Jose Carlos Melo

The Experience of Condominial Water and Sewerage Systems in Brazil:

Case Studies from Brasilia, Salvador and Parauapebas

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Shallower excavation works, Parauapebas

Foreword

This study presents the experience of applying the condominial approach to expand water and sewerage networks in three contrasting Brazilian cities. It is based on the findings of a Study Tour to Brazil organized in December 2003 for utility managers and public officials from the Peruvian water sector, who were in the process of applying large-scale condominial systems in Lima for the first time. The goal of the visit was to permit the Peruvian delegation to see mature and functioning condominial systems on the ground, and to interact with local policymakers, utility managers, residents and specialists, to obtain better idea of the challenges and potential advantages and disadvantages of implementing this system. The three cities visited –Brasilia, Parauapebas and Salvador– were chosen for their contrasting urban settings and specific experiences with the condominial model. The Study Tour was funded by the Bank Netherlands Water Partnership Program.The current study is offered as a vehicle for sharing the results of the visits with a wider audience of water-sector professionals.

I. Introduction

The so-called condominial approach to the construction of water and sewerage networks was developed in Brazil during the 1980s as a response to the challenges posed by expanding services into peri-urban neighborhoods. While the condominial model has proved capable of meeting the considerable social and engineering challenges posed by these areas, it is also a generic alternative to the design of water and sewerage systems. Indeed, the Brazilian experience illustrates how the model has been successfully applied to urban neighborhoods as diverse as the Rocinha slum in Rio de Janeiro and the affluent Lago Sul and Lago Norte districts of Brasilia.

The term condominial is sometimes misunderstood, and it is therefore important to begin with a brief description of the approach. The condominial water and sewerage system is based on two key concepts that differentiate it from the conventional model.

The first concept effectively redefines the unit to which service is provided. Whereas conventional systems essentially provide services to each housing unit, condominial systems deliver services to each housing block or any group of dwellings that could be termed a neighborhood unit or "condominium." This is similar to the concept of providing a single connection to an apartment building, except that in this case the condominium is physically horizontal and institutionally informal. As a result of this novel concept, the public network no longer needs to run through every plot of land or to be present in every street, but merely to provide a single connection point to each city block. Therefore, the required length of the network is considerably shorter than that of a conventional system. It needs about half the length for sewerage and about a quarter of the length for water service.

The household connections characteristic of conventional systems running perpendicular to the network are replaced by condominial branches running parallel to the blocks. Condominial branches for sewerage can be located in the most convenient part of the block (under sidewalks, front yards or backyards), while in the case of water they are generally located under sidewalks to allow for individual metering. This design permits the adaptation of the network to local topographic conditions and different urbanization patterns.

In addition, an integral condominial design contemplates the decentralization of the drinking water supply or sewerage treatment facilities to avoid the costs associated with transportation of fluids over long distances. This is in contrast to the conventional approach, which emphasizes the concentration of fluids at a single geographical point. In the case of sewerage, decentralization takes place through the use of drainage basins, taking into account factors such as land availability and local environmental conditions. In the case of water, the exogenous nature of water resources may limit the decentralization of treatment processes. Nevertheless, there may be opportunities for decentralizing storage reservoirs with a view to achieving greater uniformity of pressure in the entire service area.

The second distinctive concept behind the condominial approach is the development of a much closer relationship between service

Maintenance Equipment for Condominial Branches, Brasilia

providers and users, encouraging the two parties to come to an agreement to facilitate service expansion and adaptation to local needs and constraints. Thus, the condominium becomes not only a physical unit of service provision, but a social unit for facilitating collective decisions and organizing communal actions. Members of the condominium must select the appropriate design of the condominial service and commit themselves to complementary actions ranging from sanitary education to direct participation in the construction and/or maintenance process.

The purpose of this paper is to illustrate the diversity of experience within Brazil in the application of the condominial model and to document the results to date. This is done by examining three case studies chosen because of their contrasting urban contexts and the substantial differences in the way the condominial model was applied. The three cases presented are Brasilia, Salvador and Parauapebas.

In Brasilia, the nation's capital, the condominial approach was used to expand sewerage service to 500,000 people in some two dozen urban areas. The two most prominent features of this experience were the achievement of universal access at very low financial cost to the utility company as well as the conscious, consistent way in which the technology was adopted by the utility company, providing service access to a wide socioeconomic spectrum.

In Salvador, the state capital of Bahia, the condominial model was also applied to sewerage on an unprecedented scale, serving over one million people. In contrast to Brasilia, the condominial system in Salvador was adopted in a gradual and experimental manner, motivated by the extremely dense and chaotic urbanization patterns as well as the challenging topography of the city.

Sao Caetano, Salvador de Bahia

Parauapebas, a small but fast-growing mining town in northern Brazil, presents a rare example of applying the condominial model to the water sector and illustrates the potential operational advantages that condominial designs bring to water systems. Moreover, the city was able to mobilize large-scale community participation in the construction of the network. The result was the very rapid expansion of water coverage at a fraction of the cost of a conventional system.

Excavation works in the sidewalks, Brasilia

II. Brasilia: Full Institutionalization of Condominial Sewerage

II.1 City Profile

Brazil's federal district is located on the central plateau at the geographical center of the country. The city is a planned capital that has experienced rapid population growth, from 140,000 inhabitants in 1960 to its present level of 2.1 million. From an urban development perspective, the city can be divided into three broad areas with contrasting characteristics. First, there is the City of Brasilia (the nation's capital proper) with only 19% of the population of the district, and which consists of a monumental modern urban complex that has been named a World Heritage site. Next come the 16 "satellite cities," which either pre-dated the capital or were planned and established simultaneously. In addition, there are several dozen small and medium-sized peri-urban neighborhoods (or bedroom communities), with populations ranging from 1,000 to 10,000.

The last group, with a total of 600,000 inhabitants, is of fairly recent origin, growing rapidly beginning in the early 1990s and following an unusually ordered pattern of urbanization. In response to intense social pressure for housing, the local government of the time set up large-scale housing program offering "urbanized plots" with a ready-made package of infrastructure services to families that were willing to build their homes by a given deadline and to comply with predetermined building specifications. These plots were organized in a number of planned peri-urban areas or settlements and were generally provided with roads and sidewalks, and often with electric and water services. These communities were gradually transformed into real cities, some of which rapidly became as large as some of the earlier satellite cities mentioned above. However, the urbanized plots were generally deficient with respect to the provision of sewerage and drainage infrastructure, which over time led to deteriorating sanitary conditions.

Furthermore, sewerage networks were inadequate even in the capital itself. This was because the original city design was based on the adoption of individual septic tanks in the belief that the residential plots would be sufficiently large to absorb effluents. However, this did not ultimately prove to be the case, leading to the discharge of untreated sewage into Lake Paranoá, which began to show signs of serious contamination, including eutrophication.

II.2 Adoption of the Condominial Model

By 1993, the lack of sanitation in the peri-urban areas, combined with growing environmental awareness of contamination in Lake Paranoá, prompted the city's public water utility CAESB (Brasilia Water and Sewerage Company) to take serious action. Solving these problems would entail connecting 600,000 people to the sewerage network and building sewage treatment capacity for 1.7 million people in the form of two tertiary treatment plants on the lakeshores.

A major concern was the huge financial cost of these solutions. In search of lower-cost alternatives, CAESB staff made field visits to cities in the states of Rio Grande do Norte and Pernambuco (Petrolina), which already had extensive experience with the use of the condominial model. This resulted in experimentation with pilot projects that were used to adapt the condominial approach to local conditions. Thereafter, the condominial model was applied on a massive scale in Brasilia, both in the peri-urban neighborhoods and in the more affluent areas of the capital.

Funding for the project was provided by the Caixa Econômica Federal (Federal Development Bank) and the Inter-American Development Bank, but also included contributions from both the capital and federal district governments. However, it was not possible to determine the total amount invested or how it was distributed by system and source. From 1993 to 2001, an estimated 188,000 condominial sewerage connections were made in the federal district, benefiting approximately 680,000 people (Table II.1). The condominial model in Brasilia has been applied to neighborhoods spanning the socioeconomic spectrum, ranging from the modest homes of the peri-urban areas to the large luxury villas of the capital. The engineering, financial, social, and operational aspects of the experience are described in detail below.

Table II.1: Overview of adoption of condominial approach in Brasilia 1993 to 2001

Administrative Region	Population served	Estimated connections	No. of condominiums	No. of participants at meetings	Condominial branches (kms)	Public Network (kms)
Brasília	8,015	1,308	94	785	15.2	9.7
Brazlândia	8,410	1,529	69	897	16.5	7.0
Candangolândia	4,075	791	46	488	8.4	5.1
Ceilândia	23,591	4,711	177	2,345	51.2	13.9
Cruzeiro Velho	2,690	490	49	305	3.0	1.9
Gama	6,445	798	41	525	8.5	5.3
Guará II	8,742	1,644	86	911	16.6	11.9
Lago Norte	11,785	3,660	185	1,709	60.7	26.4
Lago Sul	12,133	2,092	103	752	46.0	28.4
Paranoá	38,143	11,475	274	3,744	69.0	28.4
Planaltina	51,026	9,992	377	4,742	89.7	26.2
Recanto das Emas	112,339	32,680	880	8,601	216.5	101.9
Riacho Fundo	58,720	18,831	401	4,759	103.7	63.4
Samambaia	146,663	45,455	862	10,516	282.5	199.8
Santa Maria	93,000	31,265	645	7,257	192.2	91.4
São Sebastião	55,000	13,085	408	4,733	109.3	36.2
Sobradinho II	23,338	4,070	137	2,040	33.6	17.8
Taguatinga	15,303	3,815	143	1,476	33.7	20.4
Total	**679,418**	**187,692**	**4,977**	**56,585**	**1,356.3**	**695.0***

Note: This total contains some networks built to conventional specifications at the outset of the process.
It is estimated that approximately 625,000 kilometers were built following condominial specifications.
Source: CAESB (2001) *Sinopse do Sistema de Esgotamento Sanitário do Distrito Federal*

Although the issue of sewage treatment will not be discussed in detail in this paper, it is important to note that with the expansion of the sewerage network, substantial progress was also made with respect to effluent treatment. As a result, the federal district is expected to achieve universal coverage of sewage treatment during the course of 2004. The processes used for effluent treatment combine anaerobic reactors and waste stabilization ponds, while the largest of the units (planned to serve over one million people) relies on activated sludge technology. Extensive experimentation aimed at adapting sewage treatment technology to local conditions resulted in significant cost savings, for example, by substituting reinforced concrete structures with artificial ground strengthening techniques or by employing lower-cost materials. A further advantage was the free provision of land for sewage treatment facilities given that most of federal district the land belongs to the government.

II.3 Engineering Aspects

Adapting engineering aspects of the condominial approach to Brasilia proved to be relatively straightforward thanks to a number of favorable characteristics of the local setting. First, the local topography is relatively uniform, with slightly sloping gradients well-suited to the drainage requirements of sewerage networks. Second, the unusually orderly pattern of urbanization resulting from the local government's housing program facilitated the introduction of sewerage networks, whereas construction work was made easier by the absence of roads and sidewalks in much of the area. Third, the condominial approach was introduced as a result of a conscious central decision, resulting in a coherent, uniform application of the model in the federal district.

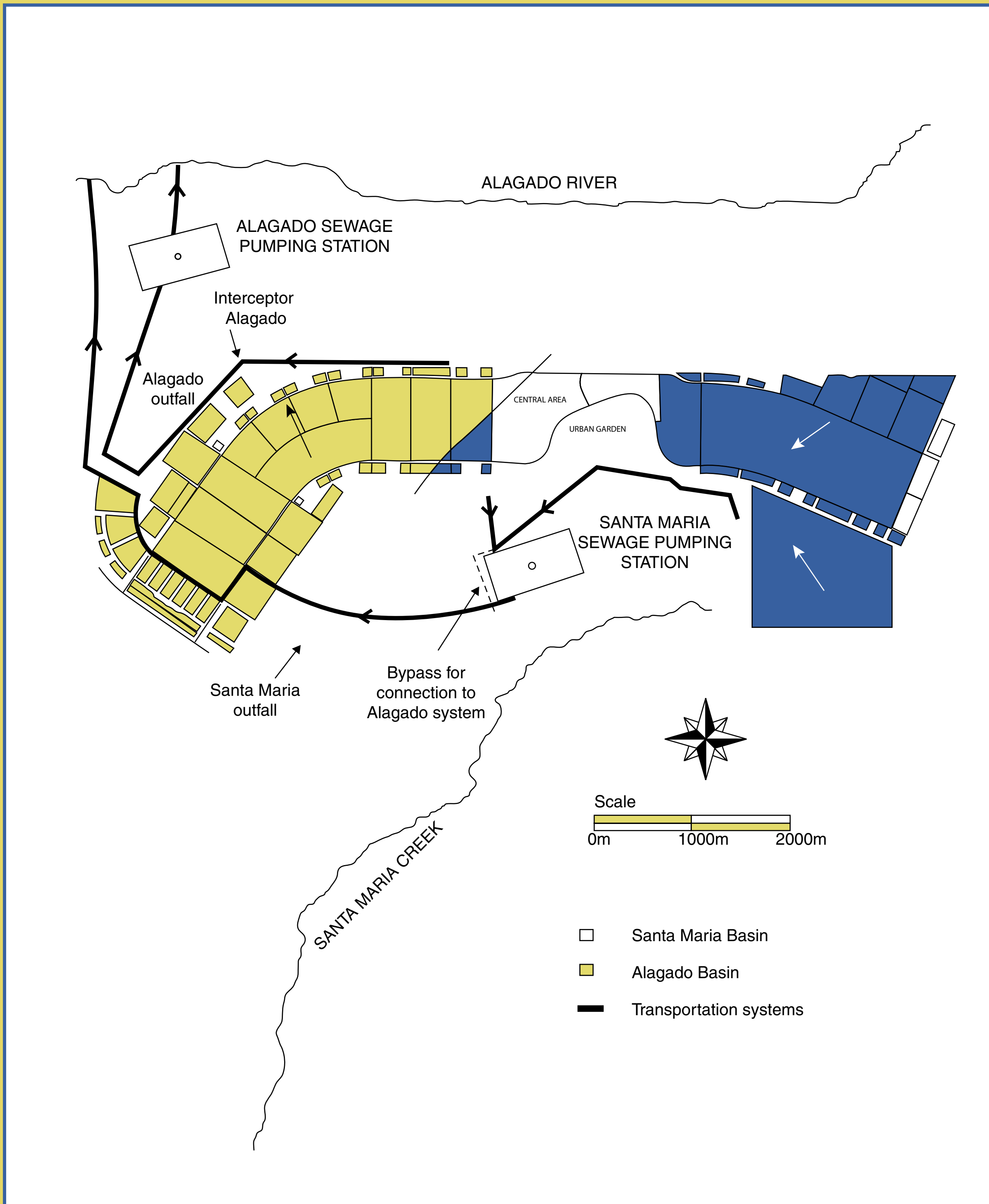
In order to illustrate the engineering issues that arose in the design of the condominial systems, this paper will focus on the Santa Maria system (Figure II.1). This system was chosen due to its large size (100,000 inhabitants), plus the fact that it aptly typifies the group as a whole. Furthermore, the Santa Maria case has been carefully documented.

