Infrastructure Maintenance in LAC: The Costs of Neglect and Options for Improvement

Volume 3
Water Supply and Sanitation Sector

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June 1992
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This study was prepared under the direction of Guillermo Yepes (LATIE). The valuable contribution of Prof. Donald T. Lauria is acknowledged. The author is also grateful to Josef Balky (OECD), Augusta Diasendera (LATIE), Harvey A. Garn and Alfonso Zavala (NUIWS) for comments on earlier drafts of this paper.
INTRODUCTION

1. Adequate maintenance of public water and sanitation infrastructure benefits individuals and national economies alike. Dependable, high-quality water supply and effective sewerage services, however, are not the product of money alone; building, and especially maintaining these public works require a shared vision, commitment of time and energy, as well as the skills of people throughout the public and private sectors.

2. Maintenance is conceived as the set of activities that enables systems to deliver, in an efficiently, the outputs for which they were designed. Therefore, maintenance implies the upkeep not only of the physical infrastructure but also of the management systems and institutional capacity necessary to obtain the maximum social benefits from this infrastructure.

3. Water supply and sewerage infrastructure is a large industry in Latin America and the Caribbean (LAC). It is estimated that in 1990 some 352 million people had access to public water supply, 76 percent of them through house connections. To serve this many people, some 60 to 70 million cubic meters (Mm3) of water are produced every day and distributed through 400,000 kilometers (km) of pipes. In addition, 253 million people make use of a sewerage system. These systems comprise about 320,000 km of pipes, and about 50 to 60 Mm3 per day of mostly untreated sewage are discharged into nearby water bodies. The replacement value of these assets is estimated at some US$120 billion. About 400,000 people are employed directly by this industry. Still, there are some 77 million people with no access to a public water supply, and 176 million do not have adequate sanitation facilities. To meet the needs of these people, and of about 90 million more based on projected population growth, estimated annual investments of US$10 billion are needed throughout this decade.

4. Unfortunately, all the available evidence indicates that existing infrastructure is not well maintained; furthermore, the institutional capacity to maintain this infrastructure has yet to be fully developed. A major problem with maintenance programs is the lack of visibility and the fact that the consequences of maintenance neglect are often not well identified at the outset. Maintenance spending does not generate the excitement associated with new capital projects. Along with being invisible, maintenance is not politically or professionally compelling.
5. The costs of this neglect are large. They have an economic dimension when, for instance, overall efficiency decreases and production costs increase as a result of heavy water losses that force the premature construction of new production facilities, or when public health is jeopardized because of poor water quality, or when private firms or families have to build backup facilities at greater cost to compensate for an unreliable service. They also have a sectoral dimension when the premature deterioration of assets increases operating costs; and water losses mean a loss of revenue to the utility. Equally important, there are equity considerations to maintenance neglect: (a) the poor suffer the most from bad service, as they often lack the resources to compensate for an anomalous situation; and (b) consumers are often required to pay higher rates to compensate for inefficiencies in the system.

6. About US$10 to 15 billion are urgently needed to correct the most urgent problems and to upgrade rundown facilities to bring the existing infrastructure to acceptable service standards. On a regional basis, sector companies are losing some US$1.0 to 1.5 billion every year in revenues and additional operating costs on account of avoidable commercial and physical losses—and this at a time of constraints on financial resources to expand and improve the systems.

EVIDENCE AND COSTS OF INADEQUATE MAINTENANCE IN LAC

7. Operations and maintenance (O&M) are two distinct but closely related functions. The results of good or bad operations and maintenance are often difficult to separate. Water quality problems, for instance, can be the result of poor operating practices, such as lack of chemicals or poorly trained operators, or of poor maintenance, such as broken treatment equipment and chemical feeders, or a combination of both.

8. The paucity of data at the country level concerning O&M operations in the sector in LAC is a serious impediment to a comprehensive assessment of the costs of maintenance neglect on a country basis. The lack of data is by itself a testimony to the lack of awareness of sector officials and the low priority assigned to the O&M functions. However, some information is available at the utility level that can be used to illustrate the main points and support the conclusions and recommendations made in this paper.

9. The chief manifestations of inadequate maintenance in many public water and sanitation systems are: (a) poor water quality; (b) intermittent supplies and unreliable services; and (c) high levels of water losses. These undesirable results clearly point to a lack of concern by sector management providing excellent services to the users of water and sanitation systems.
Water Quality

10. Water quality affects public health, public acceptance of a water supply and the cost of providing safe water. Providing good quality water and maintaining this quality in the distribution system are two of the most significant tasks facing the water utility industry. They are becoming more demanding, as increasing industrial, agricultural and municipal pollution loads make preservation of raw water quality and its treatment an increasingly complex job. Inadequate maintenance of the distribution system can also affect water quality, as sediments or scaling products in pipes provide protection for bacteria and other microorganisms. The need for routine programs to control water quality and to flush distribution systems and storage facilities should be evident but is not a practice often followed by many utilities in the region.

11. No systematic assessment of the costs of inadequate water quality has been made in any LAC country, but they are likely to be substantial. The increase in morbidity from waterborne diseases in some countries in the region can be attributed, to a large extent, to a deterioration of water quality. Morbidity from waterborne diseases, for instance, increased by a factor of 4.9 in Mexico in the decade of the 1980s and by a factor of 2.2 from 1980 to 1985 in Peru. The recent cholera epidemic in Peru is a tragic testimony to years of neglect of the water and sanitation infrastructure. In Costa Rica, about one-third of all water consumed does not meet all WHO water quality guidelines. In Colombia, two-thirds of the population served by a public water supply system in towns with a population less than 100,000 drinks water of unacceptable bacteriological quality. In Guatemala, 85 percent of the water samples taken in some 234 communities was not bacteriologically safe. In Mexico, 20 percent of the water supply systems was reported to have unreliable chlorination facilities. In Panama City, the main sewage pumping station has been inoperative for some years because of lack of parts, and sewage overflows have created an unhealthy environment in a highly valuable area of the city. In Mexico, 95 percent of all municipal waste water plants was inoperative, thus failing to reduce the already alarming levels of pollution in all major watershed basins of the country—which helps to explain, in part, the increase in morbidity from waterborne diseases.

Continuity of Service

12. Continuity of service is a very important performance indicator of the industry and the one of which the population at large is probably more conscious. Intermittent water supplies are at best a nuisance; at worst, they also pose significant health hazards, as contaminated water can easily find its way into pipe distribution systems. Intermittent water supply service is a serious problem in many cities in the region, but probably nowhere is it more severe than in Peru, where 30 percent of the users in cities other than the three largest receives water only 10 hours a day or less. In Lima, which harbors half of the urban population of Peru, there is widespread water rationing in spite of
adequate production capacity, and 70 percent of the water distribution districts are operated at water pressures below the minimum standards to ensure adequate service. Extensive areas of Caracas suffer from intermittent services, while production capacity of the water treatment plants has been reduced by 36 percent because of lack of adequate maintenance.

13. The costs of building alternative supplies to compensate for an unreliable water service can be substantial. In Lima, for instance, domestic users have been investing in pumping and water storage tank facilities at costs 40 to 80 times higher than those of the public utility. In Tegucigalpa, investments by households to compensate for an unreliable supply would have been sufficient to almost double the city water supply with deep wells. The cost to the poor that procure water from vendors is five times the level of investments needed to develop a reliable supply to attend to their needs.

Unaccounted for Water

14. High levels of unaccounted for water (UFW - the difference between metered production and metered consumption as a percentage of metered production) are always associated with inadequate maintenance practices of both the physical as well as the software (commercial) infrastructure. UFW, therefore, includes physical and non-physical or commercial losses. High levels of UFW reflect the failure to repair leaks and meters, replace old pipes, detect illegal connections, implement good commercial practices, and meter all uses of water.

15. Water has to be captured at the source, treated, and delivered to consumers. In the process, some of this water is lost to the benefit of no one. Some of this water loss is unavoidable, but most is not. Physical losses are, thus, an economic loss to society and a financial loss to the water industry. Commercial losses on the other hand are associated with water consumption that is not metered or paid for (i.e. free consumption). Commercial losses are, therefore, a financial loss to the company, but they do not necessarily represent an economic loss as consumers benefit from the use of this water. Commercial losses, however, increase consumption and production and, thus, can aggravate the level of physical losses. Within this context, commercial losses are also an economic cost.

16. Good operational and managerial practices of water utilities in the industrialized countries have resulted in UFW values of about 10 to 15 percent of net production. UFW in well-run utilities in these countries is related, by far, to leaks in pipes and to a lesser extent to meter underregistration. The situation in most LAC countries is quite different. Recent well documented studies in Costa Rica (1988) and Bogota, Colombia (1990) and other cities serve to confirm that commercial losses are the main contributing factor to UFW; they represent 51 percent of total losses in Costa Rica and 65 percent in Bogota.
Caracas, some 30 percent of all connections are not registered in the commercial system. In Panama, the increase in UFW from 37 to over 50 percent in recent years is for the most part due to an increase in the number of unregistered or unmetered connections. In Lima, only a handful of some 160,000 meters installed in the mid-1980s are operative today.

17. The location of Mexico City makes the development of additional sources of water supply very costly. In spite of this, sector authorities do not have a credible plan to meter consumption, maintain meters and reduce the number of illegal connections. The magnitude of this neglect, coupled with low rates, requires a federal subsidy in excess of US$1 billion a year (0.6 % of GDP) and equivalent to the annual sector investment needed to supply the total population of Mexico with adequate water and sanitation services by the end of this century.

18. The level of physical losses due to not maintaining the distribution network facilities in the region is also troublesome. Pipes have not been replaced in many cities at rates to compensate for old age and physico-chemical deterioration. In Buenos Aires, for instance, 65 percent of the pipes are more than 60 years old. In Lima, pipe replacements are a small fraction of needs. Pipe breaks in many distribution systems often exceed accepted industry standards.

19. In Bogota, UFW increased from 22 percent in 1975 to 40 percent in 1989. Revenue losses due to the increase in commercial losses have been estimated to be equivalent to at least 25 percent of total billings, or US$39 million in 1989 alone. If captured, these financial resources would have been more than adequate to meet all debt service obligations (US$195 million) during this period. In Costa Rica, the national sector company estimates a loss of income of some US$8 million per year on account of commercial losses, or 24 percent of planned investments over the next five years. In Guatemala City, a reduction of physical losses from 25 percent to 15 percent over 10 years would reduce capital expenditures on new production by one-third.

