.

The territory of this river basin is part of the road network of the two states and crossed from northeast to southwest by the Regis Bittencourt Highway, known as BR-116, a road of national significance. An old route that links São Paulo to Curitiba, passing through Itapetininga, Apiaí, Ribeira, Adrianópolis and Tunas do Paraná, has been paved and carries heavy cargo truck traffic. In São Paulo, an old connecting route between Juruá and Sorocaba is being used that goes up the Paranapiacaba Mountain Range through Tapiraí and Piedade. In Paraná, the road linking Curitiba to Cerro Azul was only paved in 2006. On the São Paulo side of the Ribeira de Iguape River basin, a single paved road links the riverside cities of Registro, Eldorado and Iporanga, going all the way up through the Betari River Valley to the city of Apiaí.

In the case of Ribeira de Iguape, while it is true that the main river has not yet been affected by the construction of large dams, it was once affected by a large hydraulic project that led to a serious fluvial and economic problem. At its end, after flowing for almost 500 kilometers, the river's natural embouchure into the Atlantic Ocean in the municipality of Iguape (SP), in a place called Barra do Ribeira. However, since the construction of the Valo Grande channel in 1825, a significant part of the water flow is diverted into the Pequeno Sea, between the mainland and the Comprida Island (Bitar, 1990).

While the main river has not yet been dammed, twelve power plants with a total capacity of almost 540 MW are operating on other rivers in the same basin, most of them on the Juruá River (SP), its largest tributary. Over half of this installed capacity belongs to a single company, the Brazilian Aluminum Company (CBA), owned by the Votorantim group, whose electricity is transmitted exclusively to this factory located close to Sorocaba (SP).

The most powerful among all power plants that use river water of the Ribeira basin was built by the Paraná state electricity utility (COPEL), whose dam is located on the Paraná plateau on the Capivari River (tributary of the Pardo River, which is a tributary of Ribeira), while its 260-MW powerhouse lies on the bank of the Cachoeira River in the coastal lowland of Paraná – the third largest river deviation project among the four existing ones on this same “wall” of mountain ranges (Figure 1). This issue will be discussed in this article.

This brief overview of the Ribeira de Iguape River Basin is not meant to give a complete account of its social, economic and geographic conditions, as it derives from a partial point of view, i.e., from the analysis of a number of partial and specific studies by different researches on different aspects of the region and its problems. It also results from recent visits by the authors of this paper to some parts of the region. In this case, the main motivation was to figure out what would be the physical and social consequences if the four medium-sized power plants were built on the Ribeira River basin (Sevá Filho et al., 2007).

As part of this activity, we had to create a realistic picture of the region, but we were faced with some widespread conflicting views on the “Ribeira Valley”. On the one hand, for example, it was portrayed as a miserable, old Valley, the “poor cousin” of the rich Southeast Region. On the other hand, some people strongly defended it as a Valley full of caves and preserved forest, a Valley housing Quilombola rural communities (from the revolted negro slaves who re-joined the “quilombos”) and indigenous villages, both remnants of groups that were much more numerous in the past and that survived slavery and extermination. There is also the sometimes romanticized view of the Valley as portrayed by fishermen and shellfish gatherers, the “traditional peoples”. From this point of view, the region is to be preserved and protected not only by governmental agencies, but also by entrepreneurs involved in adventure tourism, cave visits and river sports such as *rafting*. Accordingly, some local advocacy NGOs and other larger socio-environmental NGOs such as the influential Socio-Environmental Institute (ISA), which is based in São Paulo and has an operating office in Eldorado (SP) established many years ago, as well as other NGOs headquartered in Curitiba or in small cities like Pariqueira-Açu and Cananeia (SP) and Cerro Azul (PR), have shifted their focus to the Valley. In addition, a program for university extension activities was implemented by the State University of Campinas (Unicamp), with the specific aim of strengthening Quilombola communities.

Also in this research stage, we faced methodological limitations, as many sources are based on a wrong assumption: they treat the Valley as if it belonged to São Paulo only. The Paraná part is often forgotten or left out, resulting in mutilated maps and lowering the chances of correctly matching reliable data on the whole basin. In some cases, the Valley’s geographic scale also includes coastal preservation areas extending from Jureia to the Cardoso Island, while in others its geographic bounds are pushed even further down to the south coast, encompassing the Mel Island and even the Superagui National Park and the Antonina and Paranaguá bay complex in Paraná.

Meanwhile, also in Paraná, the so-called “developed center” is located in the land of the Iguapé basins – such as in the capital Curitiba and some municipalities in its metropolitan region, and in the city of Tibagi – and defines an inland route from Ponta Grossa to Londrina and upstate. In any case, this “center” faces away from the Ribeira Valley and almost all citizens in the metropolitan region of Curitiba and users of the BR-116 highway are probably not even aware that the Capivari–Cachoeira dam is located on a river in the Ribeira basin.