(a) Public network

With regard to Figure II.2 shows the detailed design for one of the sewerage collection micro-systems in Santa Maria. A micro-system in this context refers to the network that drains into a single collection point for treatment, elevation or interconnection with the trunk network. The figure clearly illustrates the standard features of the condominial model with public network sewers bordering each city block in order to provide a suitable collection point. The system uses a very low network density, occupying less than half of the city streets. As indicated in Table II.1 above, this results in an average public network length of approximately 2.8 meters per connection, considerably lower than the equivalent parameter for conventional systems, which is approximately 5.6 meters per connection.

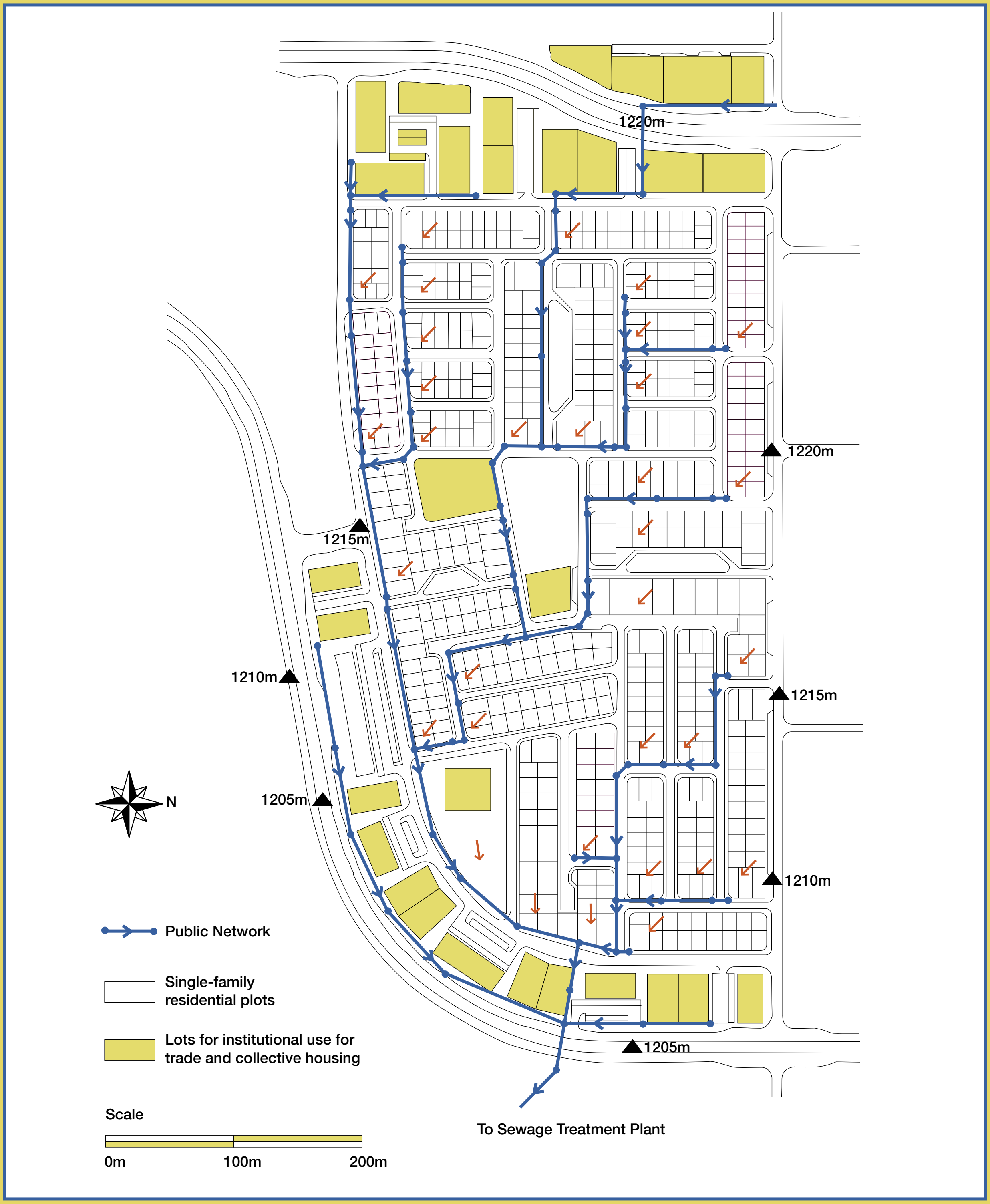
Excavation works, Brasilia

Figure II.1: Overall design concept for condominial sewerage system in Santa Maria



Source: Mello, P.L. de (1998), *Sistemas Condominiais de Esgotos e sua Aplicação na Capital do Brasil*

Figure II.2: Illustration of typical micro-system in Santa Maria

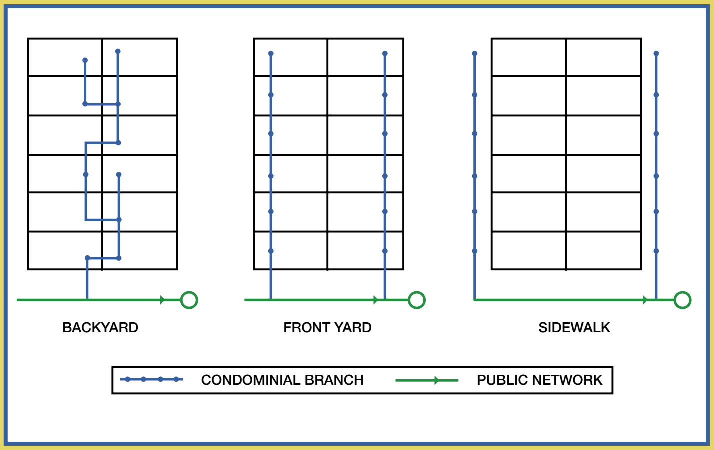


Source: Mello, P.L. de (1998), *Sistemas Condominiais de Esgotos e sua Aplicação na Capital do Brasil*

Wherever hydraulics and technical norms on drainage permitted, the network made use of the minimum pipe diameter of 100 millimeters, applied to 51.2 kilometers (equivalent to 56% of the total length of the system). An additional 26.5 kilometers of the network (representing an additional 29% of its total length) were rendered in pipes 150 millimeters in diameter, while a mere 2.7 kilometers of the network utilized pipes 250 millimeters in diameter (in other words, no more than 3% of the total). Conventional network design usually calls for a minimum pipe diameter of 150 millimeters.

Furthermore, pipes were buried at a depth of up to 1.20 meters, but ensuring a minimum depth of 0.50 meters and allowing the substitution of the traditional high-cost manholes with simple inspection chambers. These accounted for 84% of the total of 2,132 inspection devices that needed to be installed, providing one inspection point for every 24 meters of the network, which is more than adequate for operational purposes. Minimum depths in conventional networks are usually 1 meter to 1.30 meters. The cost of inspection chambers is only one tenth of that of traditional manholes, thanks to savings in excavation, compacting and back-filling as well as in chamber materials.

Figure II.3: Alternative options for routing condominial branches



Source: Mello, P.L. de (1996). *Sistemas Condominiais de Esgotos e sua Aplicação na Capital do Brasil*

(b) Condominial branches

The condominial branches adopted not only in Santa Maria but in all the condominial systems throughout the metropolis were required to conform strictly to standards of pipe location, hydraulic capacity, material specifications and building regulations. Few changes were made to the usual norms on hydraulic capacity employed by CAESB and other Brazilian utility companies. To summarize: minimum diameter pipes of 100 millimeters (virtually throughout); minimum slope of 0.005 meters per meter; use of PVC pipes for sewerage systems; interconnections with the main network through inspection boxes or chambers; and minimum depths of 0.60 meters (outside the plot) and 0.30 meters (inside the plot). Exceptions to the above were made only in response to highly localized circumstances that demanded adjustments to accommodate specific features of the physical environment.

As for the location of the condominial branches, the requirements established by CAESB and the local government permitted a great deal of flexibility. Three location alternatives were offered to the population: routing through the backyard, the front yard or the sidewalk (Figure II.3). The backyard option, and to a lesser extent the front yard option, had the advantage of being significantly cheaper to build due to shorter lengths and shallower depths of excavation. However, the potential disadvantage is that they are inaccessible to utility company staff, placing the responsibility for maintenance on the household. These advantages and disadvantages have led to considerable technical debate about the relative virtues of the different alternatives.

In the case of Brasilia, the final choice on the routing of the branches was taken by majority vote at the level of each condominium. Table II.4, for example, shows the choices finally made by the "condominiums" that were served by the condominial system at that time (1996). These consisted of a universe of 114,000 inhabitants in the peri-urban settlements (excluding the more affluent neighborhoods of the capital). The population clearly was divided over whether to place the branches at the front, the back or under the sidewalk. Overall, 51% opted for routing under the sidewalk, while 43% chose the front yard. The backyard was the least popular option, accounting for only 6% of connections. While this decision was usually based on weighing economic savings against the inconvenience of assuming responsibility for maintenance, in some cases choices were dictated by local topographic conditions or urban density considerations. In some quarters, sidewalk branches were viewed as conferring a higher social status.

It is interesting to compare the preferences of the peri-urban settlements with those of the affluent neighborhoods in the capital (Lago Norte and Lago Sul), which participated in the project beginning in 1997. The predominant choice in those areas was for internal installations, particularly for branches routed through backyards. Pragmatism evidently played a role in this decision given the existence of very spacious backyards, reasonably favorable topography and especially residents' desire to avoid the costs involved in digging up and replacing expensive paved areas along the front of their plots.

In their various forms, the condominial branches of Santa Maria covered a total length of 192.2 kilometers, which is to say double the equivalent length of the public network. The network design incorporated 23,350 inspection boxes, equivalent to one inspection point for every eight meters of piping, which in practice amounted to one box for each connection on the network. This provided plenty of access to the system for inspection during the construction process, as well as for cleaning during subsequent maintenance.

Table II.4: Community choices regarding type of condominial branch

Localities	Population	Condominial Branches (units/type)			
		Backyard	Front yard	Sidewalk	TOTAL
M-Norte, Veredas, Areal e Outras	61,992	0	3,709	8,066	11,775
Paranoá	38,143	511	5,106	1,678	7,295
Vila Planalto e Guará	9,752	787	484	484	1,755
Candangolândia	4,427	0	96	1,099	1,195
Total	**114,314**	**1,298**	**9,395**	**11,327**	**22,020**
Percentage		**6 %**	**43 %**	**51 %**	**100 %**

Source: CAESB (1996) *Esgoto Condominial no Distrito Federal*

II.4 Financial Aspects

The total cost of the public network amounted to US$1.7 million, whereas the cost of the condominial branches totaled US$2.8 million. The condominial branches accounted for 60% of the total cost of the expansion. Given that these costs were covered by the beneficiary communities, this arrangement represents a significant reduction in the financial burden assumed by the utility company. At the same time, it is estimated that consumers paid no more for the condominial branches than they would have had to pay for conventional household connections.

With regard to the public network, the cost of one meter of network built equals US$19. This can be broken down into its constituent parts: 13% spent on inspections (inspection chambers and boxes), 19% on materials and 68% on laying the network. These low costs reflect the advantages of the condominial model (in terms of reducing network size, excavation work and keeping disruption to a minimum), as well as the fortuitous presence of local circumstances such as suitable topography and the type of prevailing urbanization, both of which allowed the excavation depths to be reduced.

CAESB took great care to guarantee that the fee structure for connection to and use of the condominial systems clearly reflected the relative costs of the different options and that consumers benefited fully from the savings associated with the lower-cost choices (Table II.3). The connection fee was equivalent to the actual average costs of constructing the infrastructure for each type of condominial service.