20. The lack of reliable data of where and when consumption is taking place has also hampered attempts to improve operations of the distribution system of many cities, such as Lima, Panama City, Barranquilla and Guayaquil, and to ill-conceived and therefore ineffective plans to reduce UFW. Many such plans have been a source of disappointing results. Unreliable production and consumption data have also led to poor demand projections, usually overestimates, and therefore, to costly investments. Many Bank financed water supply projects have suffered from this problem; Bogota, San Jose and Guayaquil, to name only a few, are cases in point.
THE MAINTENANCE PROBLEM IN RETROSPECT

21. Many factors contribute, often in a synergistic way, to the lack of adequate maintenance of most water and sanitation infrastructure in the region and to poor services. These include: Institutional/Managerial—unclear roles of central and local government agencies, and shortage of experienced managers and skilled technicians aggravated by lack of formal training programs; Operational—inadequate information on systems and costs, misplaced priorities due to lack of adequate evaluation of investments, and inadequate designs, control of operations and use of indicators of performance; Budgeting/Financial—unhealthy dependency on central budgets, and inadequate cost recovery policies that fail to generate adequate financial resources.

22. International lending and donor agencies have, at times, given wrong signals or encouraged less than optimum investments, as they have not provided adequate support for the removal of long standing maintenance problems and for adequate maintenance programs being in place before new construction projects are supported. Bank appraisal and sector reports do make reference to problems on maintenance, however, only a few have attempted to quantify the magnitude and the costs of this neglect. Many rehabilitation projects would benefit from a more comprehensive analysis of monitoring indicators of operations and maintenance that can be used to gauge progress. Part of the problem, as mentioned in this report, is the lack of data, but a contributing factor is that most Bank staff working in the sector lack expertise in operations and maintenance.

A STRATEGY TO IMPROVE MAINTENANCE

23. Good maintenance is cost effective and requires: a strong commitment to provide excellent service; informing public and officials about the costs and benefits involved to obtain their support for adequately funded maintenance programs; and good management information and accounting systems. Effective management technology and grant money for new investments are not sufficient to guarantee success in achieving good maintenance. The complexity of these systems and their attendant problems demand a comprehensive strategy. Such a strategy should: (a) improve accountability; (b) develop and maintain responsive management information and data systems; (c) improve analysis of investments and cost recovery; and (d) improve training of staff. Maintenance can also be enhanced, and its costs reduced, by fostering the participation of the private sector and making the best use of its comparative advantages. Progress on these fronts entails actions in the Managerial/Institutional areas to clarify the respective roles of the central, regional and local governments in the construction, management, financing and regulation of water and sanitation infrastructure and to change managerial perceptions and practices.
Accountability

24. The delegation of responsibilities for water and sanitation to local agencies needs to be followed by delegation of the necessary authority to recover costs and mobilize resources to sustain O&M. Central governments, on the other hand, need to regulate services more effectively in order to promote efficiency, to apply consistent policies concerning evaluation and cost sharing of investments and to remove the bias against expenditures on operations and maintenance. They should also resist the temptation to subsidize services that should be on a commercial basis.

Information Systems

25. Most sector agencies need to assign resources for the development of reliable and current records of existing facilities and operations. These should include systematic recording and monitoring of maintenance history to identify—particularly troublesome sections or units—and to cure the underlying causes rather than the symptoms. This information should be complemented by reliable unit costs of maintenance operations and new facilities. Information on facilities and costs should, in turn, be used to develop indicators to help decide when a unit needs maintenance or should be replaced.

Investment Analysis and Cost Recovery

26. There is an urgent need to apply more rigorous cost/benefit analysis to new investment and maintenance expenditures. The O&M planning, programming and budgeting process should begin with the inventory and classification of assets and the establishment of quality standards of service to set the level of O&M to be provided. In turn, these needs should be translated into quantity standards and resource requirements. Adequate levels of O&M are likely to be achieved if goals and the assessment of resource needs are forward looking, framed in 3- to 5-year plans and complemented with specific and monitoring indicators to assess progress.

27. But investment analysis, planning and budgeting of maintenance cannot go too far if the utility is under severe financial stress because it is not allowed to, or does not attempt to, recover its maintenance, operating and investment costs. A sound maintenance strategy must include a sound financial one which includes not only a forceful plan to have tariffs that reflect costs but an equally convincing one for billing and collection and for reducing unnecessary costs.

Training

28. The assessment of O&M problems should place greater emphasis on staff training needs and motivation and possibilities for introducing better employment conditions. O&M strategies are enhanced by raising the awareness
of operational staff and by giving recognition to blue collar occupations and vocational training.

29. The inadequate staffing of O&M functions is a critical and most difficult issue. The often poor working conditions and difficulties in reducing redundant staff are obstacles to reconciling the demand and supply of O&M skills through firing and hiring. A systematic training effort for existing staff is, therefore, a key element of any effort to improve O&M. The end result is that sector institutions need to take a more assertive role in shaping training programs to fill this void.

30. Public education can go a long way to help improve the maintenance effort of an utility. Therefore, it is important that sector agencies make a stronger effort to develop and maintain public education campaigns to keep the public and officials well informed on what the goals of the utility are, how they benefit the public and how the public can contribute to make these goals a reality.

_Private Sector Participation in O&M_

31. The experience in many countries and in the region clearly shows that participation of the private sector in O&M can be productive and effective. Private firms can provide many of these services more efficiently than public utilities, owing to better management, greater flexibility and accountability and their ability to retain more skilled personnel.

32. The water utility of Santiago de Chile, EMOS, has been highly successful in the use of private contractors for O&M functions. In 1989, some 34 O&M contracts equivalent to 48 percent of operating costs were made with the private sector. Through this strategy, the company has been able to reduce costs and today is credited as being one of the most efficient sector companies in the region in terms of the number of staff per population served. EMOS also reports a reduction in response time and better attention to users.

33. Areas of operations and maintenance where the participation of the private sector has proven to be cost effective include: meter reading, installation and maintenance; billing and collection of service payments; transport services; maintenance and repair of water and sewerage networks; maintenance and repair of house connections; data processing centers; and water and waste water treatment plants and pumping stations.

34. Successful O&M contracts with the private sector should span several years, usually not less than five, to elicit a good response from potential bidders and to allow and justify a reasonable investment and commitment on the part of the contractor. It is also in the interest of public utilities to provide incentives in O&M contracts with the private sector to encourage more cost effective
services. On the other hand, private firms should face the real possibility of losing contracts or profitability for inadequate performance. Equivalent incentives or sanctions generally do not exist for public agencies. To achieve the desired objectives of quality and cost-effectiveness, the utility must retain very important responsibilities for planning, packaging, procuring and supervision of these contracts.
INTRODUCTION

1. The connection between infrastructure and economic growth is generally accepted, but difficult to quantify. Nonetheless, agreement is widespread that adequate maintenance of public water and sanitation infrastructure would benefit individuals and national economies alike. Dependable, high-quality water supply and effective sewerage services, however, are not the product of money alone; building and, in particular, maintaining these public works require a shared vision, commitment of time and energy, and the skills of people throughout the public and private sectors.

2. The concept of maintenance, as understood in this paper, goes beyond the conventional definition of the term which implies the upkeep of property or equipment. Maintenance is conceived as the set of activities which enables systems to deliver, in an efficient way, the outputs for which they were designed. Therefore, maintenance implies the upkeep not only of the physical infrastructure but also of the management systems and institutional capacity necessary to obtain the maximum social benefits from this infrastructure.

3. Water supply and sewerage infrastructure is a large industry in LAC. It is estimated that in 1990 some 352 million people had access to a public water supply, 86 percent of them through house connections. To serve this many people, some 60 to 70 million cubic meters (Mm3) of water are produced every day and distributed through 400,000 kilometers of pipes. In addition, 253 million people make use of a sewerage system. These systems comprise about 320,000 kilometers of pipes, and about 50 to 60 Mm3 per day of [mostly] untreated sewage are discharged into nearby water bodies. The replacement value of these assets is estimated at some US$120 billion. About 400,000 people are employed directly by this industry.

4. Still, there are some 77 million people with no access to a public water supply, and 176 million do not have adequate sanitation facilities. To meet the needs of these people and of about 90 million more on account of projected population growth, estimated annual investments of US$10 billion are needed throughout this decade.

5. Unfortunately, all the evidence available indicates that the existing infrastructure is not well maintained and, furthermore, that the institutional capacity to maintain it has yet to be fully developed. Pervasive problems with water delivered to consumers that does not meet minimum World Health Organization (WHO) drinking water quality guidelines, with intermittent supplies and with high water losses are testimony to infrastructure neglect in LAC. About US$10 to 15 billion are urgently needed to correct the most urgent problems and to upgrade rundown facilities to bring the existing infrastructure to acceptable service standards (Figure 1). On a regional basis, sector companies
are losing some US$800 to 1,200 million every year in revenues on account of commercial losses and are wasting some US$200 to 300 million a year in chemicals and energy on account of avoidable leaks in their water systems. Furthermore, this at a time of constraints on financial resources to expand and improve the systems.

6. The costs of this neglect are large. They have an economic dimension when, for instance, overall efficiency decreases and production costs increase as a result of large water losses that force the construction of new production facilities or when public health is jeopardized because of poor water quality or when private firms or families have to build backup facilities, at greater cost, to compensate for an unreliable service. In as much as water supply and sewerage systems exhibit substantial economies of scale and, thus, the costs to individuals who attempt to compensate for deficiencies in the provision of these services are much higher, they also have a sectoral dimension when the premature deterioration of assets increases operating costs and water losses mean a loss of revenue to the utility and an increase in operating costs. Equally important, there are equity considerations to maintenance neglect: (a) the poor suffer the most from bad service, as they often lack the resources to compensate for an anomalous situation; and (b) paying consumers are often required to pay higher rates to compensate for inefficiencies in the system.