### **The over-dammed Ribeira Basin rivers**

The land drained by the Ribeira de Iguapé River Basin extends over an area of approximately 25,000 square kilometers, 7,800 sq. km. of which in the state of Paraná and 17,000 sq. km. in the state of São Paulo. From the foothills of the Paranapiacaba Mountain Range in Paraná flow the Lajeado and Itapir-

apuã rivers, the left-bank tributaries of the Upper Ribeira.

Flowing from this ridge on the first Paraná plateau to the metropolitan region of Curitiba are the right-bank tributaries: the Santana and Açungui rivers, considered the sources of Ribeira de Iguape, the Ponta Grossa River, which crosses the city of Cerro Azul. There is also the Rocha River, which drains the waters from a karst region between Cerro Azul and Adrianópolis, where lead ore was mined in the past, and then the Grande and São Sebastião rivers (ADVR, 2002). Among other smaller rivers, special mention should be made of the Capivari River, where the Capivari–Cachoeira dam was built on the first plateau. From this dam, the natural flow of the Capivari River branches off: 1) a large part flows through a tunnel system under the Serra do Mar Mountain Range into the Cachoeira River, which finishes into the Antonina Bay in the Paraná coast, and 2) the second flow, when “left over” from the dam’s hydroelectric operations, follows the natural course of the Capivari River all the way down close to the Régis Bittencourt Highway, and then joins the largest right-bank tributary of the Ribeira de Iguape River, the Pardo River, which runs through the city of Barra do Turvo (SP).

From the coastal areas of Paranapiacaba and the southern recesses of Serra do Mar in São Paulo flow dozens of left-bank tributaries of the Ribeira de Iguape River, such as the Tijuco and Catas Altas rivers, which flow close to the cities of Apiaí and Ribeira (SP), and the Betari River, which flows above the city of Iporanga (SP) and is currently more geared toward tourism, though a few decades ago it was exploited for lead ore to feed the Cobrac/Plumbum industry in Adrianópolis (PR). The already mentioned Juquiá River is the largest tributary, a sister river of the Ribeira de Iguape. Further east, across the Régis Bittencourt Highway, the São Lourenço and São Lourenzinho also stand out, as they flow down and thicken the Ribeira de Iguape River in its estuarine section.



\* Figure 1 – Location of the Capivari-Cachoeira System in the Serra do Mar Mountain Range and the Paraná Coast. (Prepared by A. O. Sevá Fo. from a Google Earth image)

The known fact is that all of these sources of the Juquiá and Ribeira Rivers flow down quickly from the Paranapiacaba and Serras do Mar Mountain Ranges through many falls, waterfalls, *canyons* and rapids, a condition considered necessary in the initial phase of hydroelectric capitalism (early to mid 20<sup>th</sup> century) for the successive “utilization” of these waters through dams and power plants.

The river is full of turns and its waterfalls, one of its main characteristics, become a commodity. It is not specifically about the “altimetric accident”, the term used then, but rather about the ability to produce energy from the conversion of hydraulic power generated by moving water. In any case, one of the river’s natural features was beginning to take on an unprecedented meaning. The rivers would now be exploited to identify favourable sites to produce electricity (Aruda, 2008).

Based on the official information available, twelve power plants (still in operation, according to 2005-2009 sources) were installed on the rivers of this basin in the 1947-1989 period, two in the state of Paraná and the other in the state of São Paulo, almost all of them in the sub-basin of the Juquiá River.<sup>2</sup> Not to mention the small power plants that drove the life of farms, villages and even cities, and then, as in many mountainous regions in Brazil, were abandoned and even scrapped – such as the one that supplied the city of Eldorado with electricity for decades, built on a tributary of the Ribeira River a few miles from the municipal government seat.

The oldest of these power plants, which is still operating today, is the 7.2-MW Jurupará, built on the Peixe River in the municipality of Piedade by the Brazilian Aluminum Company. A 0.4-MW power plant called Piedade was later built on the same river and is currently operated by the company Faixa Azul Ind. de Móveis para Escritório Ltda.

