ABSTRACT

It appears that many problems associated with the key water system management tasks in the small communities of Honduras could be solved if water were treated as a marketable good. This would involve the use of meters along with a pricing system that in principle should set the price equal to the marginal cost.

This paper first discusses the theoretical aspects of using meters along with a marginal cost pricing scheme and how this could help to solve the system management problems in Honduras. Then, an examination is made of the practical aspects involved in running a metering system as it is done by a well organized utility in the United States. Finally, an assessment is made of implementing metering systems in the small communities of Honduras in light of the practical considerations. In general, the problems involved in such implementation would appear to make it impracticable, at least for the vast majority of systems. Honduras needs to stregthen its institutions before it can turn to widespread metering.

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CHAPTER I

INTRODUCTION

This thesis is concerned with piped water supply systems in small communities in Honduras. The population of these communities ranges from 10,000 to 50,000 inhabitants. The water supply source in these towns is usually a spring, a river, or a well. In the majority of systems, the water is transported from the source to the town by gravity. In some cases, however, water needs to be pumped because it comes from a well (groundwater) or because the source is at a lower elevation than the community. Pipe networks are used to distribute the water to the community, and the final delivery is made though the use of house connections or public taps. The majority of these water supply systems are not metered, although a few of them have meters on house connections and large water users such as industries and commercial businesses.

In the small towns of Honduras, community groups, town governments, or the national water supply authority, SANAA (a quasi-governmental agency of the government) are responsible for management of the water supply systems. Basically, management involves five major tasks: a) to distribute water to users; that is, to provide good quality water in sufficient quantity to meet user needs, b) to obtain revenue for operation and maintenance, c) to maintain the system, e) to decide when and how large to make capacity expansions, and d) to pay for the capacity expansions of the system. Clearly, there are additional management tasks, but these are the ones of primary concern in this report.

1.1 Water System Management in Honduras

In Honduras, distribution of water is accomplished either by public taps, by house connections and vending. Public taps generally consist of one or several standpipes, usually equipped with a main cutoff valve that sometimes can be locked. Public taps are sometimes protected with a wooden structure like a small house. To haul water from the public tap, people use plastic or metal buckets. To get water from the tap, people usually have to form a queue and wait their turn to fill their bucket. The other method of distributing water is through the use of house connections which may or may not be metered; in some instances, the connection is only a yard tap. House connections and public taps are not mutually exclusive; it is not uncommon to find communities with part of the population served through house connections and the rest served through public taps.

To obtain revenue for operation and maintenance (the second major management task cited above), water authorities in Honduras use both flat rates and commodity charges. A flat rate is a fixed charge that the user pays periodically (usually every month), regardless of the amount of water consumed. Flat rates are the most common charges in Honduras, primarily because of their simplicity. Generally, the local water authority has a list of all customers, and every month they send someone to collect and record the payments from those on the list. The other type of charge is a commodity charge in which the customer pays in proportion to the quantity of water consumed. Since commodity charges are proportional to consumption, they require the use of a water meter 1/. When a commodity charge is used, the meters are read periodically, the information is sent to the central office in Tegucigalpa 2/, bills are prepared, and they are distributed to the customers who must pay in the local office of the water authority. Both commodity charges and flat rates in Honduras are usually set low to make them affordable to the poor.

1/ In Honduras, water systems that have meters are managed by SANAA, the national water supply authority. Systems without meters are managed by the municipalities themselves or other community groups.

2/ The billing and customer accounts are centralized in the main office of SANAA in the capital.

Maintenance of water supply systems (the third management task), is woefully lacking in the small communities of Honduras. Usually, it is only large visible leaks that are fixed; seldom is there any leakage control program in these towns. No routine maintenance is performed, primarily due to lack of funds and technical expertise. Communities rely on the national government to help them solve their larger maintenance problems. Generally, communities perform maintenance only when problems becomes apparent or there is a breakdown in the system. If a community does not have the expertise, equipment or material or if it cannot afford maintenance, then it requests assistance from the national government.

In the small towns of Honduras, it is uncommon to plan ahead for capacity expansions of the water systems, which is the fourth major management task. Generally, there is little information on which to base decisions on when and how large to make capacity expansions. Consequently, the current demand and its growth are not considered at all; it is only when demands have exceeded system capacity that expansions are considered.

With respect to obtaining funds in Honduras to expand the capacity of water systems, most communities do not have the resources to perform this work by themselves. When it is required to expand the capacity of a system, communities rely on assistance from the national government or any of the international private voluntary organizations such as CARE. The government does not have many resources to make available for water supply in communities. Consequently, only a small number of towns receive help each year. On the other hand, private voluntary organizations help rural communities to build their own water systems, but very few resources are allocated for capacity expansions. Rather, most investment is for new construction.

1.2 Problems with Water System Management in Honduras

The methods used for handling the major water system management tasks in Honduras are generally deficient and result in problems. This section presents some of the most common difficulties associated with these management tasks.

In the distribution of water, there are problems with both house connections and public taps. With respect to taps, they are inconvenient and require excessive time in carrying water from tap to the home. Only a reduced quantity of water can be consumed each day due to the difficulty of hauling it. This limits the use of water to the most essential purposes, making it impossible to obtain full hygienic benefits. Another problem with taps is that they generally require water to be stored in the home, usually under insanitary conditions subject to various sources of pollution, with resulting risks to health.

There are also problems with the distribution of water through house connections. Even where meters are used, there is frequent underregistration, illegal connections, and meters that do not work.

Underregistration is a common phenomenon with meters that have been in use for some time. When a meter is new, it usually has a high degree of accuracy, but in time, the meter loses its accuracy, sometimes due to wear, or to the quality of the water, or to accidental or intentional damage. The result is that most meters register less than the actual volume of water passing through them.

Illegal connections represent a serious problem when water is distributed through house connections. Illegal connections are not registered by the water authority and consequently do not have meters. An illegal connection is usually made by tapping the main and using a connecting pipe or hose that runs to the house or by by-passing the water meter with a small pipeline. Illegal connections, like underregistration, result in real losses of revenue for the water authority. In addition, since these connections are usually poorly made, they are a source of substantial leakage.

Another problem with water distribution in Honduras results from meters that do not work, sometimes because the water in the distribution system is hard or contains solids that deposit in the meter. Another cause for the breakdown of meters is their poor quality, often due to inferior materials or workmanship that were ignored in the interest of low cost.

When water is distributed using house connections but without metering, there are often problems of water wastage and financial inequity. Because the people do not pay for each unit of water, they often leave the water running after they have finished using it. Inequity, on the other hand, results because all the customers in the community pay the same flat rate, with large users paying the same as small ones.

Another area where there are serious problems in Honduras is in connection with revenues for operation and maintenance. With a flat rate system, the revenue is more or less fixed, but the operation costs are not; great variations in costs can exist, resulting in a revenue shortfall. Another problem is that flat rates do not create an incentive to conserve water. When the users pay the flat rate, they feel that they are free to use as much water as they want. A common problem is that the revenue is insufficient to cover costs because the flat rate is set too low. In addition, with flat rates many people do not want to pay their water bills. There are many reasons for this such as, they simply expect others to pay the costs, or because they are not satisfied with the service, or because they feel they deserve free water.

Even with meters and a commodity charge, there are still many problems in Honduras. The most widespread and serious problem is the difficulty in covering operation and maintenance costs because the price of water (or the water rate schedule) is usually set too low, resulting in insufficient revenue to cover costs.

In the area of system maintenance, there are three problems of particular concern in Honduras. One is the almost complete absence of preventive maintenance. Commonly, systems are not maintained and repairs are not made until problems become apparent or there is a breakdown. Consequently, it is common to have sudden interruptions in service. The second problem is that there is usually no systematic leakage control; consequently, water losses tend to grow with time. The third problem is that it takes a long time to make major repairs. When a major problem develops, it may take months to fix it because of the lack of tools, equipment, material or skilled personnel. This frequently results in lengthy service interruptions and/or water rationing for long periods.

Planning for capacity expansions is also a serious problem in the small communities of Honduras. Since planning for capacity expansions is seldom done in advance, communities commonly face water shortages because demands have exceeded current capacity. This creates discontent among water users and leads to other problems such as difficulty in collecting revenue. In systems with meters, water rationing and/or intermittent operation brings air into the pipes causing erroneous registration or, more importantly, negative pressures in networks that cause infiltration of polluted groundwater, resulting in contamination of the drinking supply.

Small communities have difficulties getting funds to expand the capacity of their systems. When excess capacity of a system is exhausted, the community usually looks for assistance from the government. But, because in government budgets only a small amount is allocated to assist small communities, it usually takes a long time before help arrives. The only alternative that the community has then is to curtail demand, which is a difficult task, especially in systems where there are house connections without meters. In the end, water authorities usually turn to rationing by given service only certain hours of the day with the consequent negative pressures and the risk of pollution.