7. A major problem with maintenance programs is the lack of visibility. Because the effects of postponing maintenance are not immediately obvious, maintenance is the element that is easiest to defer and the one most likely to be cut from the current expense budget. Maintenance spending does not generate
the excitement associated with new capital projects. Political and professional rewards have played an important role in this trend, since new construction projects carry more professional and political glamour. Along with being invisible, maintenance is not politically or professionally compelling.

8. Public and political awareness can be raised by providing understandable and convincing information on infrastructure conditions, performance, maintenance costs and the costs of deferring maintenance. It means actively educating the public - as shareholders of the nation’s capital stock - and public officials - as trustees of this capital - about the importance of the long-term integrity of the system. In fact, public education is an important element of any strategy to improve any nation’s infrastructure.

9. This paper is an attempt to: (a) list the major consequences of maintenance neglect; (b) quantify some of the economic, financial and social costs associated therewith; (c) explain the principal reasons for maintenance neglect; and (d) propose options to improve maintenance. The importance of extending the useful life of existing facilities through improvement of maintenance becomes more and more relevant, as investment demands are large and funds scarce.

EVIDENCE AND COSTS OF INADEQUATE MAINTENANCE IN LAC

10. Operations and maintenance (O&M) are two distinct but closely related functions. In fact, they are complementary facets of the task of providing a good service, and as such, they are intimately intertwined. The results of good [or bad] operations and maintenance are, therefore, often difficult to separate. Water quality problems, for instance, can be the result of poor operating practices, such as lack of chemicals or poorly trained operators, or of poor maintenance, such as broken down treatment equipment and chemical feeders, or a combination of both. Likewise, improper operation of the distribution
system can lead to high pressures and a corresponding increase in water losses. High water losses can also be the result of poorly maintained commercial systems.

11. The lack of adequate and timely maintenance of many water and sewerage facilities in LAC has led not only to premature failure of these systems but to unreliable services and the loss of capacity of many installations. It has also made necessary the construction of new works, particularly production facilities, in an attempt to compensate for this lack of reliability and lost capacity.

12. The paucity of data, at the country level, about O&M operations in the sector in LAC is a serious impediment to a comprehensive assessment of the costs of maintenance neglect on a country basis. The lack of data is by itself a testimony to the lack of awareness of sector officials and to the low priority assigned to the O&M functions. Some information is available, however, at the utility level that can be used to illustrate the main points and to support the conclusions and recommendations made in this paper. However, an important caveat must be made. The examples presented in this paper may give the impression that the utilities mentioned are the ones with the most problems. The fact that reliable O&M data are available is often a positive sign that the utility in question has at least identified the problem and is trying to do something about it. Adequate operational and monitoring data are almost always associated with good performing utilities that, by definition, show concern about maintenance.

13. The main manifestations of inadequate maintenance in many public water and sanitation systems are: (a) poor water quality; (b) intermittent supplies and unreliable services; and (c) high levels of water losses. These undesirable results clearly point to a lack of concern, by sector management, in providing excellent services to the users of water and sanitation systems.

**Water Quality**

14. Water quality affects public health, public acceptance of a water supply and the cost of providing safe water. Providing good quality water and maintaining this quality in the distribution system are two of the most significant tasks facing the water utility industry. They are becoming more demanding, as increasing industrial, agricultural and municipal pollution loads make preservation of raw water quality and its treatment an increasingly complex job. But many times, the problem is not given the attention it needs until expensive changes or repairs are required.

15. Water quality problems can be aggravated by inadequate maintenance practices that are reflected in inoperative water and waste water treatment plants. These problems are compounded by lack of chemicals and poorly trained water treatment operators. Inadequate maintenance of the distribution system can
also affect water quality. The accumulation of deposits or scaling products in pipes provides protection for bacteria and other microorganisms. Once there, these organisms can reproduce and cause undesirable tastes, odors and slime. They can also promote corrosion themselves. Water quality problems can go unnoticed for long periods of time because of insufficient monitoring and control of water quality at the treatment plant and distribution system. The need for routine programs to control water quality and to flush distribution systems and storage facilities should be evident but is not a practice often followed by many utilities in the region.

16. Close monitoring of water quality at the treatment plant and the distribution system is, therefore, a practice followed by all good water utilities to reduce water quality problems and enforced by regulatory agencies. Water samples should be taken from representative points in the distribution system frequently enough to establish the bacteriological and chemical suitability of water in all parts of the system (Table 2). Many utilities have fancy water quality control laboratories but fail to retain the specialized manpower and resources needed to operate and maintain them. Water quality control, an almost forgotten function of regulatory or supervisory agencies in the region, is a troublesome aspect of maintenance in most systems in the region, particularly small ones (cities less than 100,000).

17. No systematic assessment of the costs of inadequate water quality has been made in any LAC country, but if the experience in the US can serve as a guide (Table 3), where concerns about water quality are more prevalent, they are likely to be substantial. The health impact of inadequate supplies can also be substantial. The increase in morbidity from water borne diseases in some countries in the region can be attributed, to a large extent, to a deterioration in

Table 2

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<th>Population Served (000)</th>
<th>Monthly Samples Minimum WHO</th>
<th>EPA</th>
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<td>&lt; 5</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
<td>100</td>
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<tr>
<td>1,000</td>
<td>100</td>
<td>300</td>
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Deterioration of water quality, including corrosion of distribution piping and house plumbing and fixtures, has been estimated to cost more than US$700 million per year in the United States.

Ref: Hanson, et al; AWWA, Feb 1987
water quality. Morbidity from water borne diseases, for instance, increased by a factor of about 5 in Mexico in the decade of the 1980s and by a factor of 2 from 1980 to 1985 in Peru.

18. The recent cholera epidemic in Peru is a tragic testimony to years of neglect of water quality and of water and sanitation services. Some 61,000 probable cases, of which 15,000 were hospitalized and 321 died in the first month of this outbreak, give a grim view of the cost and suffering. A recent investigation (9) found evidence of bacteriological contamination of the water supply in the cities of Lima, Piura and Trujillo. Ground water supplies in Lima were not chlorinated before being pumped into the distribution system. Close to 20 percent of the water samples from the distribution system in the Lima-Callao area tested positive for fecal coliforms. In Piura, several production wells were out of operation because of mechanical failure, and residual chlorine levels were inadequate [chlorination equipment was not working satisfactorily]. The cholera pathogen was isolated from three community taps in shanty towns in this city. In Trujillo, water service was not continuous, and water samples from the distribution system tested positive for fecal coliforms [three tested positive for cholera].

19. In Costa Rica, estimates by the Water Institute of Costa Rica (AYA) indicate that about one-third of all water consumed does not meet all WHO water quality guidelines (13). In Colombia, two-thirds of the population served by a public water supply system in towns with a population less than 100,000 drinks water of unacceptable bacteriological quality (Table 4) (19). A survey carried out by IMFOM in Guatemala in the late 1980s indicated that 85 percent of the water samples taken in some 234 communities was not bacteriologically safe and that chlorine was out of stock for six months. In Mexico, 20 percent of the water supply systems was reported to have unreliable chlorination facilities in the mid-1980s.

20. Water quality deterioration in the distribution system adds to the cost of water services, beyond those associated with health problems, in several ways including:

* Increased pumping costs as a result of accumulation of scaling products and tuberculations in pipes that restrict water flow;

* Accelerated internal corrosion rates resulting in the need to rehabilitate or replace water mains and infrastructure parts;

* Additional water treatment costs by households, commerce and industry.

21. In Panama City, the main sewage pumping station has been inoperative for some years due to lack of parts, and sewage overflows have created an
unhealthy environment in a highly valuable area of the city. In Mexico, it was estimated that in the mid-1980s the sector was allocating between 5 and 10 percent of the resources needed for good operation and maintenance of water and waste water treatment plants. It came as no surprise to find that only 5 percent of all municipal waste water plants were operative at the time. The economic cost of these idle waste treatment plants is substantial. These non-operating plants fail to reduce the already alarming levels of pollution in all the major watershed basins of the country which helps to explain, in part, the increase in morbidity from water borne diseases (para. 17). Viewed from a pragmatic point of view, these idle resources, valued at more that US$1 billion, could have been invested to increase service coverage of sanitation services in a country where some 40 million do not have access to a public sewerage system.

Continuity of Service

22. Continuity of service is one very important performance indicator of the industry and one that the population at large is probably more conscious of. Continuity is affected by inadequate maintenance programs that result in unreliable service and frequent equipment failures and by high water losses.

23. Intermittent water supplies are at best a nuisance but at worst they also pose significant health hazards, as contaminated water can easily find its way into pipe distribution systems. The result is a heavy cost to all customers of the system to compensate for this failure. Some are forced to invest in additional infrastructure and others, mostly the poor, have to purchase water from vendors which is also likely to be of dubious quality (Annex 2).

24. An intermittent water supply service is a serious problem in many cities in the region, but probably nowhere is it more severe than in Peru where 30 percent of the users in cities other than the three largest receives water only 10 hours a day or less. In Lima, which harbors half of the urban population of
Peru, there is widespread water rationing in spite of adequate production capacity (para. 37), and 70 percent of the water distribution districts is operated at water pressures below the minimum standards to ensure adequate service. Extensive areas of Caracas suffer from intermittent services while production capacity of the water treatment plants has been reduced by 36 percent due to lack of adequate maintenance.

25. The costs of building alternative supplies to compensate for an unreliable water service can also be substantial. In Lima, for instance, domestic users have been investing in pumping and water storage tank facilities at costs 40 to 80 times higher than those of the public utility. In Tegucigalpa, a city of some half a million people, households have invested between US$3 and 9 million for tanks and pumping systems to compensate for an unreliable supply (Annex 2); the cost to almost double the city water supply with deep wells is well within this range. The cost to the poor that procure water from vendors is five times the cost of investments needed to develop a reliable supply to attend to their needs.

26. The use of in-house storage tanks is a widespread practice throughout the region and has its roots in the failure to maintain a reliable service. This practice is expensive, given the large economies of scales associated with the construction of storage tanks. It also raises health concerns, as most house storage tanks are seldom cleaned.

27. In Buenos Aires, production capacity at the water treatment plants has been reduced by 30 percent due to lack of maintenance. In addition, 15 percent of production is lost at the largest water treatment plant due to leaky valves and inadequate operations, or about 3 times the average in well operated plants. The end result is that some 3 million people have to rely for their supply on 700,000 private wells that draw water from contaminated ground water sources.

