7.3 Macrodrenagem of the Reconstruction – Rio de Janeiro Program

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7.3.1 Program

Part of the Baixada Fluminense (Fluminense Lowlands), a region located close to the city of Rio de Janeiro, was the subject of a large number of flood-fighting interventions sponsored by the Federal Government, beginning in the Thirties. Among the interventions were building canals, dikes, locks and pumping stations, essentially aiming at fighting waterborne endemic diseases, and the recovery of extensive floodable areas. The hydraulic structures were designed for agricultural, not urban use, since the design criteria used in those days allowed for short duration flooding.

The migration process which began in the Fifties and speeded-up in the Seventies caused the areas bordering the city of Rio de Janeiro to be intensely occupied by population groups that built their homes there, generally in a disordered manner. Currently the Baixada Fluminense has over 2 million inhabitants, in 6 municipalities, approximately 350 thousand of whom suffer the effects of heavy floods. The chaotic urbanization process led to the following consequences.

- occupancy of the flood plains and in many cases the low-flow channel rendering it impossible to build chanels and provide maintenance for the water courses;
- a rapid siltation process, due to the deforestation of slopes and to the refuse which was not picked up by extremely impoverished municipal governments;
- increased surface runoff due to the fact that the river basin has been rendered impervious;
- destruction of hydraulic structures, particularly locks and pumps, to sell the components as scrap, or simply due to vandalism.

It is not surprising that as years go by, summer storms events with similar intensities provoke increasingly devastating floods, leaving more and more people homeless. The problems have been worsened by the sanitation policy which, despite bringing piped water to most homes in the Baixada, has failed to establish a structure for sewage collection and treatment. Currently, all of the Baixada is cut by a network of polluted ditches which spill over when it rains, causing serious health problems among the population.

In February 1988, an exceptionally heavy flood left a trail of destruction, deaths and diseases. This event motivated the government of the state of Rio de Janeiro to establish an emergency program to reorganize the urban infrastructure of the affected areas, emphasizing major drainage works. The Reconstrução-Rio (Rio-Reconstruction) Program obtained funding from the World Bank (IBRD) and from the Caixa Econômica Federal (CEF). For several political-administrative reasons the main part of the major drainage work, a total amount of US$130 millions, only began to be implemented in 1994, and it was to be finished in mid-1995. It is known that this intervention will not be enough to correct decades of neglect and chaotic urbanization. For this reason, the State is preparing the Integrated Flood Control Master Plan for the Iguaçu-Sarapuí River Basin, which covers most of the Baixada Fluminense. The Plan aims to complement the current works program, listing the main flood prevention initiatives, mainly in the institutional domains, land use, and urban equipment (such as garbage collection).

7.3.2 Works in Construction and Project Constraints

The ongoing intervention consists of three types of works:

- improvement of the runoff capacity of rivers and channels;
- construction of two flood control dams;
- removal of obstacles to runoff, especially inadequately sized bridges.

Next are described the criteria adopted, as well as several conditions that defined the choice of controls used.

Polders: Many areas lie below the flood stage of the main rivers, Iguaçu and Sarapuí. Under these circumstances, polders were used to protect these areas. Since internal drainage in the polder areas cannot be discharged directly into the main river, due to the dike, an auxiliary channel is built parallel to the main river, and in some places it communicates with the main river passing under the dike through pipes with flap locks. Thus, runoff only takes place from the auxiliary channel to the main river. When the water level in the main river is higher than that of the auxiliary channel, the locks close and the auxiliary channel temporarily accumulates all of the water from the polder drainage, possibly overflowing into an uninhabited area called "flood zone" , until the level of the main river goes down and the locks open. The design variables in this case are: the size of the auxiliary channel, the uninhabited area to be preserved as a flood zone for the main channel, and also the location and capacity of the flap locks. These variables can only be sized taking into account the time variation of levels, both in the main river and in the auxiliary channel. For this it is necessary to perform hydrodynamic modeling of the phenomenon.

The program rejected the alternative of using pumps to ensure the discharge from the auxiliary channel into the main river, at times when the flap locks are closed. This alternative is technically perfect, and its main advantage is that it reduced the flood area. It was used in the past in the Baixada Fluminense itself, and is currently adopted in many polders throughout the world. However, it requires effective maintenance, and this is incompatible with the capacity demonstrated by the government at all levels, over the last 30 years. Therefore, the attitude has been taken, of setting aside a technically acceptable possibility, although it may not necessarily be the best, for fear that the heavy investments could be lost, in future, due to mismanaged maintenance. An expert cannot size a hydraulic structure in Brazil as he would in Holland, based only on the principles of Hydraulics. He must also take the institutional limitations into account.

Specifically for the case of the Auxiliary Channel on the right bank of the Sarapuí River, approximately 8 km long, flowing through the municipalities of São João de Meriti (upstream) and Duque de Caxias (downstream). The hydrodynamic model which solves Saint Venant equations were used for flood condition taking into account: (i) periodical tide cycles in the Bay; (ii) flow variations over time in several places in the water course, obtained by using a rainfall-runoff model, assuming several different hypotheses for the simultaneous occurrence of storms, both in the river basin as a whole and in the polder area.