1.3 Objectives of This Report

In order to solve the problems associated with the kinds of water system mismanagement described above for Honduras, water metering in combination with an appropriate water pricing policy has proven in many countries to be effective. The basic notion is to treat water as a marketable commodity in which the purchaser pays for each unit. With metering and a proper pricing policy, enough revenue might be generated to cover not only the costs of operation and maintenance but also the cost of expanding system capacity. With a price system, it is theoretically possible to ration the water and use it more efficiently. Additionally, it should be possible to generate information for making better decisions in operation and maintenance. Finally, with metering and a price system, it should be possible to obtain proper signals for capacity expansion. The hypothesis herein is that water metering with proper pricing might be an improved method for handling the basic water management tasks that confront the small communities of Honduras.

The goal of this report, then, is to examine the applicability of metering along with a water pricing system in small communities in Honduras. Three objectives have been set in order to reach this goal: a) present the theoretical case for using meters and appropriate prices, b) present the practical realities for implementing a metering and price system, c) assess the practicability of using meters in the small communities of Honduras.

CHAPTER II

THEORETICAL CASE FOR METERING

The water distributed to consumers in a community is a good that from the economic point of view can be treated as a commodity. In order to do this, the water must have the characteristics of a private marketable good. This type of good has two fundamental characteristics: a) it can be consumed by only one user; this characteristic is called "rivalry". An example is gasoline which, if bought by one consumer to be used in a motor, cannot be used in another, and b) it is possible to exclude certain users from consumption of the good; this characteristic is called "exclusion". An example is where payment must be made before consumption; people who do not pay can be deprived from consumption. Private marketable goods can be produced and sold through markets and they can be consumed only by those who pay the market price. Water, therefore, can be treated as a marketable good if it conforms to the two characteristics described above. (Note that the water of a river or lake that is used by persons for bathing who have free access is not a private marketable good).

In Honduras, water is not always treated as a private marketable good. In cases where there are public taps, the property of exclusion is often absent. With public taps, it is difficult to separate the people who pay for the water from those who do not; besides, in many instances water is available free of charge at public taps. In cases where house connections without meters are used and a flat rate is charged, the property of exclusion is again lacking. Water users in this situation actually pay a flat rate for the right to be connected to the system, but the water consumed is basically free of charge.

There are cases in Honduras where water is treated as a private marketable good. In communities with house connections and meters, some type of commodity charge is applied, making water a private marketable good. However, in most cases, the price of the water is usually set low in order to make it affordable to the poor. Despite marketing, therefore, serious problems usually result, as described in the previous chapter. Hence, marketing alone is not necessarily a solution to the water management problems of Honduras.

Treating water as a private marketable good in principle would seem to resolve the problems related to the major tasks of water system management. But to do so requires the installation of meters, additionally, the economists recommend the use of economic principles, namely marginal cost pricing. To see how metering in combination with marginal cost pricing can help resolve the problems that exist in water system management, it is useful to consider metering on one hand, and marginal cost pricing on the other.

2.1 Metering

The use of water meters in a community in principle has two major effects: a) the water can be distributed more and fairly, and b) water losses can be more easily managed. The first is a distribution effect, and the second is an effect on maintenance.

2.1.1 Metering and the Distribution of Water

Metering makes it possible to distribute water more fairly. Without metering, water charges and water consumption are not necessarily related. This means that even though some users consume more water than others, all of them can end up paying the same water bill (with a flat rate system). This means that large users pay less per unit volume of water than small users. When metering is introduced in conjunction with commodity charges, the water becomes a private marketable good that is sold at a single price per unit volume (or single rate schedule) applicable to all users in the same class. Metering, therefore, serves as the basis for distributing water fairly among water consumers in a community because every consumer pays in proportion to consumption. The more that is consumed, the more that must be paid. An alternative to a flat rate system is to charge by the number of faucets or sinks in a house, but even here distribution is not entirely equitable since to have more taps does not necessarily result in higher usage.

2.1.2 Management of Water Losses

The second effect of metering is in connection with maintenance. A metering system can provide the information necessary for managing water losses. Water losses can be considered from the point of view of either the customer or the water utility. From the viewpoint of the customer, if the house plumbing is leaking, the water loss is going to represent an increment in the monthly bill. This will create an incentive for the householder to fix the plumbing. One way of detecting household water losses consists in closing all faucets in the house, then taking an initial reading on the meter, leaving the faucets closed for some hours, and finally taking a new reading of the meter. If there is significant leakage in the house, it is going to be reflected as a difference between the two readings.

From the point of view of the water utility, water losses consist of the total unaccounted-for water in the system. Unaccounted-for water can be defined as the difference between the total water put into the system (usually measured at the water treatment plant) and the total amount of water used by the consumers (usually estimated as the total amount of water billed), during the same period of time. Unaccounted-for water comprises all the water lost by leakage in the distribution system, the non-metered water supply, the illegal use of water, fire fighting, underregistration of meters, and accounting errors. The unaccounted-for water represents a real loss of revenue for the water utility, and for this reason should be kept as low as possible.

Universal metering can help to reduce leakage in the distribution network and reduce illegal use of water. Metering provides the information on consumption of water by users of the system and allows the utility to make water balances in the network, i.e. to estimate differences between the amount of water put into the system and the amount taken out for consumption. Consequently, metering makes it possible to determine the areas in the network with high water losses. Subsequent field work can more precisely detect leakage in pipes or illegal connections in the areas with large losses.

2.2 Marginal Cost Pricing

With marginal cost pricing, the intention is to set the price of water equal to the economic cost (real cost of resources) incurred in the production of the last unit. Theoretically, in this pricing system, water users are informed of the cost of resources used in the production of each unit of water and the consumers are left to decide how much they want to purchase based on the value they have placed to the next unit of consumption. If the consumers are willing to pay the marginal cost, it means that they place a value on the consumption of an additional unit at least as great as the cost of producing it, thereby sending a signal that it is worthwhile to produce the additional unit. On the contrary, if consumers show their unwillingness to pay a price equal to the marginal cost of production, it means that they place a value on the consumption of an additional unit lower than the cost of producing it. This implies that there is oversupply and that the additional unit should not be produced.

Marginal cost pricing is the theoretically optimal way to handle water system management tasks. It can, at least in theory, produce enough revenue for operation and maintenance and even to pay for capacity expansions. Marginal cost pricing can also provide a basis for signaling the justification for capacity expansions. The theoretical role for marginal cost pricing in water system operation is described in the remainder of this section.

2.2.1 Obtain Enough Revenue for Operation and Maintenance

To better understand how marginal cost pricing can generate enough revenue for operation and maintenance, the first step is to analyze marginal and average cost functions to see how they behave. The average cost at a certain level of output is calculated by dividing the total cost by its corresponding output. Marginal cost is defined as the cost incurred in producing the last unit of output. Marginal and average costs are derived from the total cost function and they vary with the level of output.

For any given total cost function, it is possible to plot the average and marginal cost curves. Figure II-1 presents a typical total cost function from which the average and marginal cost curves are derived (curves are shown in Figure II-2). Note that the marginal cost at any level of output is the slope of the total cost curve, and the average cost is the slope of the line segment joining the origin and the total cost curve. From the figure we can see two important relations of these cost functions: a) in the decreasing portion of the average cost curve, the values of marginal