28. The use of private wells is also a common occurrence in many cities in the region, such as Santo Domingo, Lima and Guatemala City. The cost of water from private wells is several times higher than the cost, on a unit basis, of a public system. In addition, the quality of the water from these wells is often suspect, and unfortunately, only a handful of users routinely monitor it.

Unaccounted for Water

29. High levels of unaccounted for water (UFW - difference between metered production and metered consumption as a percentage of metered production) are always associated with inadequate maintenance practices of both the physical as well as the software (commercial) infrastructure. UFW, therefore, includes physical and non-physical or commercial losses. High levels of UFW reflect the failure to repair leaks and meters, replace old pipes, detect illegal connections, implement good commercial practices and monitor all uses of water.
30. Water has to be captured at the source, treated and delivered to the consumers. In this process, some of this water is lost to the benefit of no one. Some of this water loss is unavoidable, but most is not. Physical losses are an economic loss to society and a financial loss to the water industry.

31. Commercial losses on the other hand are associated with water consumption not metered or paid for (i.e. free consumption). This is the result of fraudulent, unbilled or free consumption and of faulty meters that under-register the amounts consumed. Commercial losses are, therefore, a financial loss to the company. They do not necessarily represent an economic loss, as consumers benefit from the use of this water. Commercial losses, however, increase consumption and production and, thus, can aggravate the level of physical losses. As a result, the system’s capacity needs to be expanded earlier than otherwise needed. Within this context, commercial losses are also an economic cost. There are also economic as well as financial losses associated with commercial losses, as there are additional operating costs to divert, treat and deliver this water.

32. Good operational and managerial practices of water utilities in the industrialized countries have resulted in UFW values of about 10 to 15 percent of net production (Table 5). UFW in well run utilities in these countries is related, by far, to leaks in pipes and to a lesser extent to meter under-registration. Losses due to illegal connections or unregistered users are negligible. The situation in most LAC countries is quite different.

33. Recent well documented engineering studies in Costa Rica (1988) and Bogota (1990) and other cities serve to confirm that commercial losses are the main contributing factor to UFW. Commercial losses represent 51 percent of total losses in Costa Rica, 65 percent in Bogota and 55 percent in Medellin (Figures 2 and 3).

34. The increase in illegal connections observed in many utilities in the region is a direct consequence of lukewarm enforcement efforts to discourage unauthorized use and maintain the commercial system up-to-date, including tight procedures to account for new connections. This increase can go unnoticed for
years because of lack of adequate statistical interpretation of changes in consumption and production patterns that may signal an increase in illegal water uses.

35. In Caracas, some 70,000 connections (30 percent of the total) are not registered in the commercial system. In the Federal District of Mexico City,
more than 600,000 water connections (30 percent of the total) cannot be properly accounted for, only about a third of the connections is metered and less than one-fourth of the meters is operative. In Panama, the increase in UFW from 37 to over 50 percent in recent years is, for the most part, due to an increase in the number of illegal connections.

36. The magnitude of the neglect of operations in Mexico City, coupled with low rates, requires a federal subsidy in excess of US$1 billion a year, equivalent to 0.6 percent of GDP, and equals the annual sector investment needed to supply the total population of the country with adequate water and sanitation services by the end of this century.

37. Inadequate maintenance affects meter accuracy and, thus, aggravates the problem of commercial losses which, in turn, directly reduces the revenue stream of the utility. It also deprives it of vital information to operate efficiently. In Lima, for instance, only a handful of some 160,000 meters installed in the mid-1980s is operative today. As a consequence and in spite of an adequate production of about 400 liters per capita per day, there is widespread rationing (para. 24). The lack of maintenance of meters and of the commercial system explains this deterioration. A recent evaluation of alternative water saving schemes indicated that a program to meter consumption would produce an economic rate of return in excess of 50 percent and well above any other water supply alternative program, but sector authorities in Peru appear to be lukewarm to an extensive metering plan.

38. The level of physical losses is also troublesome, and there is plenty of evidence of the lack of maintenance of distribution network facilities in the region. Pipes have not been replaced in many cities at rates to compensate for old age and physico-chemical deterioration. In Buenos Aires, for instance, 65 percent of the pipes is more than 60 years old. In Lima, in the past few years less than 3 km of pipes have been replaced per year in a system with more than 6,200 km of pipes. Aging problems are, of course, compounded by the cumulative effects of inadequate maintenance and repair. Pipe breaks in many distribution systems often exceed accepted industry standards. In Medellin, Colombia, the number of pipe breaks is, on average, close to the level used in France (4 breaks/km/yr) as the signal to change a defective pipe (Table 6). Excessive breaks in pipes and connections also point out problems with the quality of materials, construction and excess pressures.

39. A utility confronted with high levels of UFW needs to fill the financial gap created by the non-paying consumers and the additional operating costs. A direct consequence of high UFW is that paying consumers end up paying higher rates. This, of course, raises not only some equity questions but also reservations about the effectiveness of regulatory practices by tariff boards across the region.
40. In Bogota, UFW increased from 22 percent in 1975 to 40 percent in 1989. Revenue losses due to the increase in commercial (non-physical) losses have been estimated to be equivalent to at least 25 percent of total billings, or US$39 million in 1989 alone. If captured, these financial resources would have been more than adequate to meet all debt service obligations (US$195 million) during this period. Economic losses due to this increase in UFW averaged US$10 million per year, or 16 percent of the investment program over this period (Annex 1).

41. In Costa Rica, AYA estimates a loss of income of some US$8 million per year on account of commercial losses (13). This financial loss can be put into some perspective by noting that planned investments over the next five years average US$33 million per year for the whole country. In Cochabamba, Bolivia, a reduction of UFW from 33 percent to 15 percent would increase revenues by 24 percent. This amount is about double the amount that the water company paid for all its materials and supplies in 1989. In Guatemala City, which has a population of 1.5 million, a reduction of physical losses from 25 percent to 15 percent over 10 years would reduce capital expenditures on new production by one-third. This savings is only slightly less than the amount that the company will spend on total salaries and maintenance of the system. In Tegucigalpa, a city of 520,000 people in 1988, UFW is estimated to be 40 percent. A reduction of 3 percentage points would be more than adequate to provide water to all low income areas that are forced to buy water from vendors at unit prices 16 to 35 times higher than what users with a house connection pay to the local water authority (Annex 2).

42. In five municipalities (Cananeia, Registro, Iguape, Cataji and Juquia) of Sao Paulo State, with a served population of about 100,000, cutting commercial losses in half would increase revenues by more than US$1 million a year. If, in
addition, physical losses could be reduced to between 15 and 20 percent, operating costs could decrease by nearly US$1 million a year. Thus, the net financial impact of maintenance neglect on these five towns is nearly US$2 million a year, or close to US$90 per connection per year; the potential savings represent twice the level of annual capital expenditures projected for the foreseeable future.

43. The lack of reliable data on where and when consumption is taking place has also hampered attempts to improve operations of the distribution systems of many cities, such as Mexico City, Buenos Aires, Lima, Panama City, Barranquilla and Guayaquil. Even in Brazil, where there is more awareness of the importance of metering, only 64 percent of all connections serviced by state water companies was metered in 1984. Improper maintenance of software, particularly in the commercial area, also leads to unreliable assessments of UFW components and to ill conceived and, therefore, ineffective plans to reduce UFW. Many such plans have been a source of disappointing results. In Lima, for instance, the water utility initiated in the early 1980s a program to reduce UFW under the assumption that the main cause of UFW was leakage of pipes. Millions of dollars and a couple of years later, an extensive leak detection survey confirmed that the volume of leaks was negligible pointing, therefore, to problems in the commercial system. Unfortunately, this part of the UFW reduction program was not pursued with the same vigor, and the results are in evidence today (para. 23).

44. Unreliable production and consumption data have also led to poor demand projections, usually overestimates, and therefore, to costly investments. Many Bank financed water supply projects have suffered from this problem; Bogota, San Jose and Guayaquil, to name a few, are cases in point.

THE MAINTENANCE PROBLEM IN RETROSPECT

45. Many factors contribute, often in a synergistic way, to the lack of adequate maintenance of most water and sanitation infrastructure in the region and to poor services. An assessment of the factors that led to the current situation is important in order to establish potential solutions. These factors have been grouped to facilitate discussion, but it is recognized that most of them cut across classification formats.

Institutional/Managerial

(a) Unclear roles of central and local government agencies.

(b) Low image of the O&M functions and uncertainties about the benefits obtained by good maintenance.
(c) Shortage of experienced managers and skilled technicians aggravated by lack of formal training programs.

Operational

(d) Inadequate information on systems and costs.

(e) Misplaced investment priorities due to lack of adequate evaluation of investments.

(f) Inappropriate designs and control of operations and infrequent use of performance indicators.

Budgeting/Financial

(g) Unhealthy dependency on central budgets.

(h) Inadequate cost recovery policies that produce insufficient tariffs to generate adequate financial resources.

International lending and donor agencies have, at times, given wrong signals or encouraged less than optimum investments, as they have not provided adequate support for the removal of long standing maintenance problems and adequate maintenance programs being in place before new construction projects are supported. Bank appraisal and sector reports do make reference to problems on maintenance, however, only a few have attempted to quantify the magnitude and the costs of this neglect. Many rehabilitation projects would benefit from a more comprehensive analysis of monitoring indicators of operations and maintenance that can be used to gauge progress. Part of the problem, as mentioned in this report, is the lack of data, but a contributing factor is that most Bank staff working in the sector lack expertise in operations and maintenance.

Institutional/Managerial

47. In most LAC countries, local governments are in charge, directly or through a specialized agency, of water and sanitation services. The role of the central and regional governments is more related to policy aspects, regulation of services and the provision of some [or all] of the funds for investment and operations.

48. Central-local government relations, therefore, play a crucial role in operations and maintenance. However, the regulatory function of central authorities has been, by far, ineffective in most countries in promoting efficiency of operations and in demanding reliable information to support investment decisions. Decision makers at the center are too far removed from
operational realities at the local level, and therefore, maintenance needs receive very little attention in the central allocation of resources. The signals and support from the center have been erratic or contradictory at times in respect to policies related to maintenance. New investment continues to receive more support than investment directed at rehabilitation.