The Brazilian Aluminum Company also built six more hydropower plants on the Juquiá River. Describing them in the counter-flow direction, from downstream to upstream, the first one is the 40.4-MW Barra Power Plant, built in 1986 in the municipality of Tapiraí; then there is the 24-MW Serraria Power Plant in the municipality of Juquiá, which began to operate in 1978; next comes Alecrim, the plant with the highest capacity (72 MW), built in 1970 in the municipality of Miracatu; further upstream we find the 28.4-MW Porto Raso Power Plant, established in 1982 also in the municipality of Tapiraí, and two plants in the upper portion of the river, close to the metropolitan region of São Paulo and to the BR-116 Highway: the 36.4-MW Fumaça Power Plant, completed in 1964 in Ibiúna, and the França Power Plant in Jucituba, which has a capacity of 29.5 MW and was the first to be built on this river, completed in 1958. In the municipality of Juquiá, the Brazilian Aluminum Company dammed the tributary Açungui River to build another 36.9-MW power plant, known as Salto do Iporanga, which was inaugurated in 1989 and is the newest of all these plants, thus totaling almost 268 MW installed in this sub-basin. Also in the state of São Paulo, the 4-MW Catas Altas Power Plant began operations in 1963 on a river by the same name, close to a highway connecting the cities of Apiaí and Ribeira, and is currently operated by Orsa, a business group in the pulp and paper industry. On the Paraná side of the basin, the 1.5-MW Santa Cruz Power Plant was built on the Tacaniça River in the Municipality of Rio Branco do Sul by the company Cimentos Rio Branco S/A, also owned by the Votorantim Group and established in the same city.

The largest of all of these hydroelectric projects in this basin, herein referred to as “Capivari–Cachoeira System”, began to be built in 1963 by COPEL, a Paraná state company. The powerhouse is located in the coastal lowlands of the municipality of Antonina and has a current installed capacity of 260 MW. It was later renamed “Governor Parigot de Souza Power Plant” in honor of a former governor of Paraná, and will be analyzed in greater detail in this paper.

### **River diversions from the plateau to the coast through the Serra do Mar Mountain Range**

The Serra do Mar Mountain Range, a wall with an average height of 1,000 meters that falls all the way down to the ocean coast of Santa Catarina, Paraná, São Paulo and Rio de Janeiro, aroused the creative greed of engineers in the early 20<sup>th</sup> century for a clear reason: if the waters of the rivers originating there in the countryside region, flowing to the West hinterland, could be diverted into the coastal area, the highest waterfalls in the world would be then artificially created and used to generate electricity. Indeed, this was done in an almost unrivalled

capitalist impulse that laid the actual foundations for urban-industrial development in the two largest Brazilian cities: the “Billings–Cubatão” system for São Paulo, and the “Piraí–Lajes” system for Rio de Janeiro.<sup>3</sup> Although they share the same impressive engineering scale, these two systems differ in terms of geography:

1) The Billings–Cubatão system began to be built in the 1920s and was completed in 1950 by the renowned Canadian company Light SP. It takes the waters of the Upper Tietê River and its tributary Grande Pinheiros and uses several dams equipped with gates and hydraulic pumps to reverse their flow toward the ridge of Serra do Mar and pour the diverted flow all the way down the mountains, a fall of more than 700 meters. The flow of up to 100 m<sup>3</sup>/s is conducted through surface and underground aqueducts to feed two power plants (old and new “Henry Borden”), with a combined installed capacity of 880 MW. After going through the turbines, the water flows down through tailraces to the Cubatão River in the coastal lowlands, and is also used strategically by industries in the so-called Cubatão industrial pole and to supply the Santos metropolitan region;

2) The Piraí–Lajes system was built in the same historical period by the same capitalist group, currently known as Light Rio, and diverts the waters of the Middle Paraíba do Sul River and of its great tributary Piraí – which rises high in the Serra da Bocaina Mountain Range – through the mountains into the coastal basin. The system is currently made up of six plants, four of which generating plants, one in the Paraíba do Sul River close to the city of Barra do Piraí (Pombos Island), two in Ribeirão das Lajes (Fonte Nova and Pereira Santos), and one in the Piraí–Paraíba detour (Nilo Peçanha). There are also two large pumping stations (Santa Cecília, on the Paraíba River close to the city of Rezende, and Vigário, in the Piraí–Paraíba detour) and a wide range of reservoirs high in the Bocaina and Araras mountain ranges, with several dams, dikes and tunnels. The total installed generation capacity in the Piraí–Lajes System amounts to approximately 850 MW, with a pumping power to reverse the flows of over 120 MW.<sup>4</sup> The flow diverted from the Paraíba do Sul River and its tributary Piraí can reach up to 190 m<sup>3</sup>/s and, after going several times through the turbines, is poured into Guandu, a river located in the coastal lowlands that empties into Sepetiba Bay. The Guandu River, in turn, is used by the state water company CEDAE for drinking-water supply in the metropolitan region of Rio de Janeiro.