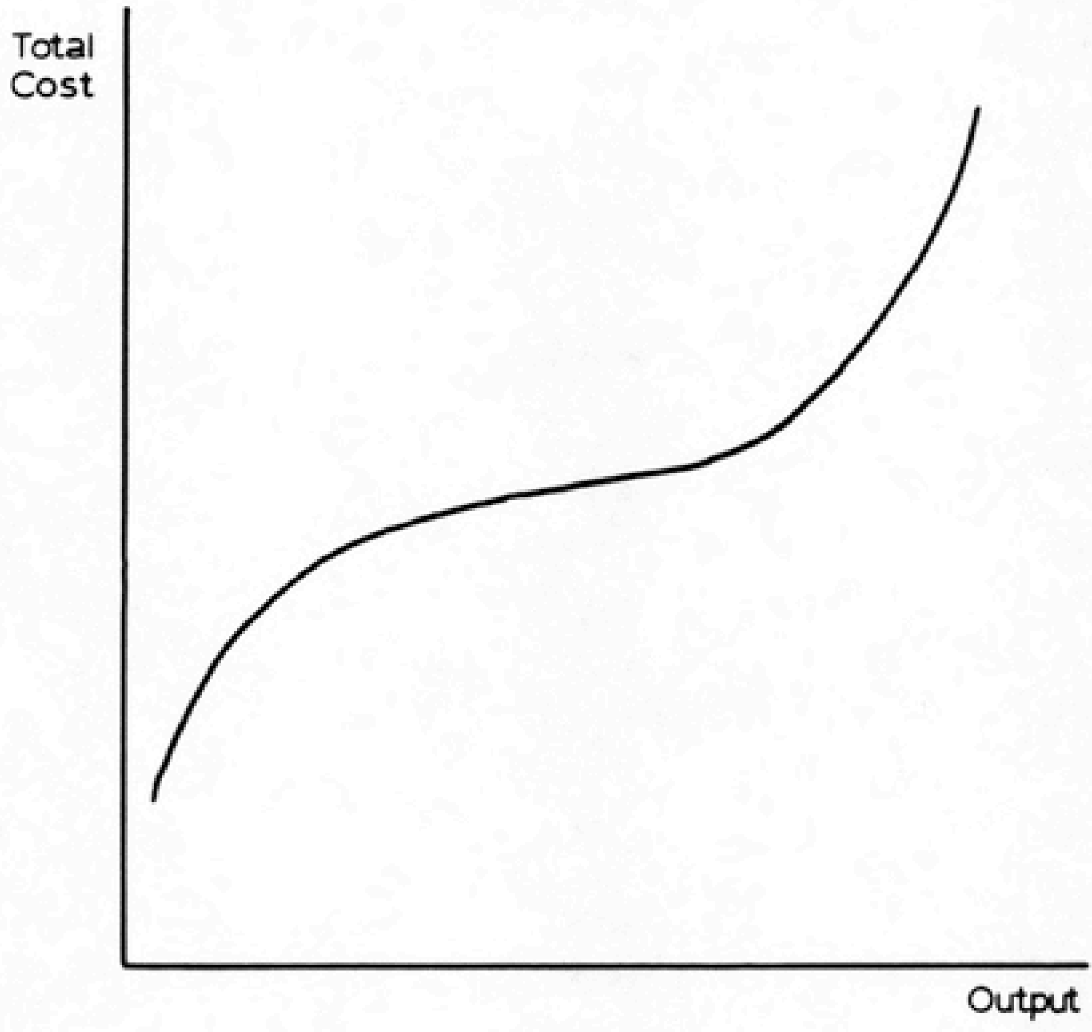


Figure II-1 TOTAL COST CURVE

cost are lower than their corresponding average cost values. When the average cost decreases, the rate of change of the cost function (the value of the marginal cost) has to be less than the average cost to let the next average cost value to be less than the previous one; b) in the increasing portion of the average cost function, the marginal cost value is grater than the corresponding average cost value. In the increasing portion of the average cost curve the rate of change with respect to the output of the total cost function has to be greater than the average cost to let the next average cost value to be greater than the previous one.

The fact that the marginal cost can be grater or lower than the average cost has great importance in marginal cost pricing. It is possible to have excess revenue (profit) or a deficit revenue (loss) depending upon the portion of the average cost curve in which the utility is operating. If the utility is operating in the increasing portion (which is thought to be the most common case), it is going to have profit. This is shown in Figure II-3(a). At level of output q, the utility is going to receive revenue equal to the marginal cost (under a policy of marginal cost pricing) times the output q, and it is going to have cost equal to the average cost times the output (q). Since the marginal cost is greater than the average cost, the utility is going to make profit, which is shown in Figure II-3(a) as the shaded area.

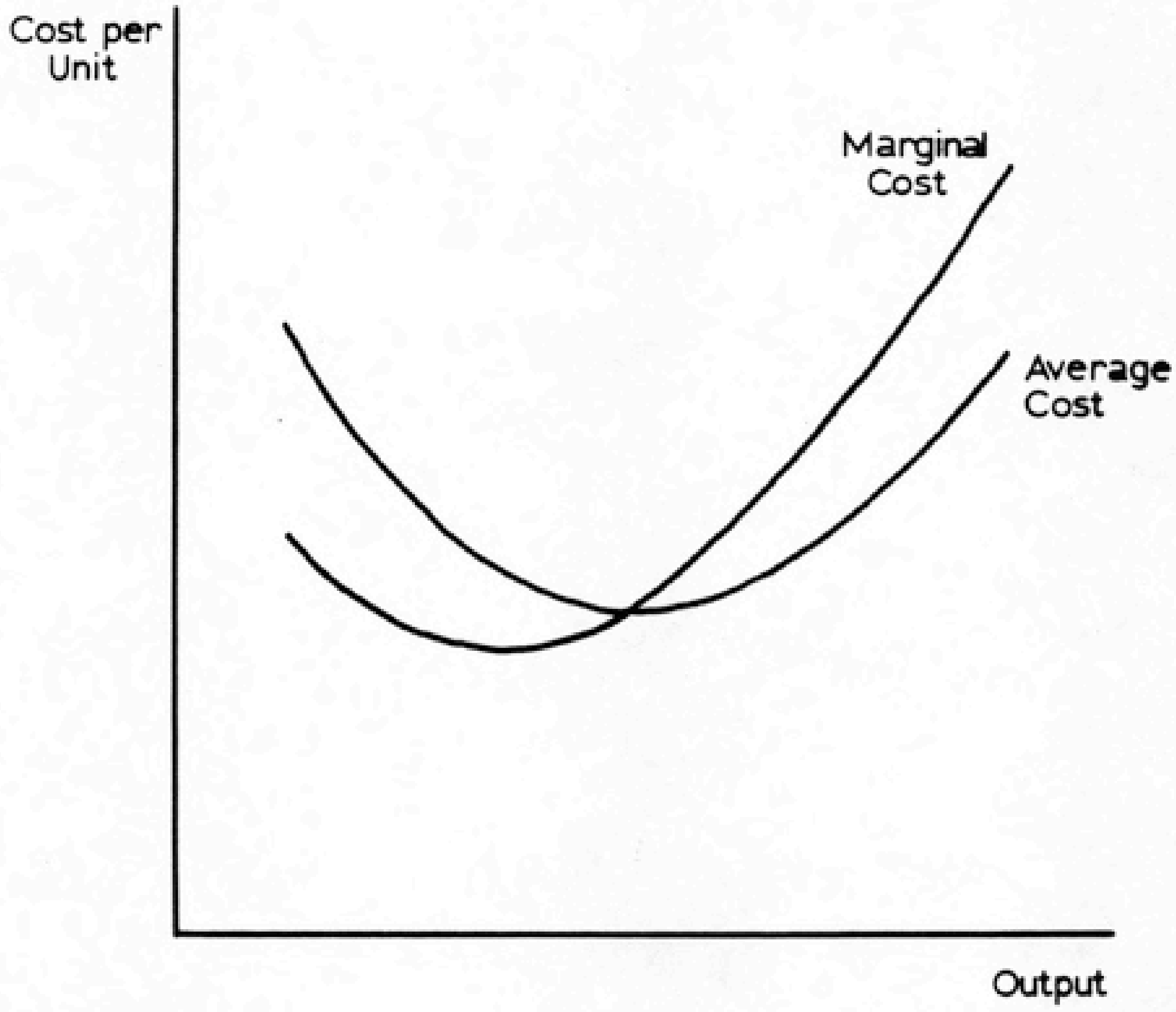


Figure II-2 AVERAGE AND MARGINAL COST CURVES

On the other hand, if the utility is operating in the decreasing portion of the average cost curve (which is the case when there are economies of scale), the marginal cost (i.e. the price) is less than the average cost and the utility will to have a loss. Figure II-3(b) presents the case of operation in the decreasing portion of the average cost curve, and the shaded area represents the loss for the utility.

Regardless of wether the system operates in the increasing or decreasing portion of the average cost curve, with marginal cost pricing it is possible to obtain enough revenue to cover operation and maintenance costs. If the price is equal or greater than the average cost, total costs, including operation and maintenance, are covered and in fact, the utility would most likely make a profit by following a marginal cost pricing policy. In the case where the utility is operating in the decreasing portion of the average cost curve, the price charged would be less than the average cost and therefore the revenue would not cover the total cost. The recommended solution to this problem is to divide the tariff into two components, one of them being a commodity charge with price equal to marginal cost, and the other being a fixed charge (independent of consumption) that would cover the losses that the utility would otherwise incur. In this

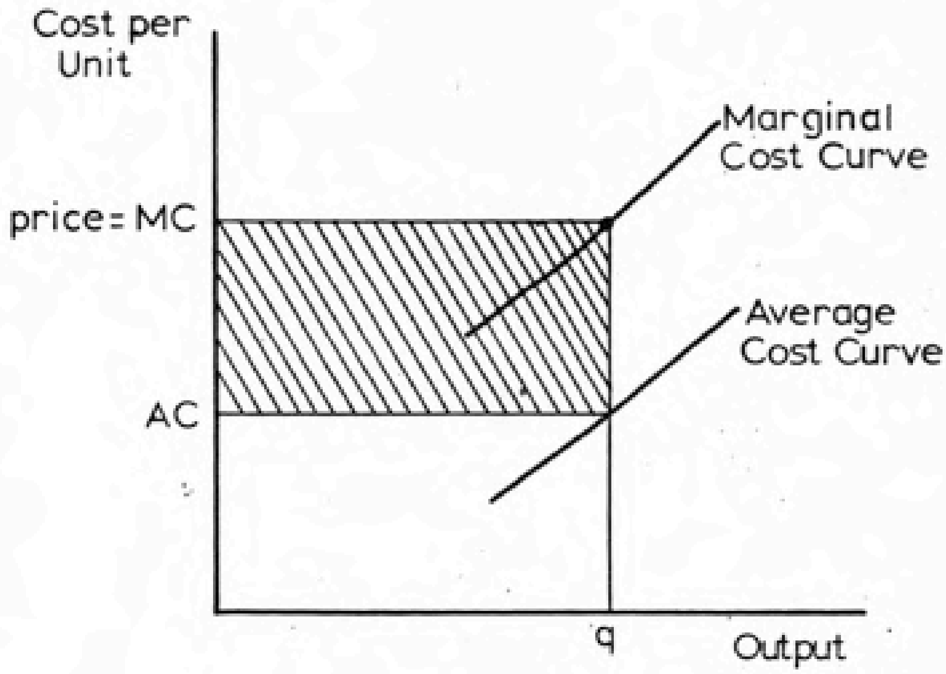


Figure II-3(a)