49. Misguided subsidy and cost recovery policies have kept service rates unrealistically low. Subsidies have been granted to support expansion of production facilities when there was clear evidence of high levels of UFW and water waste, all because of inadequate maintenance, but little or no funds were allocated to redress these problems. Low service rates, in the name of social concern, have kept the poor from receiving a good service, as utilities have been deprived of funds to maintain the quality of services and expand them (Annex 2). The result has been poor maintenance and has led to higher operating costs and inadequate services.

50. Institutional and managerial deficiencies often go hand in hand and are closely interwoven. It is not uncommon to observe ill defined or overlapping functions in or across sector institutions. The lack of clear objectives and of monitoring indicators to assess progress in reaching them reinforces this problem, and accountability is lost. Accountability is also lost by public administration controls of sector institutions that tend to be intrusive and obstructive and, in effect, make claims to autonomy rather perfunctory.

51. More often than not, inadequate managerial practices and uninspiring or inexperienced managers are an important cause of deficiencies in operations and maintenance. Most sector officials lack an interdisciplinary perspective to fully understand that poorly maintained and unreliable water and sanitation facilities are a drain on resources, that they hamper public and private sector productivity and that they can be a health hazard. Many also fail to realize that poorly maintained water and sanitation systems have an important and undesirable impact on equity, as the poor are the most vulnerable to deficient services.

52. The high turnover in managerial positions impairs institutional memory and compromises long-term plans and strategies which affect the maintenance function the most. In-transit managers are not usually interested in the development and implementation of plans, such as maintenance, that bear fruit in the long-term. Lack of competitive salaries, inadequate personnel policies that fail to attract competent managers and technicians and the lack of formal training are also factors that work against good maintenance programs.

*Operational*

53. Maintenance of water and sewerage works should be viewed as one phase in the design-construction-operation process. New equipment or facilities can and should be designed and built for ease of operation and maintenance. Timely
repairs reduce long-term operating costs and ensure the full life expectancy of existing facilities and equipment. Innovative operations sometimes can add capacity for little cost and reduce maintenance needs. On the other hand, poorly trained staff often exacerbate maintenance problems. Such is the case of water treatment plant operators that fail to apply the right chemical dosages thus accelerating the problems of scaling and corrosion of pipes and meters which, in turn, adds higher demands on their maintenance.

54. It is not uncommon to observe O&M crews in the field using improper procedures because of lack of training, proper tools, equipment or materials. A management audit in Costa Rica [1990], for instance, revealed that field crews were losing 70 percent of their time on account of bad organization (50 percent) and inadequate tools or methods (20 percent). While standards and manuals for maintenance exist in industrialized countries, they are not widely known or used by sector institutions in the region.

55. Maintenance staff is seldom taken into account in project planning, and designers often are not knowledgeable about operations. As a result, many facilities have been built without due consideration to the capacity of institutions to operate and maintain them. Inappropriate designs for facilities select state-of-the-art equipment but fail to take into account the human resources and funds needed to maintain and operate them. Failure to account for difficulties in importing spare parts and maintenance equipment can also lead to a precarious reliance on such equipment which cannot be properly maintained and soon falls into disrepair.

56. Maintenance is often seen as a series of problems to be handled as the situation demands, instead of a program requiring planning for future needs, and therefore, the normal operational mode is "management by crisis" based on ad-hoc decisions. Methods for issuing and tracking preventive and corrective maintenance are frequently inadequate. Preventive maintenance is not viewed as the cornerstone of the program but rather as "breakdown maintenance". Premature equipment failures are the inevitable result.

57. Only a handful of sector companies in the region have adequate information systems and the know-how to maintain them and have developed and make use of monitoring indicators to measure a system's performance. As a consequence, most maintenance programs are hampered by lack of adequate information on the operation, on the condition and efficiency of the systems and on costs. Monitoring indicators of performance have proven to be valuable tools to help document and pinpoint problems and costs. The systematic analysis of pipe breaks in Medellin, for instance, has been followed by the revision of specifications for, and substitution of, pipes and changes in pressure zones in the distribution system. As a result, the utility has seen the number of pipe and house connection breaks fall by 43 and 61 percent, respectively, in four years. In Brazil, the systematic analysis of consumption patterns and accuracy of
consumption meters over a wide range of flows followed by a least cost analysis led to a change in guidelines related to meter size selection (Figure 4); meters are now selected to operate at higher flows (the cost of accelerated meter wear is more than compensated by the gain in meter accuracy). Some Brazilian regional companies using this strategy, reinforced with other programs, have been able to obtain a consistent reduction of UFW on the order of 1 to 2 percentage points per year. In Costa Rica, a detailed assessment of UFW has allowed the utility to identify concrete corrective actions and monitoring indicators and reduce water losses by some 9 percentage points in two years.

**Budgeting and Financial**

58. Many sector agencies have developed an unhealthy dependency on the central allocation of funds. This dependency increases the power of central agencies but has made financial planning at the local level more erratic and, therefore, unreliable and by reducing accountability, undermines all attempts at the utility level to improve operations and maintenance.

59. Budgeting systems are often misused when they become a straight jacket to rational planning and an end by themselves rather than a management operational tool. Continuous pressures to control costs are often perceived as orders to reduce budget allocations, and the first casualty is almost always maintenance. This process goes on for years until the consequences are in evidence. Then, the often seen reaction is to increase grant financing of capital spending to compensate for this neglect, and the cycle is repeated.
60. O&M budgets are often easy to cut because voters do not see infrastructure deterioration until it is often too late. Public officials, who understand that breakdown repair is eventually more costly than preventive maintenance, are often forced to defer maintenance because of competition from other priorities. Budget reductions in maintenance expenditures are almost always a misguided and costly decision. Maintenance expenditures are a fraction of total O&M costs and, thus, represent a small percentage [under 15 percent] of the total life-cycle cost of a facility. But, as documented earlier, maintenance costs have a substantial impact on the useful life and productivity of the asset in question.

61. The use of routine cost/benefit analysis to guide decisions on investment programs is a practice followed by only a handful of the utilities in the region. In failing to do so, many utilities tend to favor new construction over rehabilitation, and in the process, the cost of the investment program is raised unnecessarily. In addition, facilities are often built without due consideration to the cost or provision of funds for O&M.

62. Sector managers often tend to blame the poor finances of their companies on external factors over which they have little control. The poor financial condition of the company, in turn, is presented as the excuse for maintenance neglect. Although there is some truth to this perception, the fact of the matter is that the poor financial situation of most sector companies is aggravated by problems of their own. The lack of liquidity, a testimony to inadequate cash generation and poor financial management, is accentuated by water losses that often exceed half the volume of total production and by the high number of illegal connections. More often than not, however, the misallocation of resources on non-priority investment programs and the amount of revenues forgone by inadequate commercial practices can be, on absolute terms, larger than the funds requested. The solution to all these problems is well within the mandate of sector companies.

A STRATEGY TO IMPROVE MAINTENANCE

63. Good maintenance is cost effective but does require a vision, a persistent and consistent effort and a consistent flow of funds. Perhaps more important, it requires strong commitment to provide excellent service. It also requires that the public and officials be kept informed about the costs and the benefits involved in order to obtain their support for adequately funded maintenance programs. It requires good management information and accounting systems as well. No single approach by itself is likely to be effective. More effective management alone will not get the job done. Technology will not save the day. Grant money may buy time, but it is unlikely to be a continuous and abundant supply. The complexity of these systems and their attendant problems demands a comprehensive strategy.
64. The objective of operations and maintenance systems should be to maximize benefits from existing assets. Effective managers of O&M tasks, therefore, need to be concerned about: (a) policies and strategies manifested in multi-year plans; (b) financial resources provided on a sustained and timely basis; (c) inventories and records of assets and their condition; and (d) sufficient staff with adequate skills and appropriate materials and equipment.

65. As noted earlier, there are biases against maintenance which have to be overcome. Policy and decision makers in the sector and in lending institutions must be convinced that maintenance is, indeed, an area worthy of priority attention and that efforts to improve it very often represent the best use of scarce resources.

66. The pervasiveness of the maintenance problem in the water industry in LAC is shared, albeit in different degrees, by all countries in the region, and it is not likely to disappear in the near future unless radical changes are brought in. A strategy to improve crumbling infrastructure must incorporate other means in addition to more funds and should focus its attention on actions intended to: (a) improve accountability; (b) develop and maintain responsive management information and data systems; (c) improve analysis of investments and cost recovery; and (d) improve training of staff. Maintenance can also be enhanced, and its cost reduced, by fostering the participation of the private sector and making the best use of its comparative advantages.

67. Progress in these fronts entails actions in the Managerial/Institutional areas to clarify the respective roles of the central, regional and local governments in the construction, management, financing and regulation of water and sanitation infrastructure and to change management perceptions through incentive schemes and managerial practices.

Accountability

68. The delegation of responsibilities for water and sanitation to sector agencies needs to be followed by delegation of the necessary authority and power to recover costs and mobilize resources to sustain O&M. Only then can accountability be squarely placed at the operational level. Central governments, on the other hand, need to regulate services more effectively in order to promote efficiency, to apply consistent policies concerning evaluation and cost sharing of investments and to remove the bias against expenditures on operations and maintenance.

69. Dealing with operations and maintenance requires not only managerial skills but also entrepreneurial talent (16). High level managers should seek, therefore, more delegation of responsibilities to lower levels of the organization to avoid getting inundated in details and to make a concerted effort to revert the predominant mode of "management by crisis" to management by objectives. In
doing so, managers will be less prone to base their decisions on political and spur of the moment considerations rather than on objective and technically sound criteria.

70. The sense of responsibility and accountability for operations and maintenance is greatest when the organizational structure responds in a rational way to current problems and when the staff is given clear and distinct tasks in line with their skills, experience and interest and the means to discharge their functions efficiently.

71. To improve the efficiency and effectiveness of the O&M functions, suitable types of activities should be clearly vested in accountability centers which function as internal service units within the organization. Examples of these centers are: meter repair shops, vehicle workshops, water treatment facilities and inventory stores. These centers should be given clear goals and indicators to monitor performance and some flexibility in their operations in order to give area managers the necessary incentives for efficiency.