### **Flow diversion to the Antonina Bay: unresolved environmental problems**

The economic progress brought about by electrification was a catchphrase repeated all over the world in the first decades of the 20<sup>th</sup> century, with a special impact on the state of Paraná, precisely because of its many areas that could be potentially used for hydroelectric generation, some of which on a large scale. This strategy would materialize later in the second half of the century, with the construction of mega power plants on the Iguaçu and Paranapanema Rivers and of the most powerful power plant in Brazil and South America, Itaipu, on the



Paraná River. Regarding the Serra do Mar Mountain Range and the possibility to divert flows to the coast, the idea of the Capivari–Cachoeira System came to light shortly after major similar works were carried out by Light in São Paulo and Rio de Janeiro. As early as 1948, the same year as the creation of the Water and Electricity Department, owned by state company COPEL, the then governor of Paraná, Moyses Lupion, made the following statement: “With the aim of addressing electricity shortages in the first [coastal] system, the state plans to use the hydroelectric system in the Capivari-Cachoeira basins, with an installed capacity in excess of 250,000 HP, in the municipality of Antonina” (apud Arruda, 2008).

Twenty-two years later, in the late 1970s, this plan was put into practice: with over 250 MW, it was the most powerful power plant in the state then, supplying electricity to the capital, Curitiba, which for decades faced difficulties resulting from an irregular supply and from several blackouts in the period during which the CFLP utility, owned by the American Foreign Power Company (AMFORP), was in charge. The dam is located on the “First Paraná Plateau”, 830 meters above sea level, and a significant part of the natural flow of the dammed-up Capivari river runs through a 14 km-long horizontal underground tunnel that cuts through the rocky heart of Serra do Mar and ends in a concrete penstock more than one kilometer long, with a steel-shielded final half feeding an underground powerhouse that is described below (Figure 2)

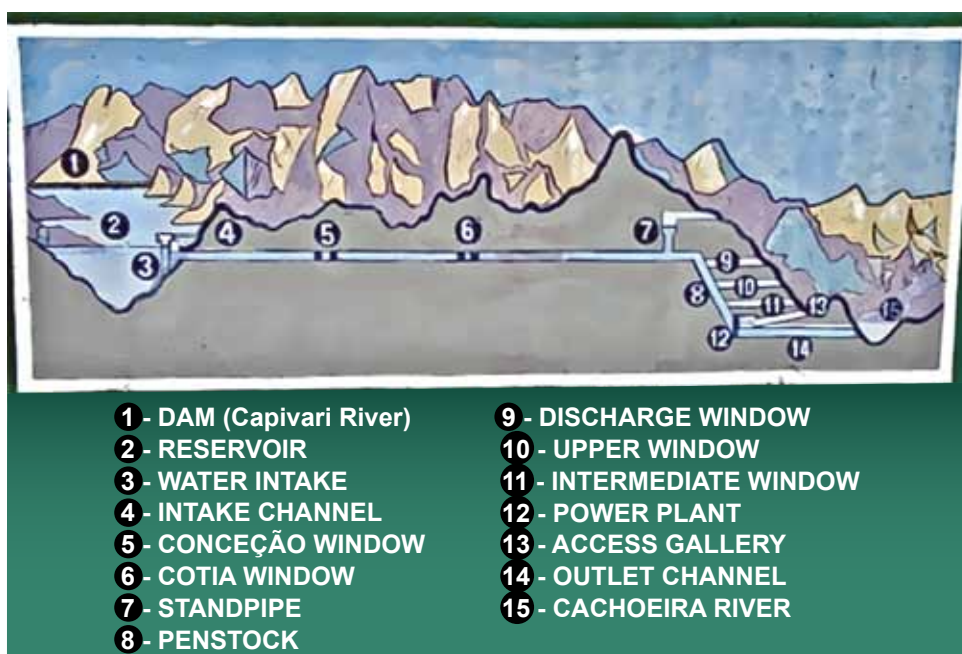


Figure 2 – Painted panel of a cross section of the Capivari–Cachoeira System (photo by Luciana Maria Kalinowski within a COPEL facility, Paraná, July 24, 2009).

The vertical difference is thus of approximately 740 meters (similar to that in the Billings–Cubatão system) and the original generating capacity was

increased to 260 MW in 1999. An additional 7 km stretch was excavated in the rocks beyond the water intake tunnel: two “windows” or vents were opened in it that reach up to the surface of the mountain range. Other secondary tunnels were excavated in the stretch where the penstock is located: one for installing the standpipe (meant to reduce the overpressure effects in the tunnels), one for installing the safety butterfly valve (automatically stops the water flow in case of emergency), and three other “windows”.

Among the several difficulties faced during the construction of the power plant, special mention should be made of violent decompression phenomena, resulting generally from dynamite explosions, which in some cases led to a sudden rupture and shattering of the rocks on the excavation walls and even to the collapse of large sections of open tunnels.<sup>6</sup> During our survey, we did not have access to the records of victims of these work-related accidents, but photos from back then show very poor working conditions. It is known that the health and safety at work standards were less stringent and comprehensive than today. Both Personal Protective Equipment (PPE) and Collective Protection Equipment (CPE) were generally not used. Because of the extreme heat and the poor and/or non-existent ventilation in the tunnels, workers used to wear only shorts, boots and inadequate helmets (Eletrocap, 1967).