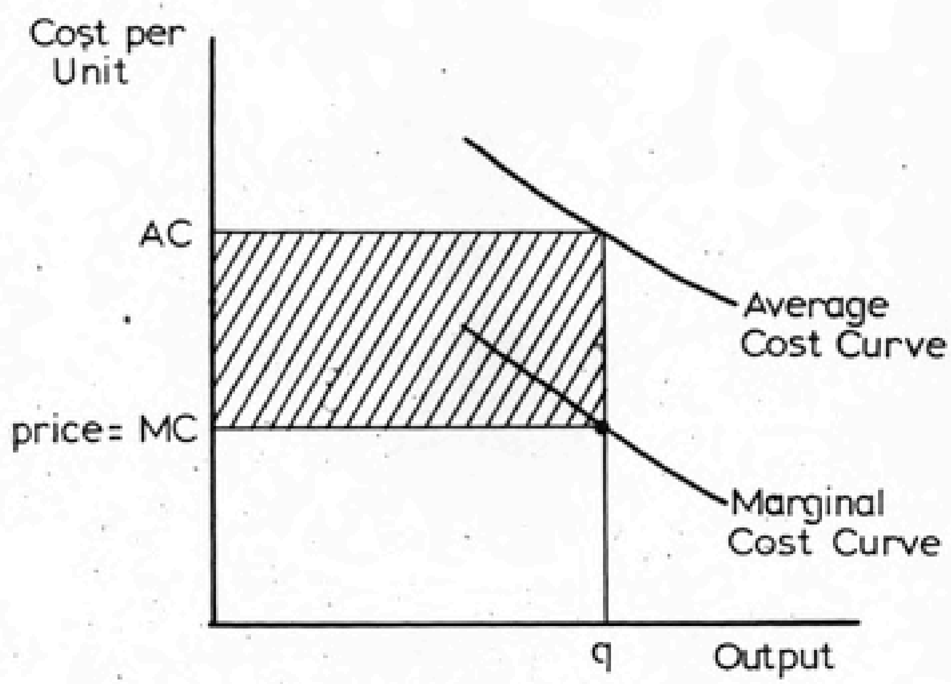


Figure II-3(b)

way, the utility would cover the total cost including operation and maintenance.

Marginal cost has two characteristics, one applicable to the short run and the other to the long run. The short run is the period of time when the capacity of the water system is fixed. Therefore, marginal cost in the short run refers to the cost of producing an additional unit of water without changing system capacity. Marginal cost in the short run basically reflects the operation and maintenance costs of producing an additional unit of output. On the other hand, the long run is a period of time long enough to allow the scale of the production plant to be changed. Marginal cost in the long to refers to the cost of producing an additional unit of output by expanding the capacity of the system. The long run marginal cost reflects, therefore, the operation and maintenance costs, plus the capital cost incurred in the production of the additional unit of output.

Earlier it was suggested that utility operation is normally thought to be at output levels where average costs are increasing. It is well known, however, that there are economies of scale in both construction and operation, which suggest falling average costs, resulting in a shortfall in revenue. It is important to note, however, that while average costs in the short run may be falling, in the long run they are usually rising, in part because of higher cost for additional water of good quality. In practice (if not in theory) prices need to be based on long run marginal costs, which accounts for the expectation that utilities would make a profit if they rigorously used marginal cost pricing.

2.2.2 When To Expand

Short and long run marginal costs are key elements in the decision on when to expand system capacity. According to marginal cost pricing theory, when there is excess capacity in the system, the price should be set equal to short run marginal cost. In Figure II-4 a representation of a short run marginal cost curve is shown. The price charged is determined at the intersection between the short run marginal cost (SRMC) and the demand curve (point A in Figure II-4). Over time, demand normally continues to grow even though the capacity of the system is utilized. This is shown by the shifting D-curves. At the point of full capacity utilization, the marginal cost curve becomes very steep or even vertical because the cost of producing an extra unit of output when there is no more excess capacity is very high. From the point of full utilization of installed capacity, the price under a policy of marginal cost pricing would have to be raised to ration the amount of water produced. As the demand grows, the price would increase, and this situation would continue until

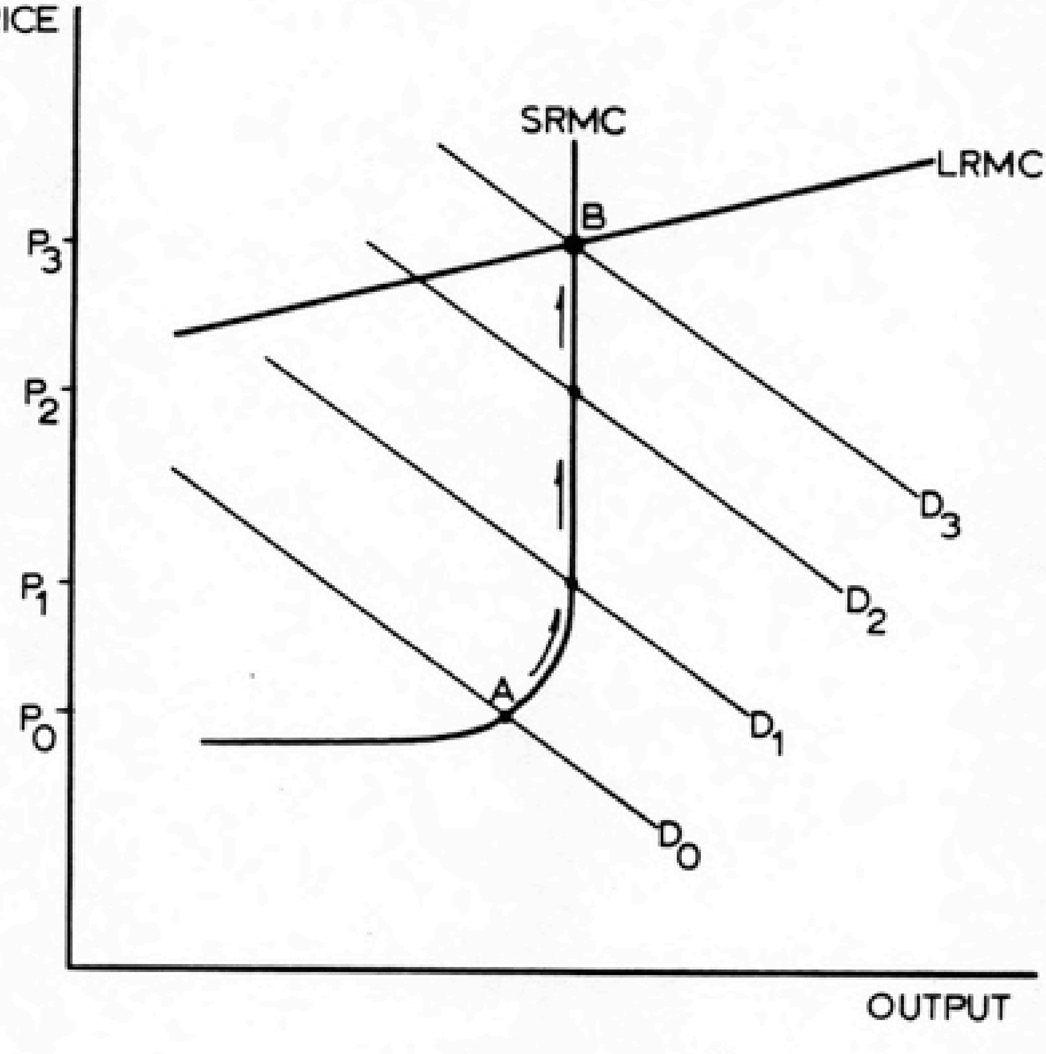


Figure II-4

the price would equal the long run marginal cost (LRMC) (point B in Figure II-4). At this point because the consumers are paying a price equal to the long run marginal cost, they are demonstrating their willingness to pay the cost of producing an additional unit of output plus the marginal capital cost that the production of this unit represents. An expansion of system capacity is then justified (i.e. at the time when demand has shifted to D_3 in Figure II-4).

Marginal cost pricing, therefore, provide a criterion upon which to base the decision when to expand system capacity. This criterion consists of letting the system become fully utilized and expanding it when consumers show their willingness to pay a price equal to the long run marginal cost (i.e. when the value consumers place on the consumption of an additional unit of output is at least equal to the cost of operation and maintenance plus the capital cost incurred in the production of that additional unit).