The connection fee for the three different types of condominial service ranged from US$47 (backyard) to US$84 (sidewalk) in the peri-urban settlements, and from US$123 (backyard) to US$256 (sidewalk) in the capital. This geographical differentiation reflects the much larger plot sizes of the houses served in the capital, necessitating a greater length of network per connection and hence a higher cost. Households had the option of either having

Micro-meter and Condominial Box, Brasilia

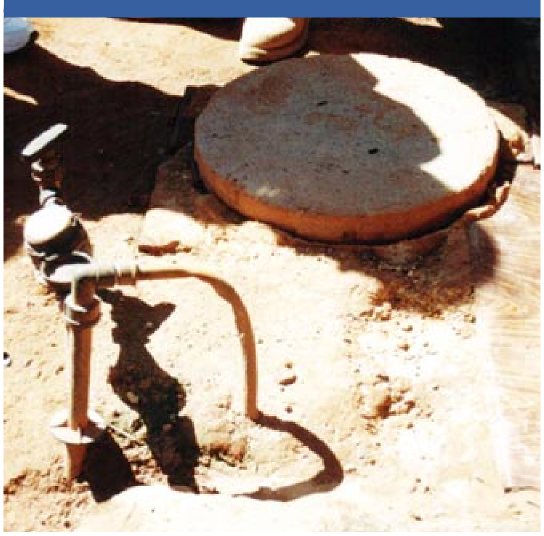


Table II.3: Connection fee for alternative types of condominial connections (US$)

	Cost of implementation of condominial branches		
	Backyard	Front yard	Sidewalk
Peri-urban settlements	47	59	85
Capital neighborhoods	89 to 123	236	256
	Sewerage charge as percentage of water bill		
Conventional	100		
Condominial	60		100

Source: CAESB (2001) *Sinopse do Sistema de Esgotamento Sanitário do Distrito Federal* the utility execute this work directly for a fee or of doing the work themselves under supervision by the utility company. In the latter case, the beneficiaries did not have to pay the connection charge but were expected to cover the cost of materials. About 1.5% of the connections made under the program were constructed using this approach.

Similarly, system use fees were differentiated to provide a discount of 40% on the standard sewerage charge for households opting for backyard or front yard condominial branches, and therefore assuming the associated maintenance responsibility.

II.5 Social Aspects

The success of the condominial approach in Brasilia was largely due to the coherent discourse adopted by CAESB and the local government authorities. From the beginning of the project, authorities carefully responded to the inevitable question: "Why substitute the existing system model for a new one in the federal district?" Local residents were largely unfamiliar with the new system, whose lower cost seemed to denote lower quality. Authorities responded by providing a clear technical justification, underscoring the political support for the system and promoting a consistent policy to apply the new model in the company's entire service area. This last point was particularly important for avoiding any potential perceptions of inferiority. The following excerpt from the project literature illustrates how effectively this issue was addressed.

> *"The new model was studied by CAESB technical staff responsible for the sewerage division of the company, and visits were made to localities where the model had functioned for a number of years (in particular, the city of Petrolina in the State of Pernambuco). Large-scale experiments were conducted in a number of different areas of the federal district before it was promoted as a universally accessible system. It was approved at the technical level and accepted by all relevant authorities beginning with the governor. It was subsequently adopted as the single model to be implemented throughout Brasilia."*

Beneficiaries of the Condominial Model, Brasilia

The process of social intermediation began with high-level meetings in each of the localities, with the participation of community leaders and senior representatives of the utility company.

The purpose of the meetings was to explain the condominial system and to present the three basic options available for its design. In addition, meetings were used to elect a representative for each condominium, who was a key figure in terms of encouraging sustained social participation, facilitating agreements among neighbors and inspecting the works. During the meetings, the draft terms of agreement was circulated. Each condominium had to complete this document to confirm its commitment to participate as well as to indicate the specific details of its chosen system. Great care was taken to transmit the concepts to the population in simple language, as well as to promote the exchange of ideas among participants and to allot time for answering questions.

Some 5,000 meetings were held with a total of 57,000 participants. The meetings always took place in the evenings in a location near the condominium (generally a school or one of the condominium houses). At least two individuals nominated by CAESB were present: the coordinator plus an assistant. The

Peri-urban households, Brasilia

former directed the meeting whereas the latter was responsible for administrative aspects (attendance records, recording the names and addresses of elected representatives, etc). Members of the CAESB supervisory team attended some of the meetings when necessary.

In spite of the inevitable disagreements that arise between neighbors, not one of the condominiums failed to reach consensus over the appropriate course of action and to sign the corresponding terms of agreement. Nor did the consensus-building process lead to any delays in the execution of the works. Moreover, in general, the degree of mobilization tended to increase with the number of meetings held. As the numbers attending meetings grew, time spent on clarifying doubts and seeking adherence to the program tended to diminish. In many cases, people had had limited contact with their neighbors before the projects began, but this changed as the program progressed. In effect, the project was instrumental in building social capital within the participating neighborhoods. Social mobilization was more limited, however, in the affluent neighborhoods of the federal district, where people faced greater time constraints, as is typical in larger cities.

In those communities that opted to build their own condominial networks rather than have them constructed by the utility company, social inter mediation was more intense, often requiring additional meetings.

II.6 Operational Aspects

It is interesting to compare the different maintenance challenges of the condominial and conventional systems. Unfortunately, CAESB makes no distinction between the two types of sewerage systems in its routine maintenance records, or at least not in a way that would permit rigorous performance comparisons. Nevertheless, Tables II.5 and II.6 below represent a specific effort by the company to provide information on obstructions in the sewerage network. The first table covers a one-year period beginning in June 1996 for the western sector of the federal district, where approximately 60% of the condominial systems were operating at the time. The second table covers the entire Brasilia network for the period May 1997 to December 1998.

When making comparisons between the conventional and condominial systems, two considerations should be taken into account. First, in order for such comparisons to be valid, it is necessary to have maintenance data for incidents occurring in the household connections of the conventional system since these play a similar role to the condominial branches in the condominial system. This information is only available in the case of Table II.6. Second, maintenance incidents are reported per kilometer of network. However, the condominial system serves the same population with a shorter overall network length, therefore, simple comparisons of incidents per kilometer of network will tend to understate the difference between the two systems. Indeed, for water service, the length of the condominial network is at most 25% of the conventional network length, whereas in the case of sewerage the percentage is approximately 45% of the conventional network length. These differences suggest that there are fewer maintenance incidents per customer for the condominial system, even while the number of incidents per kilometer is quite similar.

A number of conclusions may be drawn from the information provided in Tables II.5 and II.6. A general finding that emerges from both sets of data is that, in condominial systems, obstructions are much more likely to occur in the public network than in the condominial branches. Thus, the data show between 3.2 (Table II.6) and 3.9 (Table II.5) times as many obstructions per kilometer of public network than per kilometer of condominial branches. There are two potential explanations for this: either the condominial branches are less prone to obstructions, or the users are better placed to resolve simple obstructions on their own initiative. Comparing conventional and condominial systems, the data show that the overall incidence of obstructions per kilometer is relatively similar for the two systems, with the ratio for conventional versus condominial ranging from 0.90 to 1.20. However, the data on conventional branches, which are usually laid in the middle of streets, show 1.7 times as many obstructions per kilometer as condominial branches that perform the same function. Finally, the time taken to perform repairs is roughly similar for the two systems.

Table II.5: Occurrence of sewerage maintenance incidents in Brasilia (June 1996 to June 1997)

	Length (kms)	Percentage of total	Monthly service requests	Percentage of total	Requests per kilometer per month
Condominial					
(A) Condominial branches	713	22%	782	9%	1.10
(B) Public network	398	12%	1,710	20%	4.30
Total (A+B)	1,111	34%	2,492	29%	2.24
Conventional					
(C) Public network	2,153	66%	5,970	71%	2.77
Overall total (A+B+C)	**3,264**	**100%**	**8,462**	**100%**	**2.59**

Source: Data provided by CAESB

Table II.6: Occurrence of sewerage maintenance incidents (May 1997 to December 1998)	Length (kms)	Total service requests	Monthly service requests	Requests per kilometer per month	Average duration of repair (mins)
Condominial					
(A) Condominial branches	1,080	18,666	933	0.86	141
(B) Public network	550	30,652	1,533	2.79	148
Total (A+B)	1,630	49,318	2,466	1.51	149
Conventional					
(C) Connecting conventional pipes	1,045	30,775	1,539	1.47	144
(D) Public network	2,172	57,282	2,864	1.32	178
Total (C+D)	3,217	88,057	4,403	1.37	161
Overall total (A+B+C)	**4,847**	**137,375**	**6,869**	**1.42**	**158**

Source: Data provided by CAESB

II.7 Institutional Aspects

As indicated above, the condominial model in Brasilia was implemented in a deliberate, cohesive manner and received support from the highest levels of the utility company and local authorities.

At the outset of the expansion process, CAESB had recently restructured into two specialized divisions (water and sewerage). Since the condominial innovation was concentrated in the sewerage service, this structure facilitated the raising of awareness about the condominial approach within the sewerage division. CAESB subsequently reverted to a pre-existing operational structure, where water and sewerage operations were under unified management and sub-divisions were based on geographic areas. This change shifted the balance of power within operations towards the larger and more established water supply teams, which had no prior experience with condominial systems.

Nevertheless, internal training activities served to raise awareness and understanding of the condominial approach. Furthermore, the management division specifically responsible for implementing the condominial process within the company survived these internal changes. This division oversees all activities related to the development of the model, planning its expansion and improvement and undertaking mobilization initiatives such as delivering information and sanitation education to users.

With regard to the institutional responsibility for the social intermediation activities, CAESB initially employed firms with experience in handling participatory events of this kind, and subsequently created the conditions for a workers' cooperative to assume the task of meeting program requirements. At the same time, CAESB created a permanent in-house team which, during the implementation phase, was responsible for supervising the above initiatives and training professionals in this field of expertise.

II.8 Summary

The Brasilia case illustrates the feasibility of applying the condominial approach on a large scale and obtaining substantial cost savings without any adverse consequences for subsequent operation and maintenance of the system. In its implementation of the model, Brasilia was evidently favored by an exceptionally orderly history of urban development. The successful application of the model also reflects a number of wise decisions taken by the local authorities. Moreover, the utility company made firm policy decisions with regard to technology choice, communicated these policies clearly to the public, adapted its internal structure accordingly, and applied the new model in a non-discriminatory manner in the entire service area. Furthermore, the utility company provided residents with clearly defined alternative system designs and ensured that the associated cost savings were adequately reflected in lower user fees. All of these factors undoubtedly contributed to increasing the acceptability of the model among the general public.

Middle-class household in Brasilia

Condominial Box (seen open in the right hand lower corner), Riacho Fundo, Brasilia

Condominial Branch (showing a "T" connection and an Inspection an Cleaning Access Point –TIL in portuguese), Brasilia

III. Salvador de Bahia: Large-scale Experimentation with Condominial Sewerage

III.1 City Profile

Salvador, the capital of the State of Bahia, is the largest city in northeastern Brazil, with a population of approximately 2.5 million. As Brazil's first capital, Salvador is also one of the country's oldest cities, with an exceptionally rich cultural and historical heritage. The city is located in a beautiful natural setting, perched between the Atlantic Ocean and the ***Bahia de Todos os Santos*** (Bay of All Saints). Its cultural and geographic wealth has made it a major tourist destination.

Nevertheless, over half of the population lives in unsanitary urban slums. These densely populated peri-urban settlements are precariously built, often clinging to steep hillsides or occupying other unsuitable land. Many of the dwellings are built in a chaotic fashion, virtually on top of one another (on three or four levels) and are packed together on all sides. Due to the spontaneous and disorderly development of these neighborhoods, little attention was paid to the installation of sewerage systems. As a result, household sewage is typically discharged to stormwater drains in violation of all regulations on the separated systems.

Evidently, these types of neighborhoods present a major challenge for the development of sewerage systems. In particular, the application of conventional sewerage in such a setting appears to be virtually impossible, providing a pretext for ignoring the problem. Nevertheless, by the early 1990s, the discharge of sewage into the stormwater drainage system had led to serious environmental problems in the fragile ecosystem of the *Bahia de Todos os Santos.* Once the system started to contaminate bathing beaches, it became a threat to the leisure and tourism industries central to the local economy, motivating local authorities to take decisive action to resolve the problem.

III.2 Evolution of the Condominial Model

In response to this situation, the Bahia State Government negotiated a US$400 million package of financial support from the World Bank, the Inter-American Development Bank, the Japan Bank for International Cooperation, Brazilian development banks (CEF and BNDES) and the Bahia State Government. This led to the creation of the *Bahia Azul* (Blue Bay) program, whose objective was to prevent the contamination of the *Bahia de Todos os Santos* by installing a city-wide sewerage network. Responsibility for implementation of this program fell to the Bahia Water and Sewerage Company (EMBASA), the official concessionaire for virtually all water and sewerage systems in the state.

Table III.1 demonstrates the size and basic features of the program. The figures, taken from the EMBASA database, refer to the situation of the works in June 2000 in each of the 21 drainage basins where sewerage systems were installed. However, these figures should be viewed with caution, particularly when they refer to the condominial model since the technology used differed from basin to basin, and since additional works were undertaken in some of the basins both before and after the Blue Bay program. Moreover, the figures reflect an imbalance in the financial outlays in the different basins because the cost of large interceptor pipelines, used to concentrate sewerage flows at a single point in the city, are also included in the costs for some of the basins. In order to overcome these deficiencies in the aggregate information, subsequent discussion will focus on detailed information for two specific basins.

In contrast to Brasilia, the adoption of the condominial system in Salvador was not the product of conscious decision-making. Indeed, at the outset of the Blue Bay program, little was known about the system. Moreover, there were many misconceptions about the model, which was viewed as a "sewerage system built inside dwellings" or a "low quality system for the poor." As a result, the model was adopted gradually over a long period of time, and in response to specific constraints and challenges experienced on the ground. Three distinct phases can be identified in its evolution.