On a visible wall in the pedestrian access to the underground power plant, the engraved phrase confirms the loss of human lives with the following words:

*“On this bronze plate nailed to the rock that embraces in its fold this powerhouse, we pledge our debt of gratitude to the anonymous heroes we miss, who lost their lives working in an idealistic and selfless manner for the development of Paraná and Brazil. COPEL – January 26, 1971”.*

The powerhouse lies in the heart of the Serra do Mar Mountain Range: there are three adjoining caves, the largest of which is 82-meter long, 15-meter wide and 25-meter high, housing the four turbo-generator groups of 65 MW each and the control room. The gallery enabling the access of pedestrians and materials to the caves is 1,100 meters long and 6.4 meters wide, through which run the high voltage cables that carry energy from the three-phase transformers of 70 MVA each (13.8 kV to 230 kV) to the substation. Four transmission lines connected to COPEL’s interconnected system (2000) run from this gallery: two to Curitiba and two to the coastal cities.

After going through the turbines and falling more than 700 meters, the water – coming from the Capivari River in the Ribeira de Iguape Basin – flows through a 2,230-meter long tailrace (mostly underground, but runs in open air in the last 500 meters) until it finally empties into the right bank of the Cachoeira River, which also rises in the Serra do Mar Mountain Range, but in its coastal part, and flows into the Antonina Bay, connected to the ocean through the Paranaguá Bay. In an area close to this powerhouse, which was also expropriated by COPEL, a residential village was built with forty-seven houses, fifteen

of which for employees of the state company, thirteen for outsourced employees, three for the Parents and Teachers Association of the Hiram Rolim State School, eight for a transit hotel, and seven are empty, apart from a club. The school in the workers' village was assigned to the State Education Secretariat (SEED) through a Technical Cooperation Agreement (COPEL, 2000).

*In the Capivari River reservoir, the usual impacts, in addition to seismicity*

In the late 1969s, COPEL had to expropriate about 20km<sup>2</sup> of land on the plateau to create the dam construction site and water intake structure, as well as to build a residential village of eighteen houses. In 2000, five of these houses were occupied by COPEL staff, two by outsourced employees, one by the Forest Guard, and the remaining ones were lent to be used as a field headquarters for the workers' association – a quite common practice among electricity utilities. The company requested the then DNER to take on the task of relocating a seven-km stretch of the BR-116 Highway (Regis Bittencourt), including the construction of a two-lane bridge over a creek in the dam. In practice, the Paraná state company delegated much of its responsibility to a contractor, Electrocap, which took charge of implementing these measures, beginning with land reorganization and the removal of at least four hundred rural properties and, officially, eighty families living there.<sup>7</sup> Some of these residents allegedly used the compensation money to buy rural land close to the dam, but since Brazil was in the midst of the dictatorial regime at the time, it is likely that many social rights were violated by the companies and that problems were not even made public.

The flooding of the dam as of mid-1969 was not preceded by the removal of existing vegetation, as witnessed today by the remaining trunks that look like “toothpick holders” in the dam's creeks – which certainly favored the degradation of water quality and accelerated the formation of mud deposits across the system's pipes, apart from excessive levels of sedimentary material in the water used in the power plant to cool the different pieces of equipment. As in every dam, one can see the presence of thermal stratification, which contributes to anaerobic oxidation reactions of organic material and thus also leads to the formation of carbon gases, volatile organic acids and mercaptans (organosulfur compounds), of which some are quite corrosive. Obviously, this affects the metal equipment of the entire power plant system. From the beginning, the company has been studying the problem and trying to mitigate the damage, such as by opening the bottom spillway gate to dispose of organic sludge and by treating the water with sodium hydroxide to neutralize corrosive salts (Alberti et al., 1995). Most properties around the dam are private, with only one public-use recreation area between the new and old bridges over the BR-116 Highway, which belongs to the municipality of Campina Grande do Sul. The strip of land expropriated up to a height of 849 meters is theoretically the property of COPEL, but the landmarks there were removed by unknown people, and many surrounding owners ignore the existence of these limits and build improvements without complying with the Forest Code

or the Conama Resolution defining Permanent Protection Areas (APP) as any area within 100 meters of artificial lakes.