2.2.3 Payment for Expansions

If a water utility is operating in the increasing portion of the average cost curve, it is going to make profit. In principle, this profit could be invested in a sinking funk to pay for capital projects; in other words, the profit made can be used for expanding system capacity. In the case where the utility operates in the decreasing portion of the average cost curve, a two-part tariff would be necessary to avoid losses. In this situation, expansions of the system would have to be done through borrowing. The point is that at least in theory, a policy of marginal cost pricing makes it possible for the local community to pay for capacity expansions.

2.3 Conclusion

If water is treated as a commodity and if the utility meters every water user and follows a policy of marginal cost pricing, then in theory: (a) water is going to be distributed fairly, (b) it is going to be possible to manage water losses, (c) enough revenue will be generated for operation and maintenance, (d) a criterion will be available to tell when to expand system capacity, and finally (e) sufficient revenues should be available to pay for expansions to the system. In theory, therefore, the introduction of universal metering along with marginal cost pricing should result in efficient water system management.

Marginal cost pricing and metering, in theory, can help to resolve the problems that exist in Honduras with the tasks of water system management. However, it is necessary to examine the practical requirements of implementing marginal cost pricing and metering to determine the applicability of these principles for Honduras. This is the task of the next chapter.

CHAPTER III

PRACTICAL REALITIES: A CASE STUDY

In the previous chapter, it was shown that when water is treated as a commodity and marginal cost pricing is used, it could theoretically result in efficient water system management. However, it is necessary to consider the practical aspects involved in the implementation of a metering system and marginal cost pricing. The objective of this chapter, therefore, is to present the practical realities for using meters and applying the principles of marginal cost pricing.

When a metering system is used in a community, it is necessary to periodically make purchases to replace ones that are broken and/or to buy additional meters for new customers. It is also necessary to maintain the meters, to read them, to process the bills, and to collect the revenue. These tasks constitute the practical aspects of metering.

To determine the practical realities of implementing a metering system for the purpose of this report, a study was made of a U.S. water authority with respect to such tasks as purchasing, maintenance, reading, billing, and collection of revenue. The approach here was to study the Orange Water and

Sewer Authority (OWASA) which is responsible for providing water and sewerage services to the Towns of Chapel Hill and Carrboro and the sorrounding area, North Carolina.

This chapter is divided into the following six sections: a) description of the OWASA system, b) metering by OWASA, c) billing and collecting revenue, d) setting prices, e) discussion of OWASA water rates. The study of OWASA covered the basic aspects of metering, but it could not cover all the practical considerations regarding marginal cost pricing. Consequently, a separate section is included which presents such practical considerations based on practices of The World Bank with respect to marginal cost pricing.

3.1 OWASA System

The Orange Water and Sewer Authority (OWASA) is a publicly owned utility that was created in 1975 by the Board of Commissioners for Orange County and the governing bodies of the Towns of Chapel Hill and Carrboro. OWASA was created to take responsibility for managing the consolidated water and sewer systems of the Towns of Chapel Hill and Carrboro; previously, independent systems were owned by the University of North Carolina, the Town of Chapel Hill and the Town of Carrboro. The Authority is authorized by law to operate, maintain, and expand the water and sewerage systems in the area; to carry out short and long term planning and financing; and to set water rates and collect revenues.

The organization of OWASA consists of several hierarchical levels. A Board of Directors is the top level of decision. This board consist of nine members, five appointed by the Town of Chapel Hill, two by the Town of Carrboro, and two by the Orange County Board of Commissioners. The Authority has an Executive Director who is at the second level of decision; he has responsibility for the administration and technical direction of the Authority.The rest of the organization is divided into five divisions including Personnel, Fiscal Affairs, Customer Relations, Plants, and Engineering. OWASA has over ninety employees working in these divisions. The OWASA service area includes Chapel Hill and Carrboro in Orange County, the University of North Carolina, and part of Chatham and Durham counties. OWASA has 10,600 customers and serves a population of approximately 52,000 inhabitants. The population in the area has increased nearly 30% from 1970 to 1980 (about 2.5% per year), and is still growing due to new developments in the Research Triangle area. All customers in the service area are metered.

3.2 Metering

The Orange Water and Sewer Authority uses meters of different size from 5/8 to 8 inches. The major tasks for OWASA in connection with metering include purchasing meters, spare parts, and accessories; testing the accuracy of meters; and maintaining the larger meters that have been in the field for some time and are not working properly.

3.2.1 Purchase of Meters

OWASA purchases all the meters that are installed in the water distribution system, rather than leaving such purchase to developers, residential customers, commercial businesses or the university. This policy has been adopted by OWASA in order to ensure that meter specifications are met and to prevent the use of meters from too many different manufacturers. Another reason is to control the stock of meters all the time so as to satisfy both ordinary and extraordinary demands. Finally, by purchasing directly, OWASA establishes a direct communication with the manufacturer.

Since OWASA buys all the meters, purchases have to be planned in advance. This is done by the Engineering Division and consists basically in answering two questions: a) how many meters to buy?, and b) when to buy them?

The quantity of meters to be bought depends on the number of new houses and the replacement of old meters. OWASA keeps records of the number and type of meters installed for new customers every year; hence, it is fairly easy to make estimates of the demand for meters in the coming year. Table III-1 shows the trend of 5/8" meters installed in the past five years. There are also records on the number of new meters that are installed annually to replace old meters. Currently, OWASA is purchasing about 1,000 meters a year of which approximately sixty percent are to replace old meters and forty percent for new customers.

The purchase of meters depends on the following conditions: 1) when the estimated future demand for meters 2" or smaller would considerably reduce the stock in the warehouse, considering the time for stock replacement; 2) when a large meter not in stock is going to be installed; and 3) when the stock of any particular size of meter decreases below the minimum number that can be ordered. The information on the current stock of meters in the warehouse is provided through a Cardex system, which is a control of inventory method where all the purchases and withdrawals are recorded on small cards.

Table III-1

METERS INSTALLED IN THE PAST FIVE YEARS

Year	No. of meters 1/
1981	141
1982	227
1983	203
1984	338
1985	538

Source: OWASA

1/ All meters are 5/8" nominal size.

The purchase of meters involves several steps. The process starts in the Engineering Division where a request is made of the OWASA purchasing office. Along with the request are sent the specifications of the meters to be bought. They usually require a one year warranty against defective material and workmanship and twenty five years of warranty against defects in the register box. If the purchase cost is greater than $10,000, according to the state law, it is necessary to follow a public bidding procedure. In this case, the OWASA purchase office has to prepare instructions for submitting the bids and place an advertisement in local newspapers. The instructions for submitting bids and the specifications are obtained by the bidders at the OWASA office. Public bidding requires a bid deposit of 5% to warrant formality of the bid. Bids are publicly opened in the place and on the date and time set in the advertisement. The bids are studied and award is made "to the lowest responsible bidder taking in consideration quality, performance, and time specified in the proposal". Public bidding purchases must be approved by the OWASA Board of Directors before any contract is signed with the successful bidder. If the purchase is for less than $10,000, the process is simpler: three quotations, written or by telephone, are sufficient.

The time required between award of the meter contract and delivery of them is thirty to forty days. This relatively short time is due to several factors: a) good programming of purchases, b) good communication between the OWASA purchasing office and the bidders, and c) short delivery time from the manufacturer to Chapel Hill. For standardization purposes, OWASA has decided to consider bids from only three meter manufacturers. This allows the Authority to select well known, well established meter companies; consequently, their sales representatives respond promptly to purchases orders from the Authority.

3.2.2 Testing of Meters

One of the important tasks OWASA does is the testing of meters. Periodic testing is necessary to check that meters are registering within acceptable limits of accuracy. Through meter testing, the Authority can determine if there is significant under or overregistration. If meters are not tested, inaccuracy would tend to increase over time, which would mean a loss of revenue in the case of underregistration and unfair charges in the case of overregistration.

To warrant that meters are working within acceptable limits of accuracy, OWASA tests the meters according to the procedures recommended by the American Water Works Association in the following cases: a) before a new lot of meters is accepted by OWASA from the seller, b) as part of the routine testing and replacement activities of the OWASA water loss reduction program, and c) when a customer requests the testing of his meter.

OWASA runs tests on new meters to verify that they have the accuracy that was specified at the time of purchase. The OWASA specification states that all meters must meet AWWA standard C-700 for a period of one year and meet or exceed rebuilt accuracy standards for 14 additional years. Additionally, all new meters must test within the accuracy limits given in Table III-2. OWASA requires that meters not meeting the standards must be replaced by the manufacturer.

OWASA also performs routine testing and replacement under its water loss reduction program. This program was created after the utility realized in 1981 that the unaccounted-for water had reached an average of 25%. A study conducted by a private consulting firm revealed that there were no major leaks in the distribution system. In this program, large and small meters are tested on a frequency basis that varies with the size of the meter, usually large size meters are tested more frequently than smaller ones because a small percentage of inaccuracy in large meters represents a larger water loss. Table III-3 shows the frequency of testing for different size meters. Currently, OWASA tests about 1,000 meters a year as part of its loss

Table III-2

ACCURACY LIMITS FOR NEW METERS SPECIFIED BY OWASA

Size	Rate of Flow (GPM)	Accuracy Limits (%)	Rate of Flow (GPM)	Accuracy Limits (%)
5/8"	1 to 20	98.5-101.5	1/4	95% or better
1"	3 to 50	98.5-101.5	3/4	95% or better
1-1/2"	3.5 to 100	98.5-101.5	1-1/2	95% or better

Source: OWASA

reduction program. Even though testing and replacing are expensive, it has proven to be cost effective in reducing losses. In 1983, OWASA spent $155,000 in the loss reduction program, but it reduced water losses by 10% which represented a saving to the utility of $512,000.