Table III.1: Sewerage basins in Salvador

Localities	Population (2000)	Households (projected)	Public network (kms)	Condominial branches (kms)	Total investment(*) (US$ million)	Investment per household (US$/cx.)	Investment per person (US$/cap.)
Alto Camurugipe	163,726	43,833	105.1	200.0	13.1	298	80
Alto Pituaçu	155,000	13,077	71.8	85.0	8.8	671	57
Aratu / Macacos	8,638	1,268	10.9	3.1	2.6	2,029	298
Baixo Camurugipe	100,000	13,465	47.3	91.7	8.0	594	80
Baixo Jaguaribe	20,815	1,000	12.2	0.0	7.5	7,522	361
Baixo Pituaçu	29,000	3,200	15.5	14.5	3.5	1,101	122
Calafate	82,000	4,139	34.3	51.8	6.4	1,546	78
Campinas	90,000	13,610	47.0	72.4	11.1	816	123
Cobre	80,000	8,608	43.6	50.8	9.1	1,052	113
Comércio	58,000	7,682	62.6	14.0	5.6	732	97
Itapoã	25,500	2,800	53.5	10.0	6.2	2,206	242
Lobato	64,000	2,867	45.1	47.2	6.7	2,337	105
Mangabeira	140,000	15,413	126.7	59.6	19.4	1,259	139
Médio Camurugipe	55,000	4,620	35.7	56.7	7.5	1,625	136
Médio Jaguaribe	16,504	2,100	13.3	14.0	2.8	1,344	171
Paripe	98,484	11,397	54.5	92.5	7.8	680	79
Península	115,700	7,495	35.5	99.0	14.8	1,975	128
Periperi	124,000	11,787	75.4	77.2	19.1	1,617	154
Pernambués	70,000	13,581	47.3	66.0	6.9	506	98
Saboeiro	99,686	10,300	14.9	11.6	9.8	947	98
Tripas	133,000	21,732	74.0	60.0	9.8	450	73
Total	**1,729,053**	**213,974**	**1,026.1**	**1,177.1**	**186.3**	**871**	**108**

Source: EMBASA (2000) *Indicadores dos Sistemas de Esgotos - Programa Bahia Azul*
(*) Does not include sewerage treatment costs.

During the first phase, the condominial model served to fill gaps in places where urbanization patterns effectively ruled out the use of conventional systems, for example, along rough tracks and up steep alleys and flights of steps rising between houses. Nevertheless, the system, though inspired by the condominial model, did not constitute an integral application of this model. A key difference was the absence of any clear delineation between the condominiums that form the fundamental building blocks of condominial networks. As a result, the condominial branches were almost always confused with the public network and there were either too many or too few of them used in the design of the systems. In addition, local community participation was confined to specific localized agreements negotiated to allow pipes to be laid on private property.

The second phase began in 1994, when the Blue Bay program was implemented on a much larger scale. This period was characterized by the formal introduction of the condominial model, which thereafter would be present to a greater or lesser extent throughout the life of the program. Throughout this phase, employment of the condominial model was almost entirely confined to the highly precarious urban slums, while use of the system in more typical urbanized areas was limited. Moreover, the extent of adoption of condominal principles and practices varied considerably among the different contractors involved in the project.

From 1997 onward, the condominial model effectively began to be applied throughout the city, regardless of the type of topography, style of urbanization or incomes of the populations benefiting from the program. Indeed, the model would eventually be applied in locations as diverse as the *Bacia do Comércio* (one of the oldest and most traditional parts of the city, incorporating the historic center) and the much poorer outlying peri-urban settlements.

The essential dynamic was one of growing enthusiasm for the system as its advantages became apparent in the areas where it was first applied. As a result, there was insufficient time for the full know-how to be transferred and absorbed. Instead, numerous amendments and adjustments had to be made on a day-to-day basis as construction progressed. The various contractors proceeded to make different changes where and when they were considered necessary. While the main elements of the condominial model were introduced in this piecemeal fashion, the overall result was that the procedures and standards forming the backbone of the condominial system eventually prevailed.

III.3 Engineering Aspects

The engineering designs used to adapt the condominial model to the challenging local conditions of Bahia showed considerable creativity and ingenuity, entailing new approaches such as pressurized sewerage networks, pipes that "cut across" residences, "over-ground" pipes and the use of large vertical drop pipes (*tubos de queda*) that will be described in greater detail below. However, the condominial principles were applied only at the local level, where challenging circumstances demanded, and were not reflected in the macro-design of the project. The latter was based on the idea of concentrating the entire effluent of the city at a single point where it could be discharged via a major

Household meter in Sao Caetano, Salvador de Bahia

marine outfall, which would entail high transportation costs to centralize the sewage. An alternative approach that was not considered —but which would have been more in line with condominial principles— was to keep the effluent decentralized within the local basins and drain it into small-scale treatment plants.

The following discussion presents an overview of the engineering designs, focusing on two specific and contrasting basins. The first is *Bacia da Peninsula*, which is one of the oldest slums in Bahia. It is characterized by low-lying land prone to flooding, and

Figure III.1: *Peninsula* Basin

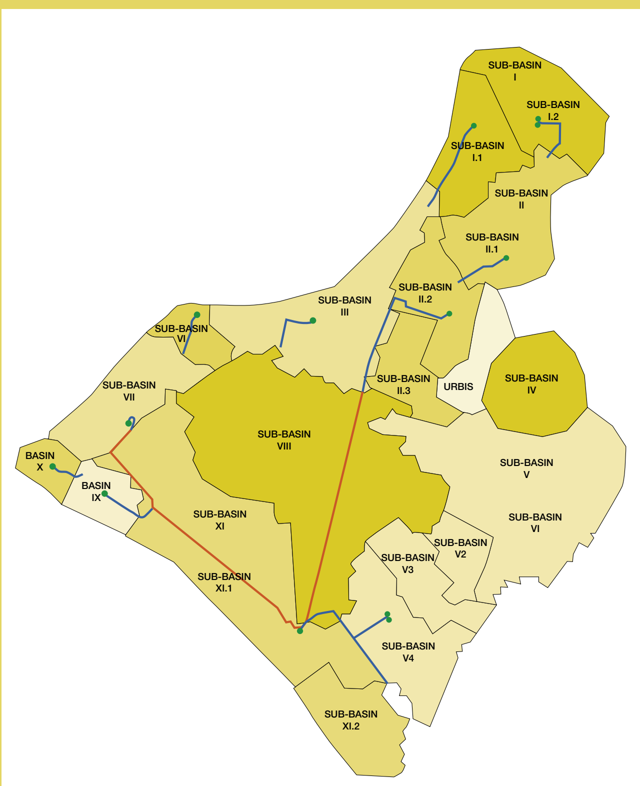
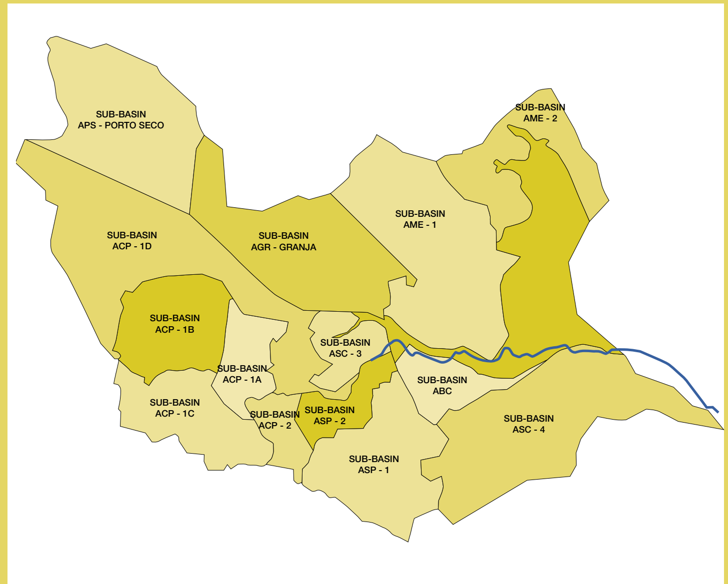


Figure III.2: *Alto Camurujipe* Basin

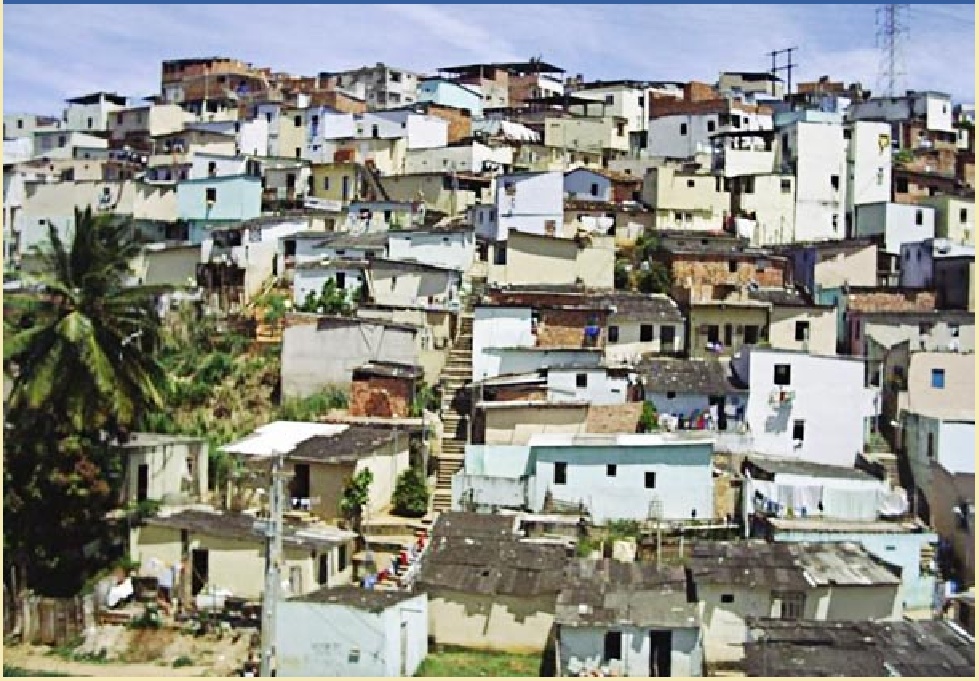


is relatively sparsely populated by a diverse population with varying income levels. The second is *Bacia do Alto Camurujipe*, which is one of the largest and poorest unplanned urban settlements in the city (see photo next page). It is a complex urbanization occupying steep hillsides, with precarious structures, high population density and widespread poverty. Figures III.1 and III.2 show the locations of the two sub-basins in the city.

(a) Public network

Figure III.3 illustrates the design of the public network in *Alto Camurujipe* basin. It clearly illustrates the key characteristics of the system, with the sewers skirting each block of housing to provide a single sewage collection point. As a result, the density of pipes needed to serve the areas is low. In general, these networks were conceived and located in situ in accordance with condominial guidelines, but tended to employ larger-diameter

Illustration of *Bacia do Alto Camarujipe*



pipes than would be strictly necessary for a condominial design —a minimum of 150 millimeters as opposed to the 100 millimeters that would have been justified by the hydraulic conditions. It is interesting to contrast some of the design features of the two basins, which largely reflect the different topographical conditions of each.

Bacia da Peninsula

In *Bacia da Peninsula*, the key engineering challenge was posed by the flat terrain just above sea level, combined with a very shallow water table with much of the sub-surface already occupied by other infrastructure. It was therefore critical to keep the network as near to the surface as possible. This was achieved by limiting the depth of the installations to three meters. To this end, the sidewalks were exploited for the basic network, using maximum depths of one meter and minimum depths dictated by the outflows from the condominial branches. A key challenge was to protect the pipes of these shallow networks, which had to stretch from one sidewalk to another under roads, that are normally subject to heavy vehicle loads associated with traffic. Two alternative strategies were used. The first was to lower the depth of the pipes by one meter where possible before crossing the street and “recovering” the shallower depth with minimum slopes on the opposite sidewalk. The second strategy was to use special protection for the pipes that had to be routed across the street at the shallower depth. When neither of these alternatives proved feasible, the maximum depth of three meters was assured by using small subterranean automated pumping stations placed on public lands to avoid expropriation issues.

Figure III.3: Design of public network for *Bacia do Alto Camarujipe*

Bacia do Alto Camajuripe

In *Bacia do Alto Camajuripe*, the key engineering challenge was posed by the very steep gradient and dense urbanization, which frequently occupied the banks of local rivers and creeks. One advantage of the topography was the possibility of installing long stretches of pipes under the sidewalks, where the shallower depth meant that standard manholes could be replaced by much lower cost inspection chambers. Nevertheless, the nature of the terrain posed many other difficulties, leading contractors to develop a range of innovative approaches, which —while they diverge from standard practice— illustrate a fundamental commitment to meeting the needs of the population under any circumstances. There are four particularly noteworthy examples, namely: pressurization of the sewerage system; large vertical pipes; surface routing of sewers; and aerial networks.

Pressurized systems. The typical sub-basins in this area have a semi-circular shape, with dense urbanization occupying the natural drainage areas along local creeks, where trunk collectors would normally be routed (see photo). Wherever space constraints prevented a traditional gravity-based collector from being installed, pressurization of the sewerage system was used as an alternative. This led to the installation of two independent concentric collector systems within the micro-basin, separated by a strip of land. The higher one, which accounted for at least 80% of the total load, discharged into a pressurized interceptor located on the available narrow banks, making it possible to transport the effluent at a minimal depth and slope. Further down, because of the narrow diameter of the condominial branches (almost exclusively 100 millimeter), the remaining 20% of the load, flows entirely by gravity until the junction where the effluents are collected and redirected to the main system by a small pump.

Illustration of the area requiring pressurized sewers

Large vertical drop pipes. One of the sub-basins in this area presented a further peculiarity calling for a unique solution. This was the case of an area whose natural outlet consisted of a ravine approximately 20 meters deep, the bottom of which was occupied by an informal settlement. The solution to this problem was to use a vertical drop pipe consisting of a 150-millimeter cast iron pipe fixed to the wall of the ravine with clamps, protected by concrete casing and ending in a pressure-break box at the base, which also served as an initial manhole. The sewerage network serves the informal settlement and the drop-pipe structure has functioned perfectly since it was installed in 2000.