Fishing activities are one of the sticking points in the environmental management of dams. In the case of Capivari, these activities are not controlled, except upon complaint, and overfishing is a common practice, with the use of nets and other prohibited methods. The fish diversity in the basin is poorly known; what is known is that minnows and discus (native) are the most numerous species and that exotic species such as tilapia, black-bass and carp were introduced by the company. In the 1970s, following recommendations of the then Fishing Development Agency (SUDEPE) and the example of other power utilities, COPEL embraced the trend toward fishing farm and indiscriminate fish stocking, with the aim of mitigating or offsetting the impacts caused by the creation of the reservoir.<sup>8</sup>

After the flooding of the dam, tremors began to be felt in the surroundings, resulting in cracked window panes in the camp's houses, and were also observed later in the powerhouse at the foot of the mountain range, 14 km from there. This is a common phenomenon in many dams around the world: it is called "reservoir-induced" seismic activity (Sevá, 2008). In this case, there was a complicating factor of the tunnels being excavated during the construction phase. Although tremors were not recorded on the seismograph, the workers in the power plant wrote down the days of these events and their effects, and this information was then compiled by researcher Berrocal et al. (1984): there was a total of forty events from February 1971, when the dam was close to peak summer levels, to 1977, of which 80 percent took place in the first two years. Most tremors were felt in the lower part, in the powerhouse, residential village and in the surroundings, reaching intensity IV and, in some rare cases, V-VI on the Modified-Mercalli scale. Furthermore, according to geophysical reports by the Technological Research Institute of São Paulo that were mentioned by one of the authors in a recent paper on the project for building the Tijuco Alto Power Plant on the Ribeira River, the land in this basin is historically prone to natural earthquakes, and this propensity increases as a result of the characteristics and weaknesses of the karst subsoil in several sections, with underground caves and rivers (Sevá Filho et al., 2007).

On January 25, 2005, a landslide in an embankment supporting the head of one of the bridges over the BR-116 Highway, located 70 km from Curitiba in the municipality of Campina Grande do Sul, opened a 50-meter gap and resulted in the death of a truck driver and in the injury of three other people in another vehicle. The heavy traffic was diverted to the other lane, which was used as a one-way road for more than one year. Lawsuits were filed against DNIT and the contractors and, in late 2006, the primary cause was found to be the lack of maintenance in drainage pipes for rainwater, which over time accumulated in the embankment that supported the bridge, as well as the lack of protection

in the embankment (sealing and containment), which was prone to erosion because of changes in the reservoir water level. In December 2006, a court ruled that DNIT was to pay compensation to the victims' families.<sup>9</sup>

*Downstream the dam in Capivari: many kilometers of a dry river and some poorly explained floods*

Two types of problems have been observed downstream the dam in the Capivari River:

1) Most of the time, the first kilometers of the riverbed remains dry, stones become exposed, and the river's ancient flow is witnessed by water puddles only. The explanation is obvious: the flow diverted to the coastal basin, which corresponds to the swallowing capacity of the power plant turbines, can reach up to 38 m<sup>3</sup>/s, a significantly disproportionate rate for a small river. The company recognizes this issue in a report (COPEL, 2001): "As the machine swallowing capacity is larger than the long-term average flow at the site (19 m<sup>3</sup>/s) and the reservoir has a large working volume (156 x 10<sup>6</sup> m<sup>3</sup>), much of the inflows to the reservoir are transported to the Cachoeira River. From July 1971 to December 1999, 85.7 percent of the inflows were transported to the Cachoeira River". Currently, any internet user can see the consequences by looking at satellite images from, for example, Google Earth.

2) In rainy periods, the company is forced to open the spillways, leading to exceptional flows and floods downstream. For this reason, COPEL has been accused of being responsible for the floods and their consequences for different municipalities in the Ribeira Valley. On this issue, it is worth presenting some contradictory, well-reasoned arguments. For example, during the heavy rains in the fall of 1983 that led to several disasters across the southeast and south regions, the mainstream media reported that the flood in Ribeira left three people dead and 12,500 others homeless in the municipalities of Registro, Iporanga, Eldorado, Ribeira, Sete Barras and Iguape, apart from significant losses in banana plantations.<sup>10</sup> Another news story recognized an aggravating effect, also as a result of the operation of CBA's power plants on the Juquiá river, which contributes mainly to the flooding in the cities of Juquiá, on the lower river, and Registro, located below the confluence of the two rivers. "This year, the floods were more severe due to the contribution of the dams in the Capivari-Cachoeira system in Paraná and of the power plants of the Brazilian Aluminum Company at the headwaters of the Juquiá River". In the 1990 floods, the mainstream media once again indicated problems in the COPEL system, not even mentioning the possible responsibility of CBA's power plants.