The water utility also tests meters when customers request it. OWASA has the policy that if the meter has not been tested in the past five years or if the test reveals overregistration, then the meter is replaced at no charge to the customer. If, on the other hand, the meter has been tested within the past five years and is found to be registering properly or underregistering, the customer is charged $35 for the test if the meter is 5/8" and $50 if the meter is larger than 5/8".

OWASA uses two procedures for testing meters. Small meters (5/8" to 1-1/2") are tested volumetrically. In this test, a certain volume of water is passed through the meter at a fixed flow rate, and the water is caught in a calibrated container; the percentage of accuracy of the meter is calculated from the difference between the volume registered by the container and the volume registered by the meter. Since meters have to work at different flows, they have to register within acceptable limits of accuracy at different rates. Therefore, the volumetric tests are done at three

Table III-3

FREQUENCY OF TESTING METERS USED BY OWASA

Size (In.)	Test Frequency (Years)
8	1
6	1
4	2
3	2
2	4
1.5	4
1	8
5/8	10

Source: OWASA

different flow rates (minimum, intermediate and maximum), according to AWWA standards. Large meters (2" and up) are tested in the field with the use of calibrated meters. In this type of test the calibrated meter is connected in series downstream of the meter in service. A flow is passed at a fixed rate through both meters, and the accuracy is calculated from the difference between the volumes registered by the service and calibrated meters. Large meters are usually of the compound type (positive displacement and turbine) and are tested according to AWWA standards.

3.2.3 Maintenance of Meters

OWASA gives maintenance to a meter under the following three conditions: 1) when a meter after testing is found not to meet AWWA standards, 2) when a meter is not covered by warranty from the manufacturer, and 3) when the cost of repair, including materials and labor, does not exceed the purchase price of a replacement meter. If the meter meets AWWA standards, it is only cleaned and put back into operation. If the meter does not meet standards but is under warranty, it is sent back to the manufacturer. If the first two conditions are met but the cost of repair is greater then the purchase price of a new one, the meter is discarded but the bronze part is sold as junk.

To maintain meters, OWASA has a meter workshop with all the equipment and tools necessary for testing, disassembling, repairing, cleaning and reassembling the meters. Additionally, the workshop has a complete stock of spare parts for making an immediate repair of the meter. The meter maintenance personnel in the workshop include four employees that not only work in meter repairing but also in meter replacing and testing. These people are highly skilled as a result of the training courses to which OWASA has sent them.

3.3 Reading, Billing and Collecting Revenue

OWASA has established a policy of billing each customer every month. This means that the Authority has to read approximately 10,600 meters and to process this number of accounts every month. To do this, OWASA has created a system for reading, billing, and collecting the revenue. First, the Authority has divided the service area into three zones, each of them with approximately the same number of meters (customer accounts). Additionally, three cycles of reading and billing has been established to be done every month. Each cycle has a zone assigned to it. In every cycle, the meters of the corresponding zone are read, and their accounts are processed for billing. The time assigned to each cycle is approximately ten days. Each activity in the process is programed every month, and each activity has a deadline, in such a way that the bills of the first second and third cycle (corresponding to the first, second and third zone) are sent every tenth, twentieth, and thirtieth of every month.

3.3.1 Reading of Meters

The first step in the process of billing is the reading of water meters. The personnel assigned to the reading include three field workers plus a supervisor. For every cycle, these personnel have to read 3,500 meters in five days. This means that every reader must read on the average 235 meters per day, or 29 meters and hour. To be able to read all the meters in the given time, every meter reader is equipped with a small pick-up truck and a radio communication system for coordination of activities.

The readings of customer consumption are registered in special books. Each book contains the information on the meters in one of the three zones into which the city has been divided. The information that each book has includes meter location, serial number, customer account number, and the previous readings taken on the meter. The record book is returned to the Customer Services Division of OWASA by the meter reader when he has finished taking his readings. The information in the book is then processed for input to the computer system.

3.3.2 Billing and Collection of Revenue

All the bills that OWASA processes every month are made through a contractor, The Network Computing Corporation. Not all of the activities involved in billing, however, are carried out by this company. The OWASA billing process is carried out in three stages: 1) input of information to the computer, 2) computer bill processing, and 3) delivery to customers. Figure III-1 shows a schematic of the billing process.

The first part of the billing process is carried out by OWASA and consist of receiving the record books containing new readings of customer meters and sending this information by telephone to the computer of the billing service company, with the use of a computer terminal and modem.

The second stage of the billing process starts when the Customer Relations Division of OWASA requests customer bills from the billing company. Usually, the OWASA request is presented forty eight hours prior to the deadline for sending bills to the customers. Once the request is received, the contractor processes the accounts, prints the bills, and sends them to OWASA.

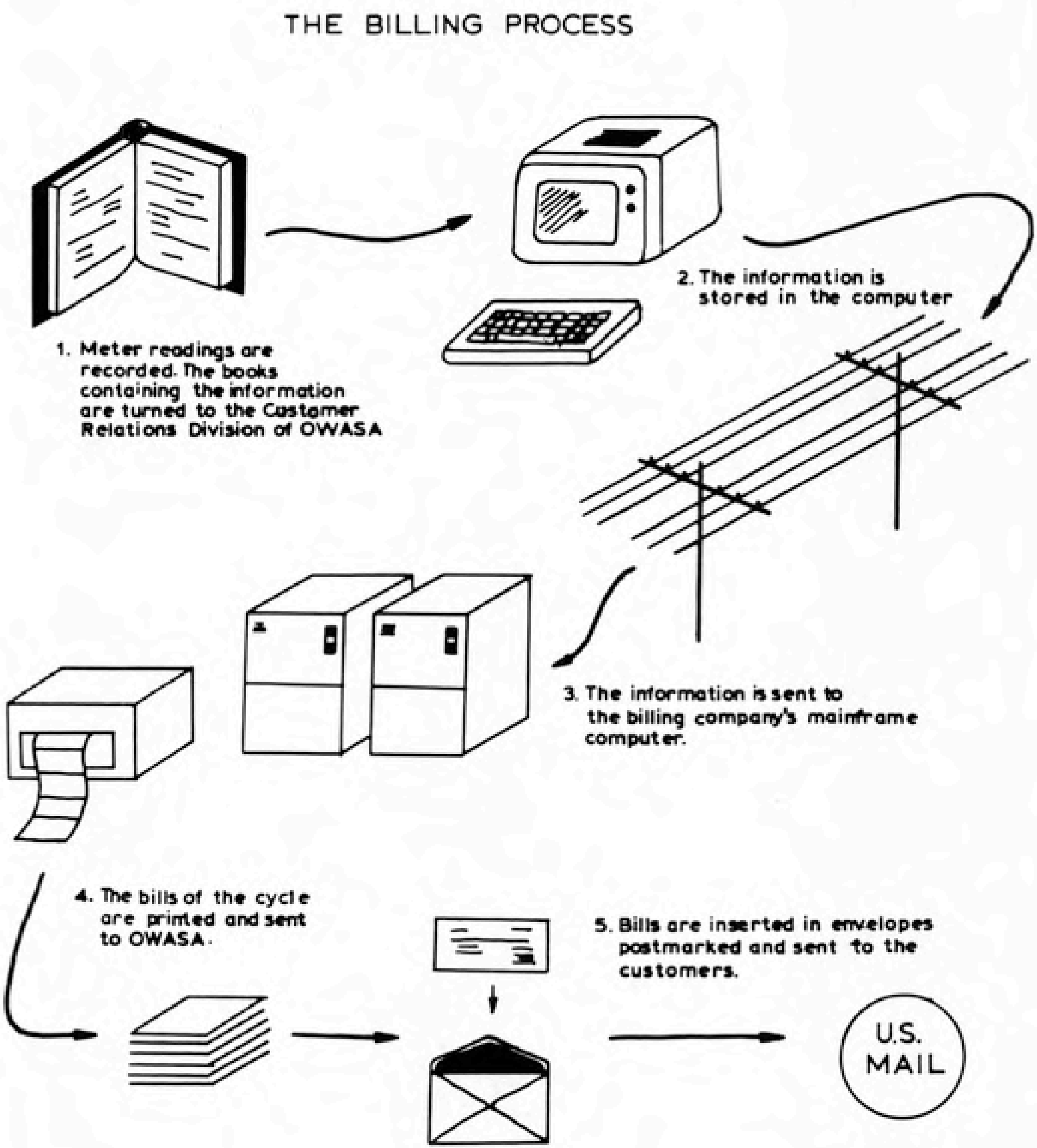

THE BILLING PROCESS
1. Meter readings are recorded. The books containing the information are turned to the Customer Relations Division of OWASA
2. The information is stored in the computer
3. The information is sent to the billing company's mainframe computer.
4. The bills of the cycle are printed and sent to OWASA.
5. Bills are inserted in envelopes postmarked and sent to the customers.
U.S. MAIL

Figure III-1

In the last part of the process, OWASA receives the bills from the billing company in the morning of the deadline date, inserts the 3,500 bills in envelopes in three to four hours with the help of an inserting machine, postmarks all the envelopes with another machine, and finally deposit them in the post office to be delivered to the customers by mail.