Surface sewers. In other parts of the basin, the natural drainage channel between houses was so narrow that it could not contain normal stormwater flows without flooding the surrounding houses. The solution to this problem was to raise the level of the houses above the flooding level to permit construction of the collector above ground without disturbing the sewerage system of the abutting houses. The superficial sewer was protected by concrete encasement, which had the added advantage of providing a sidewalk to facilitate the movement of local residents (pictures of surface sewers). This approach proved to be much more cost-effective than burying the collector in the rocky terrain and has since been widely used both in Salvador and other Brazilian cities with rocky terrain.

Illustration of surface sewers

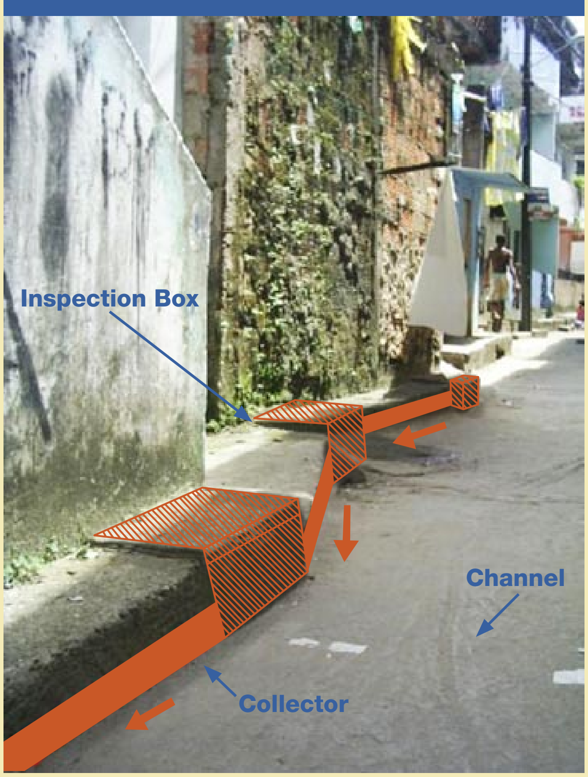


Illustration of surface sewers

Aerial sewers. An extreme case of the aforementioned approach had to be used in cases where urban density was even higher and water runoff was not adequately covered or channeled. In these cases, flooding is usually prevented by placing the lower floors of the houses above the runoff level. This normally enables the installation of network branches bordering the houses, above the water runoff channels, either by using pipes attached to the house walls or supported on pillars.

(b) Condominial branches

The combined length of condominial branches installed in Salvador had reached approximately 1,177 kilometers by 2000 (Table III.1) and may now be as much as 2,500 kilometers.

EMBASA established general standards for the design of condominial branches for the contractors executing the works. Rather than allowing the diameter of the pipes to be determined by local hydraulic conditions in each case, EMBASA limited the use of 100-millimeter pipes to the first 20 houses in any condominium, requiring diameters to increase to 150 millimeters for the next 30 houses, and 200 millimeters thereafter. These requirements were driven by the deep-rooted cultural tradition of combining stormwater and wastewater flows, which raised concerns about using narrower diameters for sewerage only. Furthermore, the general preference in Salvador was for PVC pipes.

Notwithstanding these general guidelines, in practice there was considerable variation in the application of the model, reflecting in part the diversity of contractors executing the large-scale program as well as the nature of the challenges posed in the different areas of the city. In general, the depth of the condominial branches was the minimum compatible with discharge requirements from the dwellings, up to a maximum of one meter. Furthermore, inspection boxes were placed at every point of inflow, as well as at network junctions, and near fall pipes in cases where vertical drops exceeded 0.5 meters. A key issue for the communities was the adequate replacement of sidewalks and staircases that had been damaged during the course of the installations.

Regarding the location of the condominial branches, there was general agreement that unconventional routings would be adopted wherever local conditions demanded. In some cases, this entailed routing under steps and narrow alleyways between houses, via the front or back yard, or even inside the houses. Given the numerous technical restrictions on the network design, the usual practice (observed in Brasilia) of allowing households to choose the preferred routing of the network had to be abandoned in Salvador because there was only one viable alternative in each sub-basin.

Figure III.4: Illustration of condominial branch design in *Bacia da Peninsula*

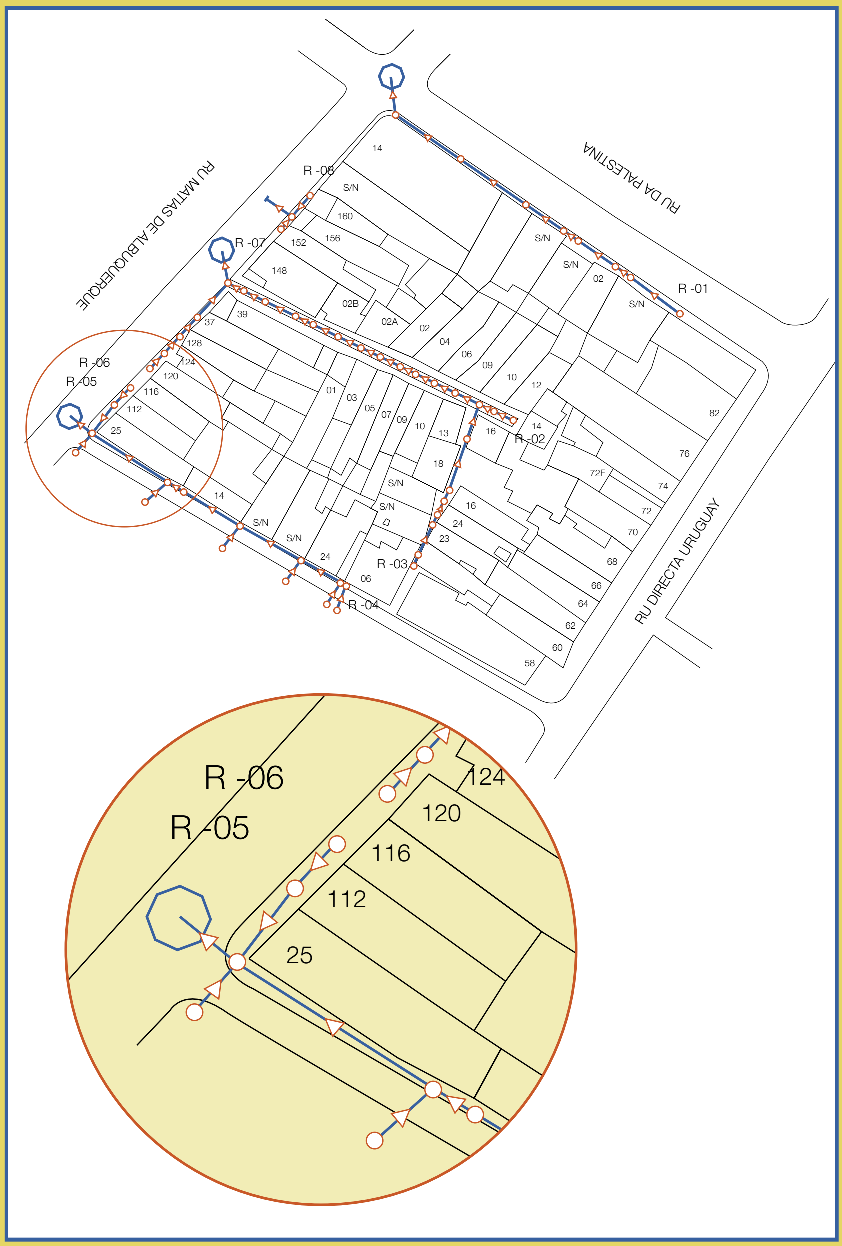


Figure III.5: Illustration of condominial branch design in *Bacia do Alto Camajuripe*

The other key consideration was the need to achieve (as far as possible) a complete separation of stormwater and wastewater systems, which went entirely against the local cultural tradition of combined networks.

Figures III.4 and III.5 illustrate specific examples of design issues for condominial branches. In the first example, taken from *Bacia da Peninsula*, the over-riding concern was to keep the network as shallow as possible to avoid the problems posed by the high sea level and high water table and to prevent the precarious dwellings from collapsing. In the second example, taken from *Bacia do Alto Camajuripe*, the key issue in this high-density area was to determine the actual layout of the pipes. Gradients did not represent a problem whatsoever, since the natural slope was always greater than the established hydraulic minimum (0.005m/m) and constantly uniform pipe depth could be maintained.

III.4 Financial Aspects

The engineering works for the two basins described in the preceding section entailed the laying of 219 kilometers of pipes in the *Bacia da Peninsula* and 394 kilometers in the *Bacia do Alto Camurujipe*, including the public networks, condominial branches and internal installations (Table III.2). Approximately three meters of condominial branches were laid for every meter of public network and the public network was not much longer than the pipe required for internal installations. This averages out to approximately nine meters of pipe overall for each dwelling served in both of these basins, of which only about two meters belongs to the public network and the remainder to the condominial branches.

The overall investment costs amounted to US$7.3 million for *Bacia da Peninsula* and US$11.2 million for *Bacia do Alto Camurujipe*. This is equivalent to a cost per dwelling connected of US$316 and US$256, respectively, excluding the cost of

Table III.2: Cost data for *Bacias da Peninsula* and do *Alto Camarujipe*

	Peninsula	Alto Camurujipe
Total population served	115,700	163,726
Total number of dwellings served	23,217	43,833
Total length (kms)		
• Overall length	218.8	394.3
• Public network	50.4	79.0
• Condominial branches	138.6	240.0
• Internal installations	29.8	75.3
Average length (m)		
• Total per dwelling (m)	9.43	9.00
• Network per dwelling (m)	2.17	1.80
• Branch per dwelling (m)	5.97	5.48
• Internal installation per dwelling (m)	1.29	1.72
Total investment (US$ million)		
• Overall investment	7.3	11.2
• Public network	2.4	4.4
• Condominial branch	3.8	3.3
• Internal installations	1.1	3.5
Breakdown of investments (US$)		
• Overall total per dwelling	316	256
• Per meter public network	48	56
• Per meter condominial branch	27	14
• Per meter internal installations	39	46

Source: EMBASA, 2000

Household meter in Sao Caetano, Salvador de Bahia

downstream trunk collectors, which varies substantially among basins, depending on their geographic location. These low unit costs were achieved by minimizing the length of the public network versus the condominial branches as noted above.The cost per meter of the public network (approximately US$50) is more than twice as much as the cost per meter of the condominial branches (approximately US$20).

With regard to the fees paid by the population, in the case of Salvador, no connection fees were charged since the cost of the investments was entirely subsidized by the Blue Bay program. Nevertheless, households were responsible for covering the costs of internal installations required to re-plumb their sanitary installations so that they drained into the new sewerage system instead of the old stormwater system. EMBASA usually did this work, and the beneficiary households and the utility company agreed on monthly payments.

Prior to the Blue Bay program, most households had some type of drainage system since they were using the stormwater network free-of-charge. With the installation of the sewerage network, households had to pay for this service for the first time. In order to facilitate this process, EMBASA offered two options: either pay the full sewerage tariff with no responsibility for maintenance of condominial branches or accept maintenance responsibilities in exchange for a discounted fee. The discount package proved very attractive to the local population and was widely accepted, although in practice the population has not always honored its maintenance commitments (see next section).

III.5 Social Aspects

The Blue Bay program required social mobilization on an unprecedented scale in Brazil. During the program as a whole, some 10,000 condominiums were established. A series of meetings was organized to address the different program issues. For example, given the urbanization density, the contract work was often very disruptive, requiring careful negotiation with the community. Meetings also focused on securing the signing of the terms of agreement document that governed the future relationship between EMBASA and each respective condominium. Nevertheless, in retrospect, the community intermediation activities were not intensive enough to prevent some serious problems arising with the subsequent operation of the system. These include

Steep Change of Condominial Branch Level
(pipe attached to wall), Sao Caetano, Salvador de Bahia

Children playing on the street, Sao Caetano, Salvador de Bahia

the relatively low collection rate and the lack of adherence to community maintenance obligations.

First, as mentioned above, the local conditions prevailing in Salvador made it particularly challenging to motivate household connection to the new sewerage system. Most households in the affected areas already had internal sanitary installations connected to the stormwater system, which was the source of the environmental contamination observed in the *Bahia de Todos os Santos*. From the household's perspective, this arrangement provided all the advantages of a sewerage system at zero cost. At the same time, switching to the new sewerage network entailed both monetary costs and disruption of service associated with re-routing of plumbing from existing sanitary installations to the sewer, as well as the ongoing obligation to pay a monthly sewerage bill. Moreover, since the resulting benefits took the form of general environmental improvements, they were not always immediately tangible to the household. For all of these reasons, it is not surprising that only around 30% of households in the Blue Bay program intervention area have connected to the sewerage network to date. Increasing this connection rate will require renewed efforts to provide sanitary and environmental education to the local communities. Additional financial incentives may also be needed.

Second, as previously noted, many households opted to assume maintenance responsibilities in return for a lower monthly sewerage fee. However, in practice, these households were not always willing or able to address the maintenance needs arising in the condominial branches, and frequently requested company maintenance crews even though they were theoretically not entitled to do so. In addition, the use of similar diameter pipes for condominial branches and public networks sometimes made it difficult for local residents to determine which segments of the network were their responsibility. The situation could have been handled better in a number of ways. On the one hand, greater efforts could have been made to inform local residents about their maintenance responsibilities. On the other hand, the company could have been more consistent in switching users who requested maintenance crews to the full sewerage tariff as they were imposing maintenance costs on the company.

Sewerage pipe attached to wall, Sao Caetano, Salvador de Bahia

III.6 Operational Aspects

The gradual, unplanned approach that characterized the adoption of the condominial model in the Blue Bay program was repeated when the newly constructed systems were handed over to EMBASA for ongoing operation and maintenance. There were no special efforts to train operational staff on the use of the new system or to adapt existing maintenance procedures to the different characteristics of these networks. As a result, the traditional operational practices developed for conventional networks were also applied to the condominial systems. Gradually, as awareness of the new designs increased, adequate operation and maintenance procedures were adapted.