Information Systems

72. Most sector agencies need to assign resources for the development of reliable and current records of existing facilities and operations. These should include systematic recording and monitoring of maintenance history for specific elements with a view to identifying particularly troublesome sections or units.
and curing the underlying causes rather than the symptoms. The technical information should be complemented by reliable unit costs of maintenance operations and new facilities. Information on facilities and costs should, in turn, be used to develop indicators to help decide when a unit needs maintenance or should be replaced (Table 7).

73. The costs of O&M can vary substantially from one utility to another depending on a number of factors such as: (a) standards of design and construction; (b) degree of utilization and age of assets; (c) labor and energy costs; and (d) local geographic and environmental conditions. Because of these factors, "rules of thumb" to guide O&M operations should be used with caution.

74. Data analysis and tracking involves more than just data collection; it requires data management (data entry, storage and file interpretation). Computer software packages of management information systems are available, but these programs can rapidly become useless unless there is a concerted effort, at the management level, to provide the resources to maintain and keep them current and to develop the administrative procedures to generate, analyze, disseminate, preserve and use this data.

Investments Analysis and Cost Recovery

75. The benefits of good maintenance accrue directly to the local authority concerned in terms of deferred capital investments, reduced operating costs, more predictable workloads and greater public satisfaction. Benefits also accrue to the users in the form of more reliable services, lower user costs and aesthetic and health benefits. There are also indirect but important benefits in terms of improved public and private sector productivity.

76. There is an urgent need to apply more rigorous cost/benefit analysis to new investments and maintenance expenditures. This analysis provides valuable insights into the costs and trade-offs of both and can help to define priorities and cost effective programs (18). It is particularly relevant under the present situation of severe constraints on the availability of financial resources. Good project evaluation will also help avoid: (a) problems in the selection of equipment because of lack of adequate consideration of resource constraints such as foreign exchange, skills and facilities to service and repair, and (b) capital-intensive solutions which are unlikely to be appropriate in situations characterized by inexpensive and unskilled labor.

77. The O&M planning, programming and budgeting process is iterative and begins with the inventory and classification of assets. It is followed by the establishment of quality standards of service to set the level of O&M to be provided which, in turn, should be translated into quantity standards measurable in suitable units. These quantity standards are, in turn, translated into types and quantities of resource requirements some of which are controlled by inventory
management systems. Such preparatory work, including cost/benefit analysis of major expenditures, can help identify and rank preventive and routine maintenance programs and their costs and support O&M budget requests. Budget exercises should be complemented by the analysis of actual allocations and expenditures over, say, the last five years to determine trends and patterns and to guide future exercises.

78. With the use of applicable unit costs, the total costs of providing the required levels of O&M can then be calculated and held against available financial resources. These levels are likely to be achieved if goals and the assessment of resource needs are forward looking, framed in 3 to 5 year plans and complemented with specific and monitoring indicators to assess progress. Such evaluation of O&M requirements is a valuable tool to bring into focus possible issues of the utility’s finances and of resource mobilization efforts.

79. But investment analysis and planning of maintenance cannot go too far if the utility is under severe financial stress because it is not allowed to or does not attempt to recover its maintenance, operating and investment costs. A sound maintenance strategy must include a sound financial one which includes not only a forceful plan to have tariffs that reflect costs but an equally convincing one for billing and collection and for reducing unnecessary costs.

Training

80. The assessment of O&M problems should place greater emphasis on staff training needs and motivation and the possibilities for introducing better employment conditions. O&M issues among operational staff are compromised by the low level of awareness of O&M and by the lack of recognition of blue collar occupations and inadequate vocational training.

81. The inadequate staffing of O&M functions is a critical and most difficult issue. The often poor working conditions and difficulties in reducing redundant staff are obstacles to reconcile demand and supply of O&M skills through firing and hiring. A systematic training effort for existing staff is, therefore, a key element of any effort to improve O&M. The end result is that sector institutions need to take a more assertive role in shaping training programs to fill this void. Training, however, is not a panacea. It is equally important to target each audience to identify, define and evaluate relevant O&M issues and to determine if they are amenable to training solutions (Table 8).

82. Public education can go a long way to help improve the maintenance effort of a utility. Therefore, it is important that sector agencies make a stronger effort to develop and maintain public education campaigns to keep the public and officials well informed on what the goals of the utility are, how they benefit the public and how this public can contribute to make these goals a reality. Community participation can be elicited to report problems such as leaks,
broken pipes and missing manholes. This participation is also valuable to help reduce the loss of property through vandalism. But, the utility must show that it is responsive to the public if it wants to elicit a lasting participation.

**Private Sector Participation in O&M**

83. In the quest for improved quality of services and cost-effectiveness of O&M, it is important to dispel apprehensions that might be in the minds of the public and sector officials about the participation of the private sector in O&M. The experience in many countries, such as France (17), Spain and the United States and in the region, notably Chile, clearly shows that this participation can be productive and effective (16). In these countries, it has been demonstrated that private firms can provide many of these services more efficiently than public utilities, owing to better management, greater flexibility and accountability and their ability to retain more skilled personnel.

84. The private sector can also be a source of additional financial resources provided, of course, that a clear legal framework exists to allow and encourage this participation. The positive experiences of many industrialized countries, particularly France and Spain, with the participation of the private sector in the financing of the water and sewerage sector should be emulated in the region.

85. The water utility of Santiago de Chile, EMOS, has been highly successful in the use of private contractors for O&M functions. In 1989, some 34 O&M contracts were made with the private sector with a total cost of US$8 million a year, equivalent to 48 percent of total operating costs (excluding depreciation). Through this strategy, the company has been able to reduce costs and today is credited as being one of the most efficient sector companies in the region in terms of the number of staff per population served [included in this ratio is the
equivalent number of staff employed by the private sector]. EMOS also reports a reduction in response time, better quality of services and better attention to users.

86. Areas of operations and maintenance where the participation of the private sector has proven to be cost effective include:

* Meter reading and billing.
* Meter installation and maintenance.
* Collection of service payments.
* Transport services.
* Maintenance of equipment.
* Maintenance and repair of water and sewerage networks.
* Maintenance and repair of house connections.
* Data processing centers.
* Water and waste water treatment plants.
* Pumping stations.

87. A service contract can, of course, include one or more of the tasks mentioned. All service contracts require adequate supervision by well trained staff to give particular emphasis to the timely resolution of problems that may arise in performing the obligations under the contract. Timely payment of contract obligations is paramount to a successful contract.

88. Successful O&M contracts with the private sector should span several years, usually not less than five, to elicit a good response from potential bidders and to allow and justify a reasonable investment and commitment on the part of the contractor. These contracts should also pay particular attention to:

(a) a clear definition of contract objectives and delimitation of the area of service.

(b) the obligations of the private company concerning standards and quality of service; to the extent possible, these should be quantified.

(c) the procedures to adjust contract prices including revision thereof when service or cost parameters exceed preestablished limits.

(d) the provisions for hand over and continuity of service at the beginning and end of the contract.

(e) the handling of staff employed by the utility when service is taken over by the contractor.
89. It should be recognized that private contractors are basically guided by profit opportunities, and in order to achieve the desired objectives of quality and cost-effectiveness, the utility must retain very important responsibilities for planning, packaging, procuring and supervision of contract works. It is also in the interest of public utilities to provide incentives in O&M contracts with the private sector to encourage more cost effective services. On the other hand, private firms should face the real possibility of losing contracts or profitability for inadequate performance. Equivalent incentives or sanctions generally do not exist for public agencies.

THE ROLE OF THE BANK

90. The water and sanitation sector in the region faces uncertainty in attracting capital and managerial talent to finance the expansion and improvement of services, particularly if abatement of water pollution, likely to increase due to better water and sanitation, is to be taken into account. The need for resources is likely to be even greater if existing assets are not maintained properly.

91. Historically, the Bank has not been a key financier for the sector in LAC. Its funding, although still expected to be substantial, is but a fraction of investment requirements by the sector. It follows that the Bank’s evolving role is to assist in developing the ability of borrowing countries to mobilize resources needed for their large investment requirements and to manage sector assets more efficiently.

92. The Bank has played an important role by fostering institution building in the sector and by assisting in developing the concepts of economic efficiency, financial sustainability and professional management through its advocacy of least-cost planning, economically rational tariffs and financially viable utilities. Nonetheless, in today’s changing environment and tight financial resources more emphasis needs to be placed on good management of existing assets before construction of new ones, on a large scale, is attempted.

93. The challenges that sector agencies are facing, insofar as improving maintenance practices is concerned, include the need for:

   1. greater accountability in the sector;
   2. better information systems to guide operations in sector institutions;
   3. more rigorous cost/benefit analysis of investment and maintenance options;
   4. better training of sector personnel; and
   5. a more active participation of the private sector.

94. These challenges provide ample room for the Bank to help improve the performance of the water and sanitation sector:
Operational efficiency is a *sine qua non* condition to investment efficiency and, therefore, to the provision of services at reasonable cost. Adequate maintenance is at the core of this efficiency. The Bank’s role to promote efficient investments and operations should continue, if anything, at a brisker pace.

The Bank needs to bring to the forefront a more open and focused discussion of maintenance problems in its sector work, public sector expenditure reviews and operations. To lend credibility to this effort, it should be followed by holding back on lending for expansion of capacity in those countries or for those agencies which show distressing signs of inadequate maintenance (high losses, poor water quality and service) until credible plans to redress the situation are firmly in place.

While the Bank has supported efforts to establish financial targets, a more concerted effort is needed to develop adequate operational targets, as the latter determines, to a large extent, what happens to the former. Additional sector work is needed to develop adequate operational indicators that take into account the range of size, area of service and types of services provided by water/sanitation utilities in the region.

To make an impact on these areas, the Bank needs to strengthen the capacity of the Bank’s sector staff to deal with maintenance issues in a more systematic and comprehensive manner.

The Bank is in a privileged position to foster dissemination of the issues related to inadequate maintenance and concomitant problems. This dissemination effort by EDI, LATIE and the Operating Departments should be channelled in a coordinated way to increase synergism. Seminars should be directed, primarily, at public officials in senior positions with the power to influence decisions.