The collection of revenue is done mainly by mail. Along with the bill that OWASA sends to customers is an envelope with the address of OWASA printed on the front. This envelope is given to the customer for paying his or her water bill. The customer usually writes a check to OWASA for the amount that appears on the bill, puts the check in the envelope, and sends it to OWASA by mail. The payment is usually received by OWASA no more than two days later. The revenue collection system is very efficient and convenient for the customer; however, if the customer wants to pay directly in the office of OWASA, he or she can do so.

3.4 Setting Prices

3.4.1 Water Charges and Fees

OWASA has established several charges and fees to cover the cost of supplying water. The set of charges and fees is known as the rate structure. The one currently in use by OWASA became effective January 1, 1986, and consists of the following main water charges:

1. Water Service Charge
2. Water Commodity Charge
3. Water Availability Charge
4. Water Front Footage Fee
5. Water Main Taping Fee
6. Water Service and Meter Installation
7. Supplemental Fire Protection
8. Temporary Hydrant Meter
9. Miscellaneous Charges

Water Service Charge: This is a fixed monthly charge intended to recover part of customer relations costs, meter and lateral maintenance and 20% of the capital costs of those facilities that serve the entire population (including, for example, trunk mains but not water distribution mains). This charge is required of all customers, and the amount varies according to the size of the meter. Table III-4 shows the water service charges for different meter sizes.

Water Commodity Charge: This is a charge per unit volume (per thousand gallons), which is intended to recover most of the operating costs and a portion of the capital costs. The charge is a single price ($1.60 per thousand gallons),

Table III-4

OWASA WATER CHARGES

I. Water Service Charge:

Meter Size	Monthly service charge
5/8"	$ 4.30
1"	$ 8.75
1-1/2"	$ 16.25
2"	$ 25.00
3"	$ 49.00
4"	$ 76.00
6"	$ 150.00
8"	$ 240.00

II. Water Commodity Charge: $ 1.60/Thousand gallons.

III. Water Availability Charge:

Meter Size	Acreage Allowance	Base Amount
5/8"	0.4 acres	$ 1,270
1"	1.0	$ 3,200
1-1/2"	2.0	$ 6,300
2"	3.2	$ 10,100
3"	6.4	$ 20,200
4"	10.0	$ 31,600
6"	20.0	$ 63,200
8"	32.0	$101,000

Acreage Surcharge = $320/acre

IV. Supplemental Fire Protection:

A. Site-Specific Fire Service

Service Size	Monthly Service Charge
2"	$ 22.00
3"	$ 44.00
4"	$ 66.00
6"	$ 125.00
8"	$ 210.00

B. Site-Specific Water Hydrants $9.00 per hydrant

V. Water Front Footage Charge:

Fee = $11.00 per foot

Minimum charge = $550.00

Table III-4 (continuation)

OWASA WATER CHARGES

VI. Temporary Hydrant Meter Charge:

Service Charge = $75.00

Security Deposit:

Meter Size	Security Deposit
1"	$100.00
3"	$500.00

VII. Water Service and Meter Installation:

Type of Service	Charge
Complete water sevice installation, 5/8"	$410.00
Complete water sevice installation, 1"	$500.00
Meter Only Installation, 5/8"	$ 80.00
Meter Only Installation, 1"	$120.00
Meter Only Installation, 1-1/2"	$255.00
Meter Only Installation, 2"	$760.00

Meters larger than 3" are installed by the contractor.

VIII. Water Main Tapping Fee:

The charge will vary according the job. It is determined based on the time and equipment used plus an allowance for overhead. minimum charge $75.00.

Source: OWASA

applicable to all customers, independent of the quantity of water consumed.

Water Availability Charge: This one-time charge was created to recover part of the capital costs of providing current capacity of the water system. The charge is levied for each new connection to the water system. The charge varies according to the size of the meter and the acreage of the property. Table III-4 presents the schedule of charge for different meter sizes and property areas. For example, a new customer with 0.5 acre lot and 5/8 inch meter would have to pay $1270 + $320(0.5-0.4) = $1302 to connect to the system.

Water Front Footage Fee: This charge is to recover the cost of extending the distribution system into new areas. The water front footage charge is $11.00 per front foot of the property. The minimum charge is $550.00.

Water Main Tapping: This charge aims to recover the cost of labor and equipment used in making a tap into the water main plus an allowance for overhead. The charge varies according to the size of the job but never is less than $75.00.

Water Service and Meter Installation Charge: This charge is to recover the cost of extending service from the street main to the customer's property. It includes the installation of the service connection and the customer's meter. The charge varies with the size of the meter and whether the job includes complete service installation or just the meter. Table III-4 shows the charge for different type of installations.

Supplemental Fire Protection: There are two specific charges in this category: 1) site-specific fire service charge, and 2) water hydrant charge. Both charges are intended to recover the costs of providing adequate system capacity for fire protection. The site-specific fire service charge is applicable to all customers with private fire protection systems. The charge depends on the diameter of the service line, as shown in Table III-4. The water hydrant charge is intended to recover the marginal cost of having to use larger diameter pipes in the network for fire protection. This charge is $9.00 per hydrant per month, which is paid by the Towns of Chapel Hill and Carrboro.

Temporary Hydrant Meter Charge: This charge is applied to construction projects that take water from the distribution system. A charge of $75 is made for having to install a temporary meter; it has to be paid in advance by the contractor plus a security deposit for the meter.

Miscellaneous Charges: OWASA includes in this classification charges such as: service initiation fee, record change charge, charge for reconnection of delinquent account, returned check charge, security deposits, bulk water sales, and field and shop meter tests charges (when the test is done at customer request).

3.4.2 Water Rates Determination

In setting its rates, OWASA generally follows the recommendations of the AWWA. The OWASA rate structure has the basic objective of making the Authority financially selfsufficient. This means that water prices, charges, and fees are set so that the generated revenue covers the financial costs of providing service. The current tariff, therefore, recovers operation, maintenance, administration and capital costs.

The current OWASA water rate schedule is the product of a cost-of-service study conducted by a private consulting firm, Arthur Young and Company, in 1985. The study covered both water and wastewater charges and consisted of three steps: 1) determination of revenue requirements, 2) determination of specific service costs and charges, and 3) cost allocation and rate setting.

In the first step, the financial costs that must be recovered from revenue were identified as "cash needs". The process consisted of selecting a time horizon of three years (1986-1988) and estimating the revenue requirements that would be needed during that period.

The financial costs that were determined for the three-year period were: a) operation and maintenance requirements, and b) capital costs and debt service. Operation and maintenance revenue requirements were calculated by forecasting to 1988 the operation and maintenance cost based on the 1985-86 operating budget, considering a 7.5% inflation rate and annual growth rates in accounts of 3.0% to 3.5%. Capital costs were also forecasted for the three years; They included all major and small water projects plus capital equipment purchases. The final component forecasted was debt service. OWASA has existing debt service related to bonds that were issued in 1985 plus general obligation bonds from the Towns of Chapel Hill and Carrboro that the Authority assumed in 1977; additionally, OWASA expects to issue bonds in 1987. The total revenue requirements for the three-year period was divided into the categories shown in Table III-5.

The second step in the rate study was the determination of specific costs and corresponding charges that should be included in the rate schedule. A specific charge is

Table III-5

CATEGORIES USED IN THE THE TOTAL REVENUE ESTIMATION

FOR THE THREE-YEAR PERIOD

I. OPERATION COSTS

   A. Water Supply and Treatment

   B. Water Distribution

   C. General Administration

   D. Customer Relations

   E. Contingency

II. CAPITAL COSTS

   A. Cash Financed Capital Project Ordenances

   B. Current Year Capital Projects and Capital Equipment

   C. Debt Service

      1. Existing Debt Service

      2. Proposed Debt Service

Source: OWASA

intended to recovers the cost of providing a specific service. If a charge is not created, the cost of proving the specific service would have to be covered from the general revenue (Arthur Young 1985). Specific charges were established for the items presented at the beginning of section 3.4 (not including monthly service charges and commodity charges).

The third stage in the water rate study involved cost allocation and setting of rates for the monthly service charge and the commodity charge. First, the projected revenue from all the specific charges for the period 1986-1988 was subtracted from total revenue requirements, calculated in the first stage. The result was net revenue requirements for the three-year period. Then, this requirement was allocated to the water and sewer components. This was done by selecting in each one of the categories of the net revenue requirement shown in Table III-5 the proportion corresponding to sewer and that to water. The net revenue requirement allocated to the water component (water net revenue requirement) was then used to calculate the service charge and the commodity charge.