The three main operational problems experienced with the condominial networks were essentially the same as those experienced with the city's conventional system, and reflect the customs and practices of the local population. First, owing to the history of combined wastewater and stormwater drainage, some parts of the sewerage network were erroneously connected to the stormwater network. This led to several problems, including overload of the network during storms, as well as unwanted litter and earth flushed into the pipes by rainfall and the sedimentation caused by heavier materials settling inside the pipes. Second, the fact that less than a third of the population had connected to the network meant that sewage flows were lower than originally envisaged and therefore not always adequate to transport solid residues. Third, the local population sometimes misuses sanitary facilities to discard solid items, revealing deficiencies in their sanitary education.

III.7 Institutional Aspects

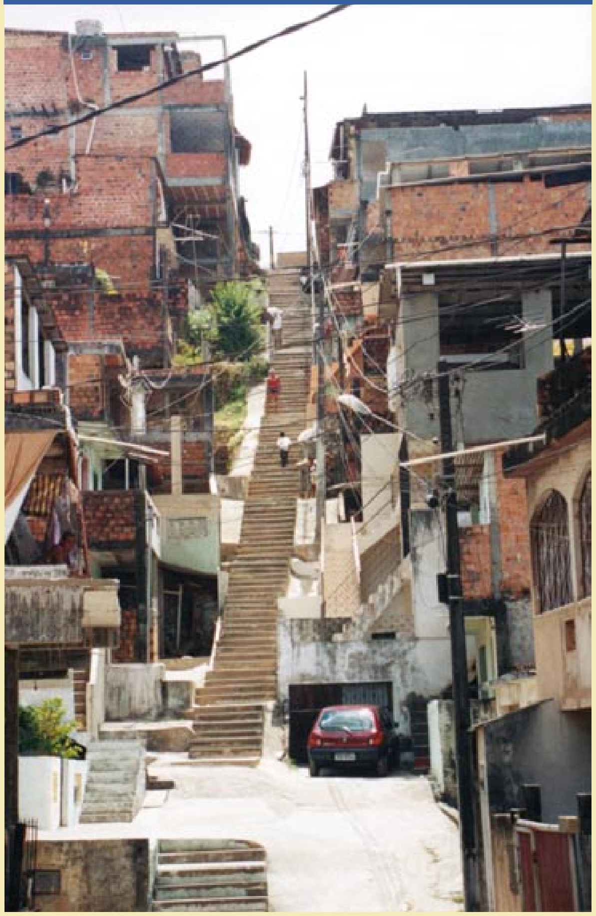
In contrast to the Brasilia case, the local utility EMBASA never made any formal decision to officially adopt the condominial model as a company-wide policy. Nevertheless, following the success of the Blue Bay program, the system has subsequently been adopted in dozens of small towns within the State of Bahia. The use of the model can thus be characterized as much more opportunistic than in Brasilia, and it has not been reflected in or absorbed into the institutional structure of the utility company.

Regarding the implementation of the Blue Bay program itself, the large scale of the initiative, together with the five-year time frame, meant that many different contractors worked simultaneously in different parts of the city, including five or six of Brazil's largest construction firms. When the project began, none of these actors was familiar with the condominial model or with the socioeconomic context of peri-urban slums. This caused that the adoption of the model to be gradual and experimental, proceeding along different parallel lines in areas managed by different contractors.

III.8 Summary

The case of Salvador de Bahia is probably the largest single application of the condominial model. It is also noteworthy for the enormous engineering challenges posed by the city and the extraordinary ingenuity with which they were overcome. A key problem in implementation has been the difficulty in convincing local residents to assume maintenance responsibilities associated with the networks. The main failing of the experience has been the low rate of connection to the sewerage network, undermining the original rationale for the program. However, this problem is not specifically related to the use of condominial technology, but rather is indicative of a wider challenge affecting the expansion of sewerage networks.

Gradients, Sao Caetano, Salvador de Bahia



Excavation works to install the Public Network, Brasilia

IV. Parauapebas: Community Mobilization for Condominial Water

IV.1 City Profile

Parauapebas is located in the State of Pará, 650 kilometers from the state capital, Belém. Established less than 20 years ago, the city owes its history and rapid growth to the development of rich iron ore deposits by the Companhia do Vale do Rio Doce (CVRD). Since its formal incorporation as a municipality in 1988, the population has grown from 20,000 to current levels approaching 100,000. Following its recent privatization, CVRD diversified its mining activities to include copper, gold, nickel and manganese, boosting the development of two neighboring towns (Canaã dos Carajás and Eldorado) and creating one of the most populated mining centers in northern Brazil. Overall, the area can be characterized as a boom town with a frontier spirit.

The City of Parauapebas is a rare example of a well organized urban area among the municipalities of north and northeastern Brazil, on account of its careful urban design and well-planned infrastructure, including a modern road and street system, water supply, sewerage services, stormwater drainage networks and garbage collection, as well as health and education facilities. This situation reflects the municipality's substantial financial resources obtained from mining royalties along with the effectiveness of the last two municipal administrations, which are generally credited with having introduced modern and efficient management.

IV.2 Adoption of the Condominial Model

When CVRD was established in Parauapebas in the late 1970s, the company invested in a water and sewerage system for residents. There was no charge for the systems. Nevertheless, the rapid growth of the city quickly rendered these initial systems obsolete. Thus, by the early 1990s, they were deteriorating and served only a small area of the city. In terms of water supply, only 1,000 residents occupying CVRD company condominiums had access to a regular supply. An additional 5,000 residents of downtown neighborhoods had piped delivery of untreated water from the local river, whereas another 15,000 people relied on contaminated water from wells, public fountains or municipal tankers. The sewerage network served only 6,400 residents in the downtown area, whose untreated effluents were returned directly to the river system. Elsewhere, residents developed their own on-site sanitation solutions, ranging from insanitary pits to septic tanks, which often overflowed onto streets and public areas of the city. The precarious conditions of both services contributed to the proliferation of diseases, particularly gastrointestinal infections, despite major efforts in public health education.

In 1993, a collaboration agreement was signed between CVRD and the Municipal Prefecture of Parauapebas (PMP) with a view to securing a World Bank loan to finance the expansion of water and sewerage services in the city. A loan of US$7.8 million (later increased to US$14.5 million) was disbursed to enable CVRD to finance the necessary works. In return, PMP agreed to earmark 25% (later 27%) of its income from mining royalties to amortize the debt. The original project design entailed construction of a river water intake of 230 liters per second connected to a drinking water treatment plant and a 6,000 cubic meter reservoir. Conventional water and sewerage networks would be developed to serve 90% of the city's population, eventually channeling effluents back into decentralized waste stabilization ponds in five sub-basins of the city (Figures IV.1 and IV.2).

By 1996, the water production system had been completed. However, it became apparent that the remaining funding would not cover the cost of the planned conventional water and sewerage systems. Construction on the network therefore came to a standstill amid allegations of financial irregularities. As a result, CVRD undertook a feasibility study for switching the network designs over to the condominial system with a view to completing the project within the original budget. Once CVRD was convinced of the technical merits of the condominial system, the decision to adopt one of the two systems depended on financial considerations.

The feasibility study for the condominial system was based on the same design parameters as the original (that is, 90% service coverage with a provision of 250 liters per capita per day) and compared the contract prices quoted for the original (unfinished) project to equivalent expenses for a condominial design (Tables IV.1 and IV.2). This analysis predicted cost savings of approximately 70% in the case condominial networks were used to supply water (a unit cost of US$45 versus US$167), and approximately 40% in the case of sewerage (a unit cost of US$56 versus US$94). It also found that in the case of the water service, just over half of the savings would result from the reduced excavation and just under half from the reduced use of materials, while in the case of sewerage about one third of the savings would originate from the reduced excavation and the remaining two thirds from the reduced use of materials. An additional advantage to the system was that the cost savings enabled the financing of water services in the poorest neighborhood of the city (*Bairro da Paz*), which had not been contemplated in the original project, and still achieve a cost reduction of 60% relative to the original scheme. Once these advantages had become apparent, the municipal council and local community representatives approved the adoption of the condominial model and the project was implemented.

Table IV.1: Cost comparison for water systems

	Original conventional design		Proposed condominial design	
	Total cost	Cost per connection	Total cost	Cost per connection
Excavation	454,000	88	101,000	19
Pipes	407,000	79	129,000	25
Total	**861,000**	**167**	**230,000**	**45**

Table IV.2: Cost comparison for sewerage systems

	Original conventional design		Proposed condominial design	
	Total cost	Cost per connection	Total cost	Cost per connection
Excavation	263,000	39	186,000	28
Inspection chambers	181,000	27	85,000	13
Pipes	185,000	28	102,000	15
Total	**629,000**	**94**	**373,000**	**56**

Source for both tables: Condomimium, 1997 'Estudo de Aplicação do Modelo Condominial aos Projetos dos Sistemas de Abastecimento D´Água e Esgotamento Sanitário de Parauapebas-PA'

Figure IV.1: Original conventional water system design for Parauapebas

Figure IV.2: Original conventional sewerage system design for Parauapebas

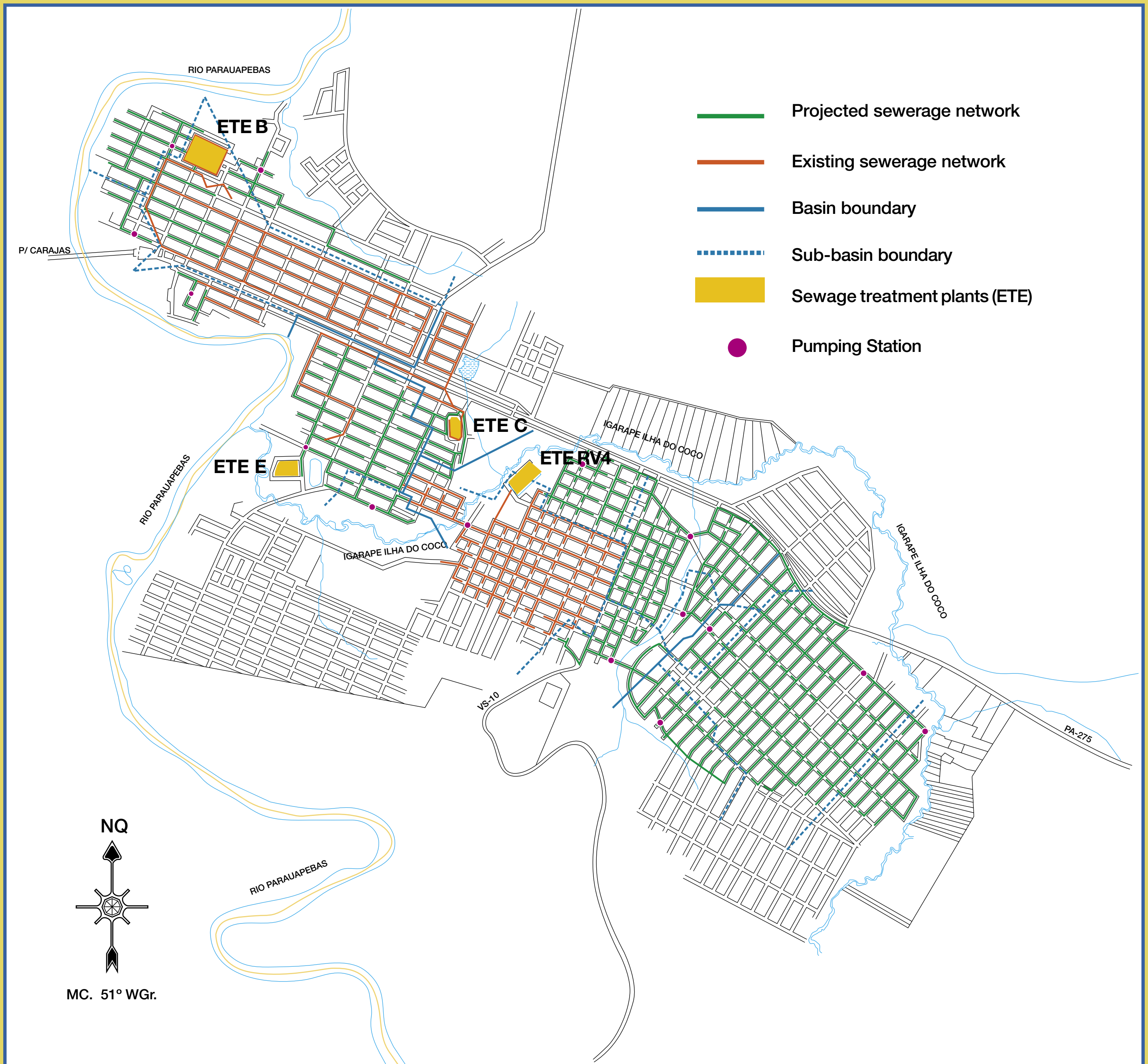
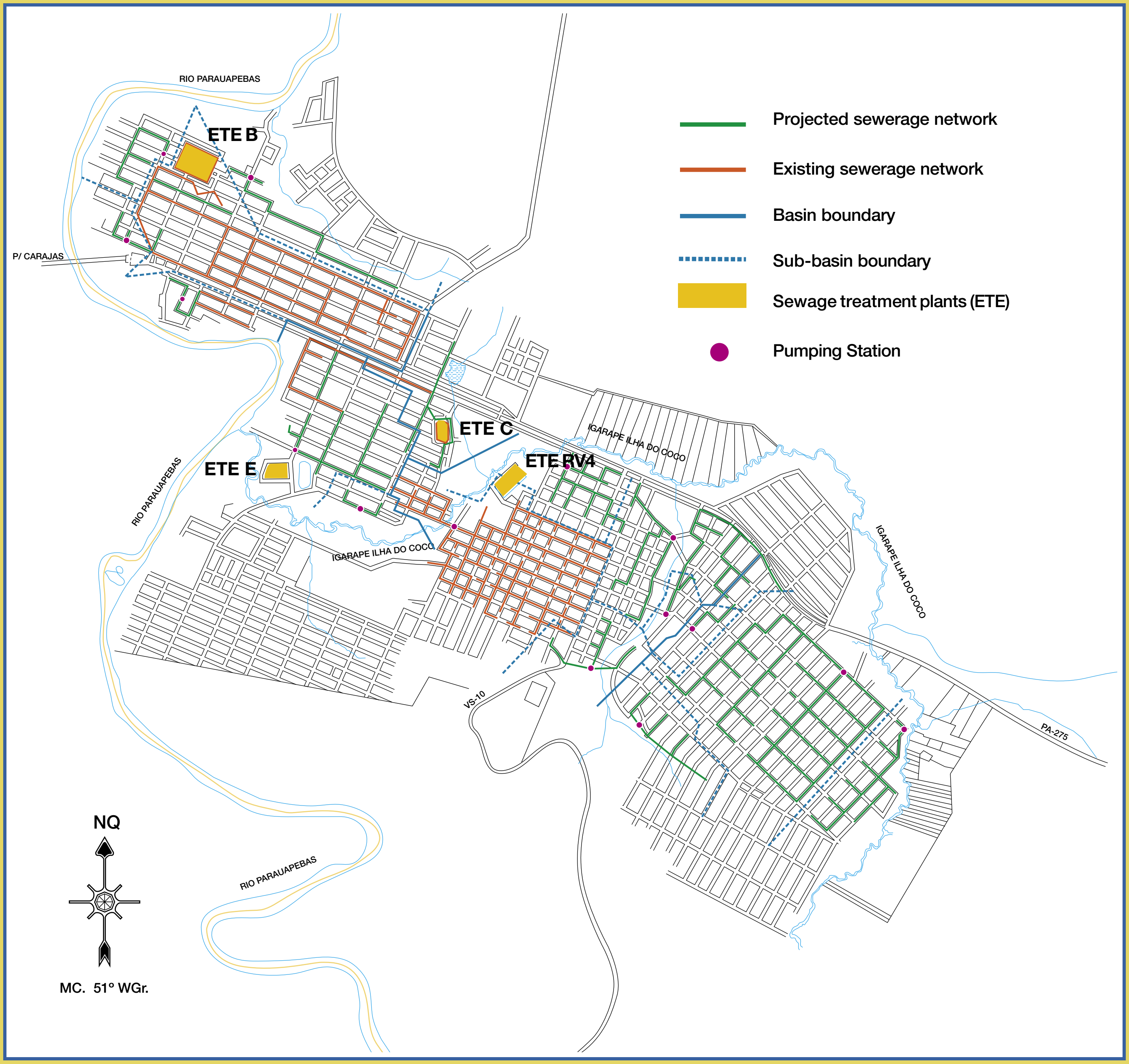