The Bank should also support governments more actively in their efforts to improve accountability of public officials and institutions and a more transparent decision making process with broader public participation. Regulatory agencies and tariff boards have a key role to play but they are often in need of technical assistance to relate operational performance to rates. This is an area where the Bank has ample room to expand its role.

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1. The first LATIE (and Bank) sector report on this topic "Management and Operational Practices of Municipal and Regional Water and Sewerage Companies in Latin America and the Caribbean" was published in August, 1989.
• If a country decides that the best means to develop the water/sanitation sector is to promote a more active participation of the private sector, the Bank will support the adoption of reforms tailored to the particular situation. Nevertheless, the Bank has a stronger role to play in this area by helping disseminate more forcefully the good practices, both within and outside the region, of private sector participation in the maintenance and operation of sector utilities.
BIBLIOGRAPHY


WATER SUPPLY AND SEWERAGE SECTOR

MAINTENANCE: THE COST OF NEGLIGE AND OPTIONS TO IMPROVE IT

Case Study: The Cost of Unaccounted For Water in Bogotá

BACKGROUND

1. The Empresa de Acueducto y Alcantarillado de Bogotá [EAAB] has increased coverage of water services from 83 percent in 1975 to over 97 percent in 1989 and of sewerage services from 78 to 96 percent over the same period. EAAB is also in charge of the storm drainage system. In 1989, EAAB had a staff productivity of 2.04 staff per thousand water plus sewerage connections.

2. The increase in service levels has been achieved by a consistent long-term investment strategy by borrowing from international organizations and suppliers' credits and by increasing pension liabilities. Over the period 1976-1985, EAAB invested US$904 million [current terms] of which 36 percent was internally generated. The Bank's association with EAAB began in 1968, and since then, the Bank has provided US$253 million to help finance four investment projects. EAAB receives no national or local subsidies in support of its investment program.

3. One blemish on the otherwise distinguished record of EAAB is its high UFW. For many years, management paid little attention to UFW, and the problem grew worse. In the 1960s, EAAB's UFW averaged about 24 percent; it increased somewhat in the early 1970s, but it was brought down to 22 percent by 1975. Since then, UFW has steadily increased; it reached 40 percent in 1985 and has remained in the 40-45 percent range ever since. The evolution of UFW in EAAB as well as other pertinent production and consumption data is presented in Table 1 and Figure 1. Only in the past two years or so has EAAB began to pay serious attention to the reduction of its UFW and renewed its efforts to bring this problem under control.

1. This note is not intended to describe possible actions to reduce UFW.
4. No hard data is available to allow a detailed breakdown of past UFW figures. Recent studies \(^2\) tend to suggest that most of the increase in UFW is associated with problems in the commercial area related to unregistered connections and loss of meter accuracy. These studies helped to provide a breakdown of the existing level of 40 percent UFW:

a) physical losses, 9 percent,

b) macrometering losses, 5 percent,

c) micrometering losses, 9 percent, and

d) illegal connections, 17 percent. \(^3\)

5. While water connections increased by 127 percent from 1975 to 1989 and consumption volumes by 57 percent, production increased by 104 percent as a result of an increase in UFW from 22 to 40 percent. During the same period, unit consumption decreased from 56 m³ per connection per month to 35 m³/connec/month.\(^4\)

**ECONOMIC AND FINANCIAL COSTS**

6. In order to quantify the costs of this increase in UFW, the 1975 UFW figure of 22 percent has been taken as the reference level. The implicit assumption is that this level of UFW could have been maintained by a sustained maintenance effort of both the physical and commercial system infrastructure. This reference level does not avoid further arguments as to the feasibility and cost effectiveness of reaching even lower UFW levels, but this analysis is beyond the scope of this case study.

7. The additional costs attributable to an increase in UFW can be grouped into three main categories:


\(^3\) There is some evidence that the highly progressive rate structure in Bogotá may have contributed to the rise in illegal consumption. Some consumers in the high rate (and consumption) brackets may have resorted to illegal means to reduce their water bills.

\(^4\) This decrease in unit consumption is attributable to two main factors: an increase in the number of low income population served with house connections and to price elasticity (-0.27) effects.
a. Operational costs associated with the incremental production to compensate for the increase in UFW.

b. Additional costs incurred because new production facilities had to be advanced to meet additional demand requirements.

c. Loss of revenue due to an increase in commercial losses.

8. There are economic costs, as mentioned earlier, associated with a and b. As indicated previously, there are economic costs associated with c as well. All three categories affect the finances of EAAB and, therefore, its financial capacity to tackle its ambitious investment program.

Additional Production Costs

9. The difference between the actual and the reference level of UFW is considered as "excess" UFW or production. This "excess" volume represents an additional quantity that had to be produced to compensate for a loss in productivity. Over the fifteen year period, this additional production was 988 Mm3 or 66 Mm3/year on average (2.1 m3 per second).

10. Based on EAAB’s operating cost data, only about 30 percent of the operating costs [depreciation and debt service excluded] can be directly related to the level of production (short-term marginal cost). Therefore, the economic and financial costs associated with this "excess" production amount to US$33 million over this fifteen year period [see Table 2 for calculations]. These costs were, for instance, US$4.3 million in 1989.

Loss in Revenue

11. The portion of the UFW attributable to commercial losses (unpaid consumption) also affects the financial position of EAAB, as it represents water consumed but not billed. All of these losses can be considered, in theory, as capable of being captured as revenue by the sector agency. Commercial losses represented 65 percent of all UFW in 1989. Over the fifteen year period (1975-1989) commercial losses have been estimated by assuming a) that the ratio of commercial to total losses remained constant at 65 percent or b) that the level of physical and macrometering losses remained constant at the 1989 level (14 percent) and the rest, by definition, represents commercial losses. The outcome

5. Economic costs are somewhat higher, as electricity rates are below marginal cost in Colombia. Pumping costs, however, are not substantial and, therefore, have not been quantified.
is not very sensitive to either assumption, and the reported values are the average of the two.

12. Although the distribution of the "unpaid" consumption among different users is not known in detail, a first approximation to the corresponding loss of revenues can be obtained by assuming that all this water could have been sold at the average rate. The corresponding financial cost in terms of lost revenues during this period is US$319 million [current terms] [see Table 2 for calculations]. The corresponding value for 1989 is US$39 million.

13. The economic losses derived from this "excess" unpaid consumption beyond the optimal point (at which price equals marginal cost) are somewhat more elusive to quantify. Taking into account that the long-term incremental cost is about US$0.29/M3 and that about 65 percent of the "excess" losses is attributable to faulty meters and illegal consumption, the economic cost of this increase in consumption is estimated at US$19 million over the period 1975-1989 (Figure 2).

Anticipated Investments

14. The Chingaza project was implemented to increase production and treatment capacity at a cost of US$182 million 7. Its main components were completed in 1982.

15. As shown in Figure 1, the "excess" production represents a volume that had to be produced to compensate for the increase in UFW. This lost volume in 1989, for instance, would have been adequate to supply the needs of 1.7 million people at the average consumption rate (and 22 percent UFW). Consequently, additional capacity had to be brought on line in 1982. In other words, had EAAB been able to maintain UFW at the low historical level of 1975, the construction of additional production capacity could have been delayed by some 7 years. The savings, therefore, from a 7 year postponement of the Chingaza project (10% rate of discount) would have been US$89 million.

6. Includes water and sewerage charges, as both are linked to water consumption.

Recapitulation

15. The extra costs and loss of revenues (in current terms) incurred during the period 1975-1989 because of the undesirable increase in UFW can be summarized:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Economic Costs</th>
<th>Financial Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Costs</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Anticipated Investments</td>
<td>89</td>
<td>89</td>
</tr>
<tr>
<td>Non paid consumption</td>
<td>19</td>
<td>319</td>
</tr>
</tbody>
</table>

16. These costs can be put in perspective by looking at EAAB investments and debt service obligations during the same period. From 1975 to 1989, EAAB invested US$904 million and aggregate payments for debt service obligations were US$195 million. The net financial loss is equivalent to 42 percent of all operating income and to 1.13 times the total internal cash generation during this period.
BOGOTA
UNACCOUNTED FOR WATER

Million M3/Year


350

Production at 22% UFW

Consumption

Installed Capacity

to 802 from 1982

Production
### Table 9

<table>
<thead>
<tr>
<th>Year</th>
<th>Popul. (Mill.)</th>
<th>Connections</th>
<th>Production Demand (1000)</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>3.19</td>
<td>322 (83%)</td>
<td>303 (78%)</td>
<td>253</td>
</tr>
<tr>
<td>1976</td>
<td>(84)</td>
<td>265</td>
<td>205</td>
<td>22.6</td>
</tr>
<tr>
<td>1977</td>
<td>3.57</td>
<td>369 (85%)</td>
<td>347 (80%)</td>
<td>286</td>
</tr>
<tr>
<td>1978</td>
<td>(86)</td>
<td>299</td>
<td>208</td>
<td>30.4</td>
</tr>
<tr>
<td>1979</td>
<td>3.87</td>
<td>414 (90%)</td>
<td>385 (83%)</td>
<td>314</td>
</tr>
<tr>
<td>1980</td>
<td>(90)</td>
<td>350</td>
<td>315</td>
<td>32.2</td>
</tr>
<tr>
<td>1981</td>
<td>3.98</td>
<td>453 (91%)</td>
<td>422 (85%)</td>
<td>353</td>
</tr>
<tr>
<td>1982</td>
<td>(94)</td>
<td>356</td>
<td>239</td>
<td>32.9</td>
</tr>
<tr>
<td>1983</td>
<td>4.28</td>
<td>518 (94%)</td>
<td>478 (87%)</td>
<td>401</td>
</tr>
<tr>
<td>1984</td>
<td>(99)</td>
<td>407</td>
<td>241</td>
<td>36.0</td>
</tr>
<tr>
<td>1985</td>
<td>4.71</td>
<td>595 (96%)</td>
<td>551 (89%)</td>
<td>424</td>
</tr>
<tr>
<td>1986</td>
<td>(96)</td>
<td>452</td>
<td>257</td>
<td>40.5</td>
</tr>
<tr>
<td>1987</td>
<td>4.96</td>
<td>659 (97%)</td>
<td>613 (90%)</td>
<td>474</td>
</tr>
<tr>
<td>1988</td>
<td>(97)</td>
<td>499</td>
<td>280</td>
<td>43.9</td>
</tr>
<tr>
<td>1989</td>
<td>5.21</td>
<td>732 (97%)</td>
<td>722 (96%)</td>
<td>515</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5,648</td>
<td><strong>3,635</strong></td>
<td><strong>35.6</strong></td>
<td>2,013</td>
</tr>
</tbody>
</table>