It should be stressed that the sizing was performed on the assumption that the area which is presently uninhabited, especially along the Auxiliary Channel in the municipality of Duque de Caxias, will function as a flood zone. Therefore, any compromise on the part of municipal authorities, allowing edification in this area, will annul the flood control system over large areas of the municipality of Duque de Caxias itself, as well as in São João de Meriti.

Return Period: The Program adopted a risk of 5% or a return period of 20 years. In many cases this risk could not be adopted because it would involve high costs. In one of the galleries (Délio Guaraná Street in São João do Meriti), and for the widening and deepening of the Bota River, in Belford Roxo, overflow risks of 10% and 12%, respectively, were adopted.

In other cases, although it is feasible to adopt the criterion of an annual risk of 5%, this could lead to a decision which would not be sensible, since it leads to a much higher cost than would be associated to an alternative with a risk slightly higher than 5%. In order to attain a 5% risk it would be necessary to build a concrete channel, which is rather expensive. On the other hand, if a risk of, let us say 7%, were accepted, it would be possible to adopt a solution with an earth section (profile), at a much lower cost. In such situations, the solution of a earth channel would have been chosen, privileging common sense.

Ideally, arbitrary risk goals should not be adopted; instead, each design alternative, associated with a risk possibly different from 5%, would be analyzed seeking to compare the cost of implementation to the value expected from the benefit.

Campo de Gericinó: In the Baixada Fluminense, a large area of land belongs to the Army and is used for military maneuvers. SERLA (the Rio de Janeiro flood control management organization) and the Army established an agreement to allow a flood conrol dam to be built across the Sarapuí River which crosses the Campo de Gericinó (Gericinó Field). Later the agreement was extended to allow a second dam to be constructed, across the Pavuna River, which also crosses the Gericinó, with an alignment approximately parallel to the Sarapuí. Both dams have their crests inter-linked at the height of 23 m by a lane with a total length of about 3600 m, and they are located close to the downstream end of the Gericinó. The joint drainage area of the two basins, in the dams, is 73km2.

The dams can be visualized as a long wall, with a maximum height of 20 m, at right angles to the course of both rivers, with two orifices, one located in the course of Sarapuí River, and the other in the course of the Pavuna River. In a normal situation, when it is not raining, or it is only raining "a bit" , the rivers will flow through the respective orifices, without much change. However, whenever heavy storms occur, the river flow may be greater than the capacity of the orifices, retaining water behind the dams, which will flood part of the Campo de Gericinó for a few hours. In order to have an idea of this effect, for the event with a return period of 20 years, the peak of inflow to Gericinó will be 171 m3/sec at the Sarapuí dam, and 51 m3/sec at the Pavuna dam. On the other hand the effluent flows, i.e,. those which go through the orifices, will be respectively 32m3/sec and 12 m3/sec. This means that the discharge peaks for the same meteorological event will be respectively 19% and 24% after the dams are built of what they were before construction. Consequently, the water level downstream from the dam will be much lower than it was before construction, for meteorological events with an analogous intensity. This lowering will have an effect not only on the main water courses, but also on the tributaries which drain the municipalities of Nilópolis, Rio de Janeiro, Belford Roxo, São João de Meriti and Duque de Caxias. Everything takes place as though the floods were transferred from the region downstream from the dams where the population lives, to upstream from the dams, where no one lives. For the aforementioned event, with a 20-year return period, the water level in Sarapuí River would be lowered by almost 3 meters in the municipality of Nilópolis, and the volume retained in the reservoir would be approximately 1.5 million cubic meters.

In the temporary reservoir, the water level would be below the 19 m stage which is the water level beyond which water flows over the spillway, besides the discharge through the orifice. For the critical situation, in which the water level reaches the 22m stage, only one meter from the dam crest, the lake will have a volume of 13.8 million cubic meters.

Dam construction made it needless to channel the Sarapuí River downstream from the dam, a structure whose cost had been estimated at more than US$30 millions. On the other hand, for Pavuna River it was impossible to avoid channeling the approximately 6.5 km stretch which functions as a limit between the municipalities of Rio de Janeiro and Nilópolis (upstream)- São João de Meriti (downstream). The dam enabled the channeling, because it reduces the size of the cross section, which resulted in a substantial reduction in the amount of resettlement required.