Figure IV.3: Subsequent condominial water system design for Parauapebas

Figure IV.4: Subsequent condominial sewerage system design for Parauapebas



Although the condominial model was applied to expand both the water and sewerage systems in Parauapebas, this case study will focus on the study of the water system. The reason is that while there are other examples of condominial sewerage systems in Brazil (such as the preceding case studies of Brasilia and Salvador), application of the model to the water network is comparatively rare and thus of special interest.

IV.3 Engineering Aspects

Following this decision-making process, the construction of the condominial water distribution system began.

(a) Public network

By the time the construction of the condominial networks began in Parauapebas, the upstream construction associated with the town river-fed water supply reservoir was already complete. This sequencing of events prevented an integral approach to the design of the water supply and distribution systems. In effect, the prior decision to build a single large reservoir imposed a centralized structure on the design of the water distribution network, which was not necessarily the optimal one. For example, in some areas of the city that were not well placed with respect to the reservoir in terms of their relative gradients, the maintenance of prescribed pressure levels proved difficult. This is evident in the fact that the reservoir has a median level of 205 meters above sea level, while about half of the city is located below 165 meters above sea level. The problem could have been avoided by adopting a more decentralized design entailing a number of smaller reservoirs. Given that this possibility had already been ruled out, another alternative would have been to allow a lower pressure service in some areas of the city by introducing pressure-break valves or boxes, since this also would have helped to contain distribution losses caused by the highly-pressurized system. However, this solution was not acceptable to authorities, who preferred the easier system operation associated with a high-pressure network.

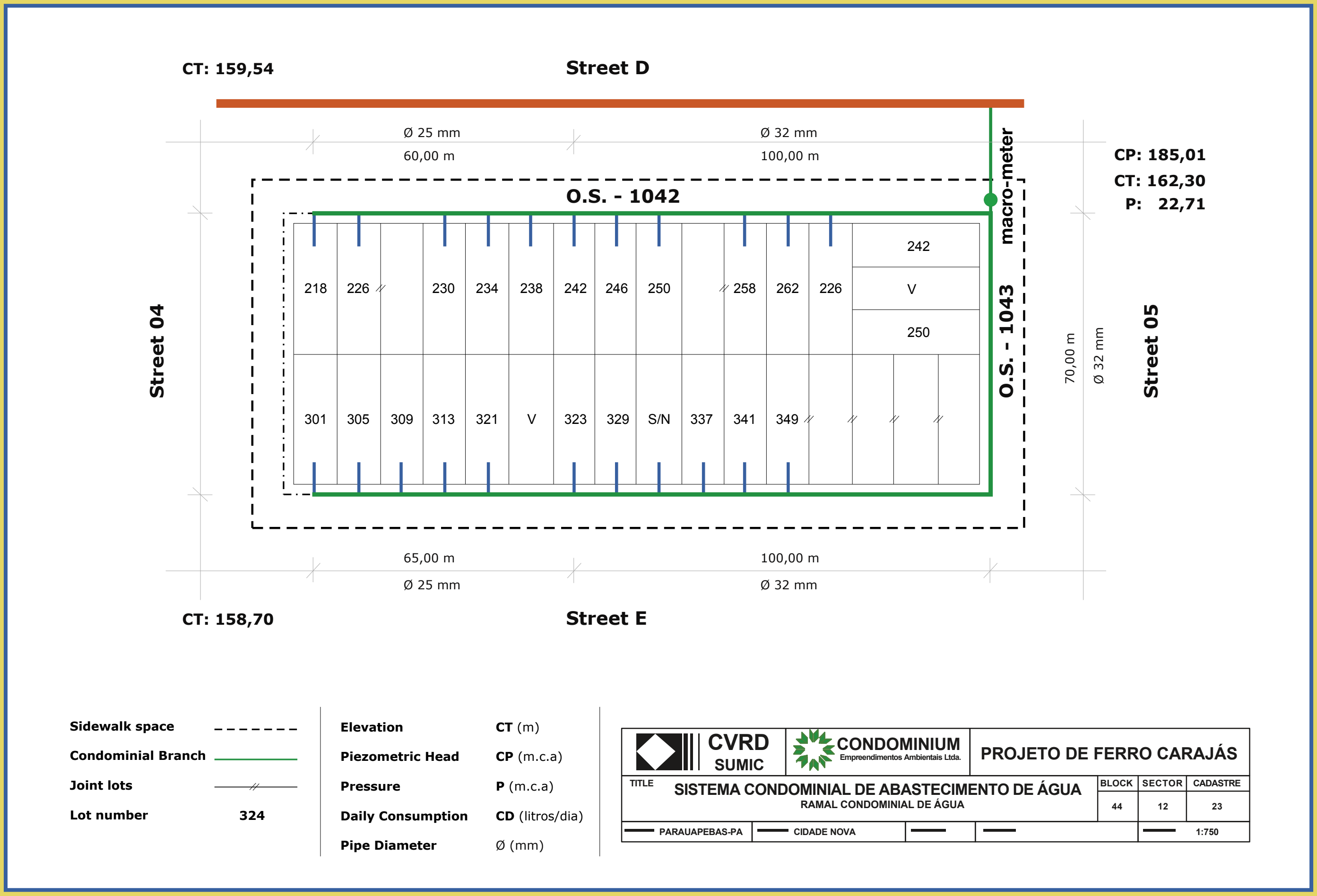
The resulting public distribution network covered 287 kilometers of streets with a total length of just 43 kilometers. Given that a conventional network would have been laid out along the full extension of the urban road system, this represents a reduction of 85% in the total length of water mains needed to complete the public water supply network, resulting in major savings in terms of reduced excavation, breaking and resurfacing of sidewalks, fewer materials, as well as a more minor, briefer disruption of urban life in the execution of the works. The hydraulic capacity of this network complied with all Brazilian regulations applicable to networks of this kind. The same was true for the location of component parts and accessories, such as valves for cleansing outlets at the lowest points of the network, as well as closing valves for interrupting the water supply at predetermined points for maintenance purposes.

More recently, the water distribution network has been further expanded to meet the demands of a growing population. In this second round, it was possible to improve on the first-generation design, achieving additional cost savings as illustrated in Figure

Installation of micro-meter in household connection, Parauapebas

IV.5. The new design involved an even lower pipe density than the first, with only 41 meters of distribution network per hectare, as opposed to 46. A key innovation was the use of a computer model of the water network that permitted automatic determination of the accessories, valves and pipe diameters necessary to modify the system operation and expansion in response to events such as increases or decreases in occupied areas, building densities, variation in consumption patterns, etc. while maintaining the basic hydraulic requirements. In simple terms, given the new and different conditions associated with the introduction of this system, deficiencies in water supply provision to one particular area could be immediately diagnosed and corrective measures taken for restoring service standards as necessary.

Figure IV.5: Second-generation design of condominial water distribution network



(b) Condominial branches

The condominial branches for water were invariably routed along the sidewalks. This is in contrast to the sewerage networks described in the cases of Brasilia and Salvador, where branches were sometimes laid within lots. The main reason for this difference is the over-riding need in the case of the water service to ensure individual connections to each plot for subsequent metering of use. The condominial branches of the water network were placed at an average distance of one meter from the front of the plots and at a depth of approximately 0.40 meters. The branches were split at the double-tee junctions placed along the network at points coinciding with street intersections so that each was capable of supplying water to up to two condominial branches (that is, two urban housing blocks).

Intersection of Condominial Water Branch, Parauapebas

Moreover, the design called for the installation of both block valves and macro-meters at the entrance to each condominium. As discussed below, this feature of the design of condominial water networks brings significant operational advantages in terms of facilitating leakage reduction initiatives and allowing operational problems to be isolated at the condominium level in order to reduce the impact of system maintenance on other users.

Connections to each plot were made into the condominial branches at the most convenient points in each case. The diameter of the condominial branches was similar to those used in vertical buildings and conformed to the specificities of each case. A detailed survey of part of the network indicated that approximately 55% of the branches used 32-millimeter pipes while the remaining 45% used 25 millimeter pipes.

One of the main problems encountered in the development of the condominial branches was the relatively large number of unoccupied plots. In cases where there were residents occupying the plots on either side, pipes had to be laid across empty plots, leading to a higher unit cost for the existing residents of the condominium. It also raised the risk that the network capacity would have to be upgraded if plots were subsequently occupied and urban density consequently increased.

IV.4 Financial Aspects

There was no formal connection fee for the service; rather, all households were expected to purchase the materials required to complete the condominial branches and household connections, as well as to contribute their labor for the excavation of the trenches (see below for further details).

The fee system for the new condominial service was based on a series of studies conducted on the economic and financial viability of the city's water supply and sewerage systems. In contrast to the sewerage systems considered above, residents did not assume any maintenance responsibilities in the case of condominial water networks and hence there were no issues of differentiation in service fees between conventional and condominial systems.

The tariff structure consists of a fixed monthly fee equivalent to US$2.78 and a social tariff of US$0.25 per cubic meter for the first 10 cubic meters of monthly consumption. Residential consumption beyond the social tariff threshold, as well as all non-residential consumption, is charged at a rate US$0.99 per cubic meter. In contrast with other parts of Brazil, a separate fee structure is applied for water and sewerage services. Nevertheless, the 38% of households that are not metered (because the metering program was discontinued for some of the new connections) are charged based on a monthly consumption of 10 cubic meters, making the adoption of metering financially unattractive to them.

IV.5 Social Aspects

The adoption of the condominial model in Parauapebas was motivated by the desire to reduce the project costs to make the goal of universal access feasible. Nevertheless, the price bid by the winning construction company for the development of the condominial systems still proved to be prohibitively high, largely as a result of the cost associated with the development of the condominial branches. In order to resolve this problem without sacrificing the universal access goal, a proposal was made to mobilize community labor for the construction of the condominial branches. In the original project design, the objective of the social intermediation effort had been merely to educate the population regarding the proper use of the new water systems. Nevertheless, with this change of strategy, the community mobilization exercise took on the much more ambitious task of facilitating large-scale community participation in the construction of the condominial branches. In that sense, the social component of the condominial system in Parauapebas was by far the most challenging of the three cases considered here.

The authorities were clearly concerned as to whether the community would be willing to participate in this way. In retrospect, three decisions made at the outset of the process proved critical in securing the commitment of local residents to this approach.

The first decision was to enter into a dialogue process with the community, whereby the rationale for the decision was carefully explained and the rules governing the process publicly consulted. Residents were given exhaustive information about the condominial systems and the authorities' conclusion that its adoption was essential for reaching universal access. Authorities made it clear that residents would have to pay no more for the development of the condominial branches than they would to make a household connection to a conventional network. The consultation process was implemented by local grass roots organizations, including churches, social clubs, trade unions, political parties and community associations.

The second key decision was to develop workable rules for the implementation of the project, based on a fair and transparent division of labor between the community and the municipality. The municipality agreed to assume all the more technically complicated aspects of the works that would have been beyond the capability of the users to implement, such as determining the hydraulic capacity of the pipes as well as their installation. Moreover, all urban water supply standards were met so that the community was assured of the company's obligation to keep the system in good working order in return for payment of a reasonable fee.