---

*Volumes in million cubic meters per year.*

*Population in millions.*

*House connections in thousands.*

*Population served in percent.*
### Table 10

<table>
<thead>
<tr>
<th>Year</th>
<th>Average $/\text{Mm}^3/\text{year}$</th>
<th>Financial Losses (US$ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Revenues</td>
<td>Costs</td>
</tr>
<tr>
<td></td>
<td>US$/M3</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>0.11</td>
<td>0.05</td>
</tr>
<tr>
<td>1976</td>
<td>0.13</td>
<td>0.05</td>
</tr>
<tr>
<td>1977</td>
<td>0.19</td>
<td>0.06</td>
</tr>
<tr>
<td>1978</td>
<td>0.20</td>
<td>0.07</td>
</tr>
<tr>
<td>1979</td>
<td>0.21</td>
<td>0.10</td>
</tr>
<tr>
<td>1980</td>
<td>0.23</td>
<td>0.11</td>
</tr>
<tr>
<td>1981</td>
<td>0.25</td>
<td>0.11</td>
</tr>
<tr>
<td>1982</td>
<td>0.26</td>
<td>0.14</td>
</tr>
<tr>
<td>1983</td>
<td>0.28</td>
<td>0.13</td>
</tr>
<tr>
<td>1984</td>
<td>0.28</td>
<td>0.12</td>
</tr>
<tr>
<td>1985</td>
<td>0.23</td>
<td>0.11</td>
</tr>
<tr>
<td>1986</td>
<td>0.24</td>
<td>0.10</td>
</tr>
<tr>
<td>1987</td>
<td>0.26</td>
<td>0.11</td>
</tr>
<tr>
<td>1988</td>
<td>0.29</td>
<td>0.12</td>
</tr>
<tr>
<td>1989</td>
<td>0.29</td>
<td>0.12</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Para.11:
(a) assumes ratio of commercial to total losses at 65%  
(b) assumes physical losses represent 14% of total.

$g/ \quad$ Revenues per m3 sold.  
Variable operating costs per m3 produced.
Figure 6

ECONOMIC COST OF ILLEGAL CONSUMPTION

Price

Effective demand

Net Economic Loss

---- commercial losses ----

Quantity

Economic Cost

Metered Demand

--- commercial losses ---
Table 11

**Economic cost of unpaid water.** (example developed for year 1989)

Additional Commercial losses (ACM): 65 percent of total "excess" UFW (para. 13).

Marginal cost $\approx$ US$ 0.29/m3

$$P_m = \frac{0.29 \times 309}{309 + 77} = 0.23$$

ACL = 0.65 $\times$ 119 = 77 Mm3/year in 1989.

$$e = \frac{AQ}{Q} = -0.27$$

Therefore AQ = -27 Mm3/year for AP = 0.06

Economic Cost = $27 \times 0.06 = US$0.81 million

The total economic cost for the period 1975 - 1989 can then be estimated at:

$\approx 988 \times 0.65 \times 0.03 \approx $US19 million.
WATER SUPPLY AND SEWERAGE SECTOR

MAINTENANCE: THE COST OF NEGLECT AND OPTIONS TO IMPROVE IT

Case Study: The Cost of an Unreliable supply in Tegucigalpa¹

1. Water and sewerage services in Tegucigalpa, Honduras, are provided by the National Water and Sanitation Company (SANAA). The city suffers from a shortage of supply and intermittent service aggravated by high UFW. This has caused households to install their own backup systems where affordable and to use vendors.

2. In 1986, production, sales and UFW for Tegucigalpa were as follows:²

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total city population</td>
<td>520,000</td>
</tr>
<tr>
<td>Population in Barrios Marginales</td>
<td>250,000</td>
</tr>
<tr>
<td>Total Water Production, Mm3/year</td>
<td>35</td>
</tr>
<tr>
<td>Total Water Sales, Mm3/year</td>
<td>21</td>
</tr>
<tr>
<td>UFW, Mm3/year</td>
<td>14</td>
</tr>
<tr>
<td>UFW as % of production</td>
<td>40</td>
</tr>
<tr>
<td>Average Water Price, US$/m3</td>
<td>0.25</td>
</tr>
<tr>
<td>Total Revenues, US$ M/year</td>
<td>5.2</td>
</tr>
</tbody>
</table>

3. Nearly half of the population was in barrios, most of which are located in the hills surrounding the city at elevations up to a few hundred meters above the main city. The high level of UFW made it impossible to entirely meet the demand of the barrios, and because these people were poor, they had no alternatives except to use vendors. Unreliable service, on the other hand, affected both the barrios and the formal sector, many of whom in the formal sector installed backup systems. Because good quality groundwater is deep, most of the backup

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1. Prepared by Professor Donald T. Lauria, University of North Carolina, Chapel Hill, N.C.

systems consisted of storage tanks that were filled either by system pressure or a pump that withdrew water from the distribution network; private wells were less common, although data on this are not available.

4. The population can be categorized according to the level of water supply; in decreasing order of service, the categories are:

<table>
<thead>
<tr>
<th>Population</th>
<th>(000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Formal sector</td>
<td>270</td>
</tr>
<tr>
<td>2. Barrios with house connections</td>
<td>144</td>
</tr>
<tr>
<td>3. Barrios with mixed service</td>
<td>25</td>
</tr>
<tr>
<td>4. Barrios with public taps</td>
<td>58</td>
</tr>
<tr>
<td>5. Barrios with no piped system</td>
<td>23</td>
</tr>
</tbody>
</table>

The Cost of an Efficient System

5. All the households in category 5 used vendors to meet their basic water needs. On average, they consumed 20 liters per capita per day (l/cd). During the 6-month dry season, they purchased water from vendors at a price of US$8.5/m3 (35 times the official SANAA price). During the 6-month rainy season, they obtained most of their water from roof catchments and other free sources. Consequently, the amount these households paid to vendors in 1986 was about US$700,000.

6. For households in category 4, there was a tap for each 1,000 to 1,500 persons. Hence, under the best of circumstances, service was poor and required long queues (average collection time was one hour per day in the rainy season and 1.5 hours per day in the dry season). Hence, these households spent about 7,800 hours per day collecting water from public taps. Based on the minimum wage rate of US$2.0 per day (US$ 0.25/hour), the cost of this waiting is conservatively estimated at US$400,000 per year. About half of the households in this category purchased from vendors in the dry season, and they obtained water free in the rainy season. These households used an average of 20 l/cd and paid vendors about US$900,000 a year. The other half of the population in this category obtained their water from public taps in the dry season and got free water in the rainy season. However, the price paid to “aguateros” at the public taps was US$ 4.0/m3 (16 times the official SANAA price). Hence, for using these public taps, these households paid about US$400,000 a year. SANAA, in turn, was reimbursed at its official price.
7. Households in category 3 had a mixture of private connections, public taps, or no piped service, in which case they used public taps or neighbors. It is conservatively estimated that half the houses purchased 20 lpc from private taps during the rainy season for which they paid about US$200,000 per year. Households with private connections paid the official price to SANAA. Households in categories 1 and 2 obtained all their water from the SANAA system.

8. The table on the following page summarizes how basic water needs were met and the cost incurred. This table shows that payments of about 80 percent of the population (categories 1 and 2) amounted to US$13 per year per capita. The remaining 20 percent of the population (categories 3, 4 and 5) paid to "aguateros" and public vendors an average of US$21 per year per capita.

| Category | Population (000s) | Average Paid to (US$ M) |  |  |
|----------|-------------------|------------------------|  |  |
|          |                   |  | SANAA | Public Taps | Vendors |
| 1        | 270               | 140                     | 13.9 | 3.4 | 0 | 0 |
| 2        | 144               | 140                     | 7.4  | 1.6 | 0 | 0 |
| 3        | 25                | 20                      | 0.2  | 0   | 0.2 | 0 |
| 4        | 55                | 20                      | 0.4  | 0   | 0.4 | 0.9 |
| 5        | 23                | 20                      | 0.2  | 0   | 0 | 0.7 |
| Total(Ave)| 520               | (116)                   | 22.1 | 5.2 | 0.616 |

- Not including the cost of time spent on waiting.

9. In the report to PAHO, it was estimated that a stand alone deep well system serving public taps with 200 users each could be constructed for US$30 per capita, an amount similar to what households in categories 4 and 5 paid to vendors each year for the same quantity of water. Hence, by constructing independent well systems costs to consumers could be reduced from US$30 to US$6 per year per capita or a net savings of almost US$2 million a year, equivalent to 40 percent of SANAA’s annual revenues. It should be emphasized that the basic water needs of people cannot be met from the SANAA system due to the high level of UFW.

The Cost on an Unreliable System

10. Households in category 2 were too poor to afford backup systems and for the most part, chose not to purchase water from vendors because of high prices. As a result, they simply learned to live with unreliability and collecting and storing their water in 55-gallon drums whenever there was pressure in the system. Households in this category and all other categories in the barrios generally had
two drums each for storage, which costs about US$5 per drum. Altogether, there were about 45,000 households in the barrios, which, at US$10 per household, spent nearly US$0.5 million on drums for storage.

11. The population in category 1 comprises 48,000 households and had the best water service in Tegucigalpa. Nevertheless, many of these households suffered from unreliability during the dry season, which caused them to install their own backup systems. Some of these systems consisted merely of storage tanks connected to the distribution system, sometimes equipped with float valves. These tanks cost about US$100 each. Other systems included a pump in addition to the tank, with a cost of about US$300 each. It is likely that some 60 percent of the households in this category had tanks, and therefore, they spent between US$3 million for the simpler version of the tank and US$9 million for the type with the pump.

12. By the way of comparison, in the report to PAHO it was estimated that a well 300 meters deep to serve 1,000 people with 250 l/c/d would cost about US$20,000. Hence, for an equivalent expenditure of US$6 million it would be possible to construct 300 wells that could serve 300,000 persons which is more than the entire population in the formal sector.