*The intrinsic problem of the water flow diversion: the increased flow to the Cachoeira River, and the levees in the Antonina Bay estuary*

The same serious problem of disproportion between the project's scale and the river's size in the upper part of the system is also observed in the lower part: the Cachoeira River, with an average historical flow of 22 m<sup>3</sup>/s, began to receive the water released from the power plant turbines in 1970, meaning a twofold increase in the river's natural flow when all turbines operate at peak

performance. The river has obviously become another hydrological entity, with the increased flow forcing the enlargement of the old pipeline and causing bank erosion. What is even worse is that, apart from the seasonal variation in the river's natural flow, now there is also the operational variation (i.e., determined by commercial criteria for energy sales) of the water flow discharged into the Cachoeira River after the turbines of the Parigot de Souza Power Plant. This changes almost everything, starting with the micro- and macroscopic aquatic life and sediment transport.<sup>11</sup> These water flows are discharged into an area relatively close to the lower river and its estuary, resulting then the siltation of the riverbed and the erosion of banks. The probable consequence is the progressive levees of many parts of the Antonina Bay, where one can see forming shoals and even new islands. This problem ultimately affects the movement of vessels on account of reduced channel depth – in front of the Náutico Club, for example, this depth appears to have decreased from 7 to 4 m in the last two decades.<sup>12</sup>

### **Concluding message: denial of the transposition between basins and the fearful continuation of the construction work surge**

Environmental Licensing was not a mandatory requirement when the Capivari–Cachoeira system was built. However, with the passing of CONAMA Resolution 001/1986 and, particularly, the introduction of article 225 in the 1988 Federal Constitution, this requirement became mandatory for new projects. Through resolutions and additional instructions, the existing projects would have to be “licensed ex-post”. The power plant concession granted to COPEL expired in 1995, and yet no measures had been taken to regulate environmental aspects, which only happened in 1999 by means of an agreement with the Paraná Environmental Institute (IAP). The company then requested an Operating License for the power plant and, to this end, it would need to submit an environmental impact report pursuant to Paragraph 5, Article 12 of CONAMA Resolution 006/87. On September 17, 1999, COPEL applied for the Operating License for the Parigot de Souza Power Plant with the IAP and, on the same day, the institute carried out an inspection. Surprisingly, the state agency found that the power plant site (Bairro Alto in Antonina) and its surroundings were “stable” because of the environmental recovery plan implemented by COPEL.<sup>13</sup> In the dam, the IAP found five cases of slope landslides, probably due to the effect of ripples and water-table oscillations resulting from the operational drawdown of the dam's water level, and called upon COPEL to prepare an action plan to prevent overfishing, illegal deforestation, slash-and-burn practices, and irregular buildings in the region (COPEL, 2000).

A more rigorous analysis would show that this could be seen as an “institutional schizophrenia”, because:

1) the Capivari River, which is dry during one part of the year and subject to major floods during the other, empties into the Pardo River and enters the São Paulo territory, and yet the licensing was obtained only from the Paraná Environmental Agency;

2) several documents submitted by COPEL, by the Water Resources Development and Environmental Sanitation Agency (Suderhsa) and even by IAP do not consider the Cachoeira River as part of the power plant's water body, ignoring the deviation of a significant water flow between the two basins;

3) the environmental agency ignores all sorts of influence from the turbined flow discharged into the Cachoeira River, its estuary and the Antonina Bay, as well as the problems faced by residents and landowners (usually small) who live off agriculture, fishing and animal husbandry resulting from the increased flow of the Cachoeira River, such as water turbidity, erosion, and loss of riparian vegetation and productive land.

Finally, the agency does not even mention the use of the bay for recreation and tourism purposes, much less for navigation and operation of maritime terminals.

In the Ribeira Basin, another power plant is being built on the same Capivari River in the state of Paraná, an old project called Salto do Inferno. Other 26 power plant projects were studied and inventoried in five rivers, including four medium-size projects in the main river, Ribeira de Iguape, the best known of which is the Tijuco Alto Power Plant, with a dam more than 120-meter high located a few kilometers from the cities of Ribeira (SP) and Adrianópolis (PR). Should the criteria used so far and the idealized images continue to prevail, the future outlook is alarming. The land of this two-state basin is being degraded and its rivers are disappearing, like so many others throughout Brazil.

#### Notes

1 Please see <<http://www.socioambiental.org/prg/rib.shtm>> e <<http://www.preac.unicamp.br/novoquilombolas/evento/barragem.html>>.

2 Sources: 1) Nomenclature and location in accordance with the Hydroelectric Potential Information System (Sipot) developed by Eletrobrás. 07/2005. Available at: <<http://www.eletrabras.gov.br>>. Accessed 20 Aug. 2006. 2) Order n.141 of January 24, 2007 – Aneel. 3) Amaral & Prado (2000). 4) *CBA Power Plants*. Available at: <<http://www.aluminiocba.with.br/workers'party/plants.php>>. Accessed 10 Aug. 2009.

3 Apart from the two largest flow reversal projects in the Serra do Mar Mountain Range, special mention should be made of the small Macabu-Macaé system in the mountainous region of Rio de Janeiro: through a five-km tunnel, a dam in the Macabu River in the municipality of Trajano de Moraes feeds a small 11-MW power plant completed in 1950 at the foot of the mountain range, where it empties the water into the São Pedro River belonging to the Macaé River Bay. A serious environmental consequence of this project is that the Macabu River, which had much of its flow diverted to another basin, is the main responsible for the freshwater volume in the Feia Lagoon, the largest one in the entire lagoon system on the coastal region of Rio de Janeiro (Embrapa, 2004).