The third key decision was to implement a pilot project once an initial level of support had been established. The pilot comprised the planning and execution of the approach within a limited area of the city. This had an important demonstrative effect that helped to increase support for the project and provided a true test of acceptance. It also helped clarify the practical implications of the construction process.

The implementation period consisted of a number of distinct phases. The process began with the organization of at least one

View of Condominial Water Branch, Parauapebas

meeting in each of the housing blocks, which were considered condominiums for the purposes of the project. The meetings were used as an opportunity for residents to clarify any doubts, discuss the rules of access to the service and elect a condominium representative for the subsequent phases of the process.

On the basis of the consensus reached at these meetings, all members of each condominium signed the terms of agreement signaling their willingness to fulfill the commitments required to initiate the construction phase. Contractors then analyzed the hydraulic capacity of each condominial branch and made a list of the materials needed for construction. The community was responsible for purchasing these materials. This was undoubtedly the most delicate stage in the entire process, particularly in poorer neighborhoods where such expenditures constituted a significant percentage of household budgets. Once the condominium representative determined that all materials were ready, the route of the condominial branch and associated connecting pipes was marked out and the community excavated the trenches. The contractor then laid the pipes and registered new users. Finally, when the entire system was ready, the valve at the entrance to each condominium was opened, permitting the water to flow. Overall, the social mobilization process in Parauapebas involved 60,000 people organized into 800 condominiums. The provision of water service to the various condominiums did not reflect traditional political patronage patterns but merely the efficiency and efficacy with which each condominium organized itself and advanced through the various stages of the process.

IV.6 Operational Aspects

The operation of condominial water networks poses many of the same challenges as that of conventional networks. However, there are also a number of key operational differences between the two systems. First, the overall shorter length of the condominial network means less maintenance per connection, and also reduces the volume of distribution losses that can take place in transit. Second, the architectural structure of the condominial network facilitates the introduction of macro-metering and condominium-level meters, which both contribute to reducing leakage and allow smaller areas of the network to be isolated to minimize the disruption of service when repairs are made to the system. Third, the network design reduces the number of easily accessible points to the network and pipes, such as junctions and others, thereby reducing losses and discouraging illegal connections.

In the case of Parauapebas, maintenance data are available on the number of breakages on the water distribution system during 2002 and 2003 (Table IV.3). This information indicates that breakages on the public network accounted for little

Table IV.3: Overview of breakages on water distribution system

		2002		2003	
		Total number	Percentage total	Total number	Percentage total
Condominial Branches	25 mm	180	24.2%	198	18.5%
	32 mm	174	23.4%	252	23.5%
	Condominial meter	337	45.3%	545	50.9%
	Sub-total	691	92.9%	995	92.9%
Public Network	60 mm	19	2.6%	17	1.6%
	75 mm	3	0.4%	9	0.8%
	150 mm	3	0.4%	4	0.4%
	250 mm	1	0.1%		-
	300 mm		-	1	0.1%
	600 mm	2	0.3%	2	0.2%
	Sub-total	28	3.8%	33	3.1%
Household connections	Household pipes	13	1.7%	27	2.5%
	Condominial valves	12	1.6%	16	1.5%
	Sub-total	25	3.4%	43	4.0%
	Total	**744**	**100.0%**	**1071**	**100.0%**

Source: Condominial Operating Systems

more than 3% of breakages on the system, and in absolute terms amounted to no more than 0.7 maintenance incidents per kilometer. More than half of these breakages occurred on the narrowest diameter (60 millimeter) segment of the public network. By contrast, approximately 93% of the breakages on the system were concentrated in the condominial branches. Almost half of these were related to the meter serving the condominium.

In order to measure the impact of maintenance activities on the continuity of water supply in the city, a Supply Interruption Index was developed, which expresses the aggregate duration of interruptions for all customers as a percentage of the maximum total hours of supply that would be possible under a continuous 24-hour service. The Supply Interruption Index for 2001 oscillated between 1% and 3% monthly. The higher values of the index coincided with a major road asphalting program in the town,

Table IV.3: Overview of coverage, metering and distribution losses

%	1998	1999	2000	2001	2002	2003	2004
Household coverage	18	56	74	74	79	82	82
Meter coverage	46	72	77	70	60	64	62
Distribution losses	56	44	43	51	62	65	66

Source: Condominium Operating Systems

during which time the heavy machinery used caused significant pipe breakages. For the rest of the year, the index averaged no more than 0.6%. Operational data from 2004 suggest that the typical duration of a supply interruption was 15 to 30 minutes, while the number of affected connections was approximately 25, which is to say a single condominium. The very small scale of the disruption illustrates the convenience of the valves that isolate supply to each individual condominium.

Installation of the Public Water Network, Parauapebas

With regard to metering, condominial systems allow for conventional individual household meters and facilitate macro-metering as a result of the block structure of the network design. The original design of the water system in Parauapebas envisaged extensive macro- and micro-metering. However, this was not fully implemented in practice. On the one hand, the authorities proved unwilling to finance the modest budget associated with the macro-metering program (estimated at US$10,000). On the other hand, the population was not always willing to accept individual metering. As a result, meter coverage, which peaked at 77% in 2000, has subsequently declined to 62% of the total as overall coverage expanded (Table IV.3).

For a small sample of the city (comprising 16 blocks), detailed information is available on household meter coverage and average monthly household consumption (as measured by the macro-meter at the entrance to each condominium). Analysis of this data indicates that the correlation coefficient between household meter coverage and average monthly household consumption is no more than 0.13, indicating a relatively weak effect of metering on household consumption decisions.

Interestingly, distribution losses, which improved substantially from 56% in 1998 to 43% in 2000, subsequently rose to 66% in 2004 (Table IV.3). There are two likely explanations for this. The first is the decline in meter coverage since 2000, which makes it more difficult to detect and eliminate leaks. The second is the growth in illegal connections after 2000, as unserved households in peripheral areas of the city began to tap into the system.

As noted in Table IV.3, the water coverage rate in the city increased fourfold over the period 1998 to 2004, increasing from 18% to 82%. Nevertheless, these official figures do not necessarily capture the real situation on the ground. This is because clandestine connections are a major problem in Parauapebas. These have taken one of two forms. First, there is the issue of persistent non-payment by customers, leading to eventual disconnection by the utility company and often, the illegal reconnection to the system. This problem has been exacerbated by the lack of a clear legal framework on non-payment, as well as police reluctance to enforce existing regulations. Second, there is the issue of the unserved peripheries of the city. Those located close to the existing network have made clandestine connections to ensure access to the service. This problem can only be adequately resolved by expanding the network to those areas.

Installed household meter, Parauapebas

Repaired Condominial Branch, Parauapebas

IV.7 Institutional Aspects

Prior to the development of the condominial system in Parauapebas, the limited service available had been provided directly by CVRD to its employees. Following the expansion of the system, responsibility was transferred to the local municipality, which had no prior experience with the construction and operation of water and sewerage systems. An outside engineering firm was hired to build the system. However, there was considerable debate and indecision about the appropriate institutional model for the subsequent operation and maintenance of the system. The initial proposal was to delegate this function to a private contractor, but subsequently it was decided to create a Municipal Water and Sewerage Service within the local authority to assume responsibility for this function. However, when this proved to be problematic, management was eventually contracted out to a private operator. The Municipal Water and Sewerage Service continued to be responsible for regulating and overseeing the work of the contractor.

Considerable care was taken to develop an appropriate regulatory framework for the service, which was introduced as a Municipal Law following extensive debate and unanimous endorsement by the municipal council. This law incorporated principles for determining and updating water and sewerage fees, as well as service quality provisions that set a maximum of 5% for the Supply Interruption Index. Because the municipality has a weak institutional capacity, the regulatory framework has not always been adequately enforced and upheld, particularly with regard to tariff provisions and sanctions for non-payment of service.

IV.8 Summary

The case of Parauapebas is particularly noteworthy for a number of reasons. First, it is one of very few cases in which the condominial approach has been applied to water (as opposed to sewerage) networks. Second, it illustrates the challenges involved in constructing a city-wide system virtually from scratch and achieving a fourfold increase in coverage in the space of six years. Third, it is one of the most ambitious examples of community mobilization with 100% of residents both financing the materials for the condominial branches and contributing the labor to excavate the trenches. Fourth, it provides some insight into the potential operational advantages of condominial designs for water systems, even if these have not been fully realized in the case of Parauapebas.

Installation of the Public Water Network, Parauapebas

Excavation works to install Public Network, Brasilia

V. Conclusions

This study described and compared the experience of the implementation of the condominial model in three Brazilian cities: Brasilia (the nation's capital); Salvador (a major, historic metropolis in northeastern Brazil); and Parauapebas (a small but fast-growing boom town). Together, the projects analyzed have succeeded in providing condominial networks to 2.5 million urban residents in Brazil, with 214,000 connections organized in close to 16,000 condominiums (Table V.1).

The case studies differ in a number of ways. For instance, Parauapebas is the only case in which the condominial system was applied to the water network. In Brasilia and Parauapebas, the model was adopted in a conscious, planned manner, whereas in Salvador it was adopted gradually and opportunistically in response to major engineering challenges. In Brasilia and Parauapebas, the implementation of the model was facilitated by relatively orderly urbanization, whereas in Salvador the systems had to be adapted to the demands of particularly dense, steep and precarious urban slums. In Brasilia and Parauapebas, local residents covered the full cost of the condominial branches, whereas in Salvador these were constructed free-of-charge. In Brasilia and Salvador, the system was almost entirely constructed by contractors, whereas in Parauapebas the condominial branches were installed almost entirely by community members. In Brasilia, community maintenance of condominial branches has not posed serious problems, whereas in Salvador it does not seem to have functioned very effectively. These contrasts illustrate the considerable variety of forms that the condominial model can take.

Notwithstanding, comparing some of the key parameters from the case studies reveals basic underlying similarities. The average cost of connecting a household to the sewerage system in Brasilia and Salvador was approximately US$300. The main reasons behind this low unit cost are the reduced length of the public network (representing only 25% to 35% of the total length of the system), reduced diameter (with a substantial proportion of the sewer networks rendered in pipes measuring 100 to 150 millimeters in diameter), and reduced depth (with public networks laid at a maximum of one meter and condominial branches laid at approximately one-half meter).

The main lessons and conclusions from the case studies as a whole can be summarized as follows.

First, the implementation of condominial systems for both water and sewerage has proved feasible on a large scale in major urban areas of Brazil, and at relatively modest cost. Moreover, such systems have demonstrated their versatility in the most challenging peri-urban environments, where conventional systems are simply not an option.

Second, the large-scale social mobilization demanded by the condominial approach has also proven feasible in the Brazilian context, and there have been no major difficulties for residents to reach consensus about system design issues at the level of each condominium. The intensity of social mobilization efforts needs to be considerably greater in cases where the community has chosen or is expected to contribute labor to the construction of the system. However, even in other cases, it is important for community mobilization efforts to include educational messages relating to proper system use and maintenance, the motivation for and process of connecting to the network once available and the public health benefits associated with using the service.

Table V.1: Comparative overview of case studies			
	Brasilia	Salvador	Parauapebas
Overview			
• Years	1993/2001	1995/2000	1998/2004
• Service	Sewerage	Sewerage	Water
Scale			
• Population	700,000	1,730,000	60,000
• Households	188,000	214,000	11,000
• Condominiums	5,000	10,000	800
Distribution by type of system			
• Backyard	6%	Na	0%
• Front yard	43%	Na	0%
• Sidewalk	51%	Na	100%
Engineering			
Network length per connection (m)			
• Public network	3.30	2.00	3.80
• Condominial branch	7.20	5.75	10.00
Depth of trenches (m)			
• Public network	0.50 to 1.20	Na	Na
• Condominial branch	0.30 to 0.60	Na	0.40
Network pipe diameters			
• 100mm	56%	0%	–
• 150mm	29%	Na	–
• 200mm	12%	Na	–
• 250mm+	3%	Na	–
Branch pipe diameters			
• 100mm	≈100%	Up to 20 households	–
• 150mm	0%	21 to 30 households	–
• 200mm	0%	Over 30 households	–
• 250mm+	0%		–
Financial			
Cost per connection (US$)	340	290	45
Cost per meter of network (US$)			
• Public network	Na	52	Na
• Condominial branch	Na	21	Na
Tariff discount for connection	Backyard (45%)	No connection fee	Na
Tariff discount for maintenance	Yes (40%)	Yes (44%)	Na
Social			
Participation in meetings	8%	Na	Na
Self-construction of branches	1%	0%	100%

Source: Table prepared by the author.

Third, the available evidence does not suggest that the operation and maintenance problems posed by condominial systems for the utility company are significantly different or more severe than those posed by conventional systems. Relying on the community to assume responsibility for maintenance has not worked particularly well in Salvador, but has apparently been more successful in Brasilia. Community maintenance of networks is an optional feature of condominial systems and as long as local conditions allow for pipes to be routed along sidewalks, the system is perfectly compatible with traditional utility maintenance approaches.

Fourth, it is important to ensure a fair fee structure for both connection to and use of condominial systems so that residents benefit from any cost savings associated with the choices they make. This entails lower connection costs for systems routed through backyards and lower fees for cases in which residents genuinely assume maintenance responsibilities.

Fifth, public acceptance of the condominial approach is greatly aided by a decisive and coherent policy on the choice of technology for network expansion, which is communicated to the public in a clear, comprehensible way. This was the case in Brasilia and Parauapebas, where the application of the same technology in a non-discriminatory fashion throughout the service area greatly contributed to the credibility of the approach.

Finally, the condominial model also has implications for the design of upstream drinking water treatment and downstream sewage treatment facilities. Namely, it suggests that it may be more feasible to decentralize these facilities in an effort to avoid the high transportation costs associated with concentrating large volumes of fluids at single geographical points to feed large-scale plants. Nevertheless, this aspect of the condominial model was not widely applied in the cases considered.

Excavation for the Public Network, Brasilia

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