Resettlement: The main difficulty in implementing the building plan is related to the resettlement of the riparian population, whose homes prevent the services from being carried out. It is almost always the poor population that has invaded the banks of the water courses due to the lack of a better alternative. Historically, the government, including the Judiciary, has been very quick to see to it that the principle of private property is upheld, preventing private land from being occupied although it is not being used, if it does not lie in areas of risk. On the other hand , the government has not been very quick to create mechanisms which will prevent real estate speculation with fallow land lying in places appropriate for building, nor in preventing the occupation of public lands at risk, such as river banks. In this way, the government goes against the interests of most of the population that will suffer as a result of floods, due to the "corking" effect caused by riparian constructions. As to the Baixada Fluminense, in several stretches it proved impossible to find a feasible solution for resettlement, because of the reduced availability of alternatives for the construction of housing which could fulfill the social and political conditions. In these cases it was necessary to change the alignment of the initial project, making it worse, either by small changes in the design which sought to minimize the resettlement difficulties, or by building auxiliary galleries, located under streets approximately parallel to the thalweg. It was observed that the use of aerophotogrammetric restitution, complemented by topographical surveys, were insufficient to proceed to the small changes in alignment, because they did not allow quantitative analysis of the buildings to be relocated. In theses cases aerial photographs taken from helicopters were very useful.

7.3.3 The Plan for the Iguaçu-Sarapuí Basin

Both the Governor of the state of Rio de Janeiro, and the funding agencies IIBRD) and CEF, perceived that because the Rio-Reconstruction Program was conceived under emergency circumstances in a manner certainly insufficient to solve all problems, it lacked an integrated view of the basin. This view is essential, because often the consequences of each action go beyond municipal boundaries. For instance, the removal of a bridge that has an insufficient span, could relieve the flood in the municipalities upstream from the bridge. On the other hand, it worsens floods in municipalities downstream. Or else, a municipal real estate development in a flood zone may worsen the floods in another municipality, as shown previously for the municipalities of Duque de Caxias and São João de Meriti.

The Integrated Flood Control Master Plan of the Iguaçu-Sarapuí River Basin is being developed from analyses of basic thematic maps and hydrological and hydraulic studies for the purpose of rendering explicit the main causes of the flood problems, including those institutional in origin. Currently the plan is being finalized and has already been used to implement a number of harmonious interventions , both structural (works) and non-structural (land use planning and proposal of a new institutional architecture), which will consolidate the works developed in the Rio Reconstruction Program. The Plan is being developed using methodologies that are not limited to the Iguaçu-Sarapuí basin, considering that the scope may be broadened in two dimensions: (i) at a geographical level, to be applied to the other river basins in the state of Rio de Janeiro; (ii) on the thematic coverage level, to allow further work in other sectors besides flood control (water availability for supply, irrigation and water quality, for instance). Equally, data collection is not limited to aspects related only to flood control, but covers the whole range of interests in the management of water and environmental resources. Actually, the long term goal of the task force is to contribute to establishing the Water Resources Management System in the state of Rio de Janeiro.

Traditionally, good initiatives in public administration provide meager results due to lack of continuity. An antidote to this sad tradition consists of involving civil society in the whole planning process, from the word go, so that, as a result of the interest aroused, they will not only

contribute to performing the tasks, but also interfere directly in continuity, demanding that it be finished. Thus, it was decided to establish the Plan Follow Up Committee, consisting of representatives of the city administrations, federations, and associations of inhabitants of the different municipalities in the basin, as well as of different state agencies such as FEEMA, CEDAE and IEF. The Committee began its work in September 1994, and since then has met once a month, at different places in the Baixada. Attendance at the meetings is not yet complete, especially by representatives of the state agencies and municipal administrations (except for Belford Roxo, which is always present). The quality of discussions is excellent and, on many occasions, joints visits have been organized (members of the task force + representatives of the associations of population) to diagnose drainage problems "at the site" , with solutions that became part of the Plan.

7.3.4 Public Utilities Company

It is well known that street paving is often removed and redone several times, as a result of lack of coordination among the different state and municipal agencies, and the public service concessionaires responsible for urban infrastructure. Worse yet, often one agency has to undo what another has just finished. Examples: (i) SERLA had to redistribute a large number of pipes belonging to CEDAE (the water and sanitary sewage company of the state of Rio de Janeiro) that were built with an alignment that conflicted with the channel works performed during Rio-Reconstruction; (ii) SERLA had to redo the channel works performed by municipalities that did not base them on any discharge computations, in some cases replacing pipes by galleries with a cross section 8 times larger than the previous one; (iii) if it had the resources, SERLA should redo several bridges which get in the way of water flow, both on highways and railways, some of which built recently, with beams installed too low, and/or with an insufficient span and /or with badly located pillars. Obviously, from the viewpoint of the other agencies, it is certain that there are similar complaints regarding SERLA. The problem is lack of integration.

Simple solutions range from establishing incentives for computer systems so that agencies will begin to share information to unified planning.

A more ambitious solution would be to create a single "retail" company per municipality or river basin, which would take charge of all urban infrastructure services. This company would charge for services directly to the consumers, and since it is local, public control would be easier. The company would buy the specific products required to satisfy its clientele from the "wholesale" companies. In other words, it would pay to receive water and deliver sewage to CEDAE, to deliver garbage to some "large garbage wholesaler", and to receive power, gas and telephone, respectively from Light, CEG and Telerj (utility companies in the state of Rio de Janeiro related to the above mentioned services).