4 In accordance with a document submitted by Light Rio during a hearing at the Brazilian Electricity Regulatory Agency for concession renewal: Available at: <<http://>

www.aneel.gov.br/aplicacoes/audiencia/arquivo/2005/004/contribuicao/light\_anexo\_i.pdf>. Accessed 12 Feb. 2010.

- 5 “The Guandu River, which under natural conditions would have a flow rate of about 25 m<sup>3</sup>/s, receives an average contribution of 146 m<sup>3</sup>/s from the Paraíba-Piraí detour and of 10 m<sup>3</sup>/s from the Tócos-Lajes detour. This additional contribution allowed CEDAE to build the Guandu River Water Treatment Station, which began operations in 1955 and currently processes 47 m<sup>3</sup>/s of water to serve the population in the metropolitan region of Rio de Janeiro. The obligation to keep the flow in the Lajes Complex power plants at levels consistent with the catchment needs of the Guandu River Water Treatment Station is part of the electricity concession contract granted to the company”. Note: same source of previous note.
- 6 These risks were partly minimized by using anchor bolts, totaling 50,000 parts and about 4,750 metal straps – as is done in underground mining (COPEL, s. d.).
- 7 According to newspaper *O Estado de São Paulo*, July 14, 1970.
- 8 More detailed surveys carried out in this and other dams in the state found that the number of species introduced is high, that the density of introduced species is very low, and that the repopulation of the Mourão and Capivari reservoirs did not produce the expected fishery yield, contributing less than 5 percent of the full catch (Nupelia/UEM, 2000).
- 9 “Queda da ponte sobre rio Capivari-Cachoeira: responsáveis são alvo de ação de improbidade administrativa”; December 5, 2006. Available at: <<http://www.pgr.mpf.gov.br/noticias/noticias-do-site/patrimonio-publico-e-social/queda-da-ponte-sobre-rio-capivari-cachoeira-responsaveis-sao-alvo-de-acao-civil-publica>>. Accessed 14 Feb. 2010.
- 10 According to newspaper *Folha de São Paulo*, June 2, 1983. *O Estado de São Paulo*, July 3, 1983.
- 11 According to the historical series of the former National Water and Electricity Department (Dnace), the average flow rate of the Cachoeira River in the 1931-1966 period reached 21.7 m<sup>3</sup>/s, while the average flow of the Capivari River, according to data from COPEL for the 1931-1992 period, was 17 m<sup>3</sup>/s (Lambertucci, 1996). A study carried out by Odreski et al. (2003) comparing bathymetric surveys in the Antonina Bay between 1901 and 1979 indicated a sediment volume of about 60 x 10<sup>6</sup> m<sup>3</sup>, equivalent to a sedimentation rate of 2.6 cm/year.
- 12 The siltation of the Antonina Bay draws the attention of the local population, researches and companies. The “Ponta do Félix Port Terminals – TPPF” launched the Contaminant, Siltation and Dredging Program (CAD) to simulate rainfall, flows and different behaviors of rivers and estuaries. COPEL’s Environmental Coordinating Body, concerned about the accusations of responsibility for the impact of its power plant, commissioned a project from state laboratory Lactec (Boldrini, 2007). Moreover, Bandeira (2007), Branco (2004) and Odreski (2002) analyzed the morphological and sedimentological changes in the Cachoeira River estuary since the 1950s, concluding that the power plant’s discharge was directly responsible for such changes.
- 13 According to Technical Opinion n.139/99 issued by the Paraná Environmental Institute (ERCBA) of October 22, 1999.



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*ABSTRACT* – The image of the Ribeira do Iguape basin is usually linked to environment protection, to natural caverns and to traditional people communities (descendants of runaway slaves, indigenous peoples, fishermen). This paper draws another diagnosis, lightening up important geo-economic issues, such as mining fields, plantations and hydraulic works. The main river has not yet been dammed for the hydropower plants located in its tributaries, featuring an amount of 540 Megawatt capacity. The most impressive one, called Capivari– Cachoeira system, was built forty years ago and is based on a flow derivation from the high Ribeira basin to the coastline of the Paraná state. Its consequences are negative downstream the Pardo and Ribeira rivers in the São Paulo state, also affecting the Antonina Bay on the other side. These damages were not recognized during the licensing process for this power plant. The environmental degradation in this region will only worsen if some other hydroelectric projects are implemented in the future.

*KEYWORDS*: Ribeira do Iguape, Hydropower plant, Riverflow derivation, Environmental impacts, Reservoir-induced seismicity.

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