Having obtained the water net revenue requirement, before calculating the service and commodity charges, it was necessary to calculate the unit cost of service. First, the water net revenue requirement was divided into five categories: 1) customer relations, 2) meter maintenance, 3) lateral maintenance, 4) 20% of water capital, and 5) commodity costs (including about 80% of the capital costs). Then, an estimate was made of projected monthly customer accounts, the number of meter equivalents in the system 3/, and the total volume of water that will be billed to the customers in the three-year period. The next step was to calculate the unit costs for the previous five categories. The service relations costs were divided by the projected number of accounts, the meter maintenance, lateral maintenance, and 20% capital cost were divided by the number of meter equivalents in the system, and the commodity cost was divided by the estimated total volume of water to be billed. Having obtained the unit cost, the next and last step was to calculate the service and commodity charges.

The monthly service charge was calculated for different size meters. It was first necessary to estimate the total number of equivalent 5/8-inch meters in the system. This was done using the values in Table III-6, which are from AWWA.

3/ A meter equivalent is a number that relates the rated hydraulic capacity of a given meter to the capacity of a 5/8" nominal size meter. For more information refer to the AWWA Manual No.5 page 90.

The meter equivalents for the whole water distribution system is calculated as the summation of the meter equivalents of all the meters in the system.

Table III-6

METER EQUIVALENTS USED IN THE OWASA RATE STUDY

Meter Size	Number of Equivalents
5/8"	1.0
1"	2.5
1-1/2"	5.0
2"	8.0
3"	16.0
4"	25.0
6"	50.0
8"	80.0

Source: OWASA Water Rate Study, based on AWWA.

Total customer relations, meter maintenance, lateral maintenance, and 20% capital costs to be recovered were divided by the total number of equivalent meters to obtain the service charge for a 5/8-inch meter. The corresponding charges for larger meters were simply determined by scaling up the basic meter charge using the values in Table III-6.

The commodity charge in the rate study was decided to be the same for all customers, which is basically consistent with economic theory. The commodity charge was obtained by dividing the total cost to be recovered by the estimated total volume of water to be billed to customers in the three-year period for which the study was made.

3.5 OWASA's Pricing Practices

OWASA does not strictly follow marginal cost pricing principles but instead, for most of its tariff structure, uses average cost pricing. This is particularly true for the commodity charge, which as seen previously was calculated by dividing commodity costs by the total volume of water to be billed, resulting in an average cost price.

There are three main reasons for the Authority to follow average cost pricing principles. The first is that the Authority is not allowed to have excess revenues (i.e.

profits), which probably would result from strict application of a marginal cost pricing policy. The second reason is that by setting the price of water equal to marginal cost, the resulting price would probably be much greater than the current price, which the Authority wants to avoid because of its effect on poor customers. The third reason is that it is common practice in the United States to follow the recommendations of AWWA, which are to set the price more or less equal to average cost.

Another aspect of the OWASA rate schedule is that the pricing system does not signal when to make a capacity expansion, as is theoretically possible under a policy of strict marginal cost pricing. To decide when to expand the system, the Authority continuously monitors water demand, and when it gets close to being equal to system capacity, an expansion is made.

3.6 Practical Considerations of Marginal Cost Pricing

The purpose of this section is to present some practical considerations regarding application of marginal cost pricing theory. The implementation of strict marginal cost pricing alone presents several practical difficulties, including:

3.6.1 Financial and Price Stability of the Water Authority

As discussed in Chapter II, the use of marginal cost pricing can result in a profit or loss for the water utility, depending upon whether average costs are rising or falling (see Figure II-2(a) and (b)). In the case of profits, they could be used to finance future water supply investments or to cover future losses. In the case of a loss, a solution that has been proposed by economists is to have a two-part tariff (Warford 1977). Perhaps more importantly, strict marginal cost pricing would result in highly variable prices over time, with high prices immediately before an expansion (to ration capacity) and low prices thereafter. Most customers would be confused by the fluctuations, and such prices could be politically infeasible.

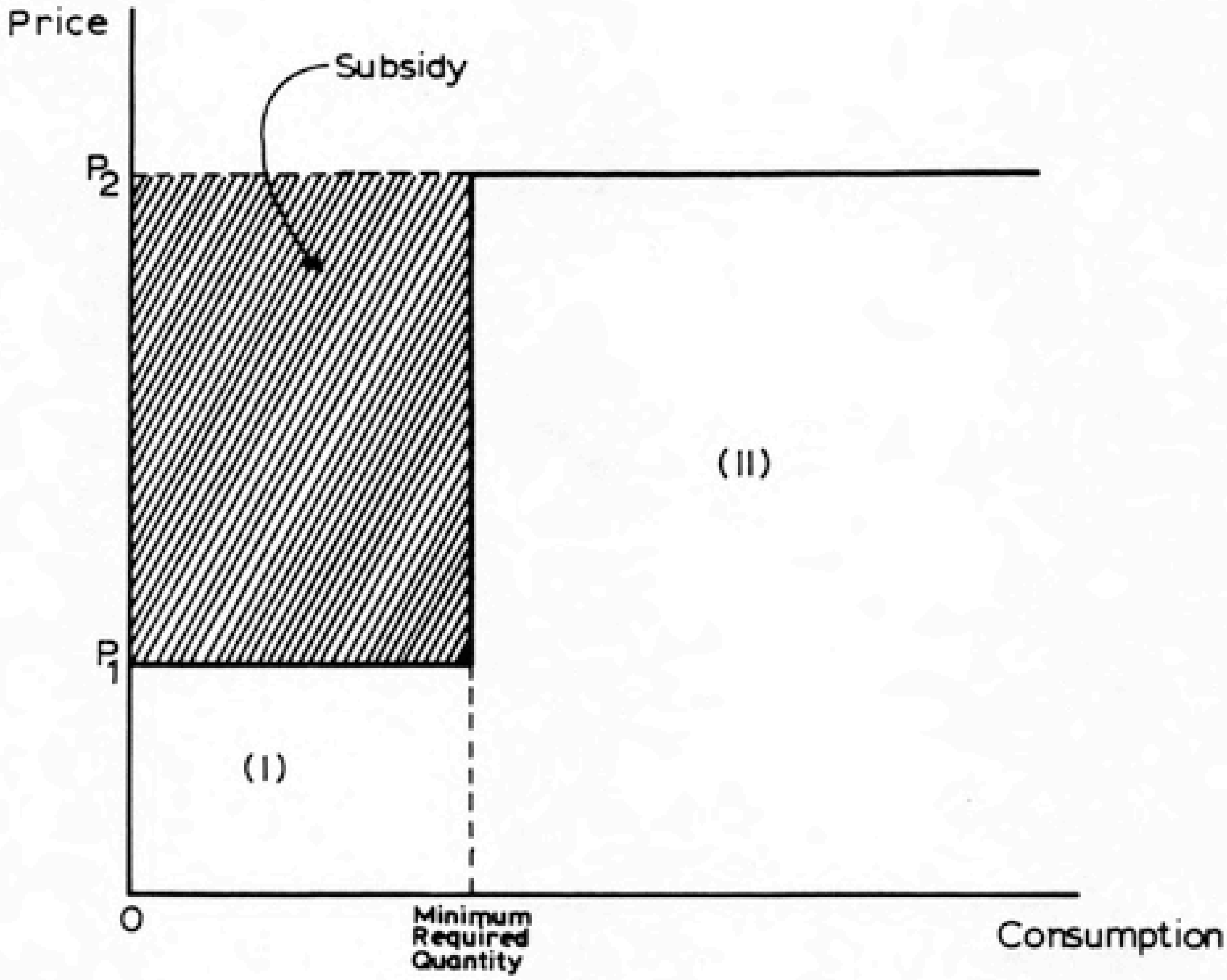
3.6.2 Marginal Cost and The Poor

The strict application of marginal cost pricing would probably result in prices that would restrict the poor from using the system. One proposal for applying marginal cost pricing principles without hurting the poor would be to establish lifeline rates. A lifeline tariff consists of a water rate schedule with two blocks: the first block includes a subsidy wherein the water is sold at a relatively low price to make it affordable to the poor. In the second block, water is charged at the full marginal cost. This enables the poor not to be deprived from a minimum adequate supply of water, while the rest of the water consumers face the true cost of water for additional consumption beyond the minimum. Figure III-2 shows a schematic price schedule including a lifeline rate.

3.6.3 Capital Indivisibility

Capital investments in the water supply sector are made in lump sums. Generally, water supply projects are built with excess capacity in order to capture economies of scale. This means that during the period of excess capacity, only operation and maintenance costs are incurred. However, when capacity is exhausted, a major investment several times larger than operation and maintenance costs is required.

The phenomenon of lumpiness or capital indivisibility in the water supply sector creates problems in the application of marginal cost pricing principles. Strict application of the marginal cost concept produces large fluctuations in the water price. Marginal cost pricing requires the water price to be set equal to the short run marginal cost when there is excess capacity in the system. Then, as discussed in Chapter II, when the demand grows equal to the capacity of the system, the demand is curtailed by increasing the price.



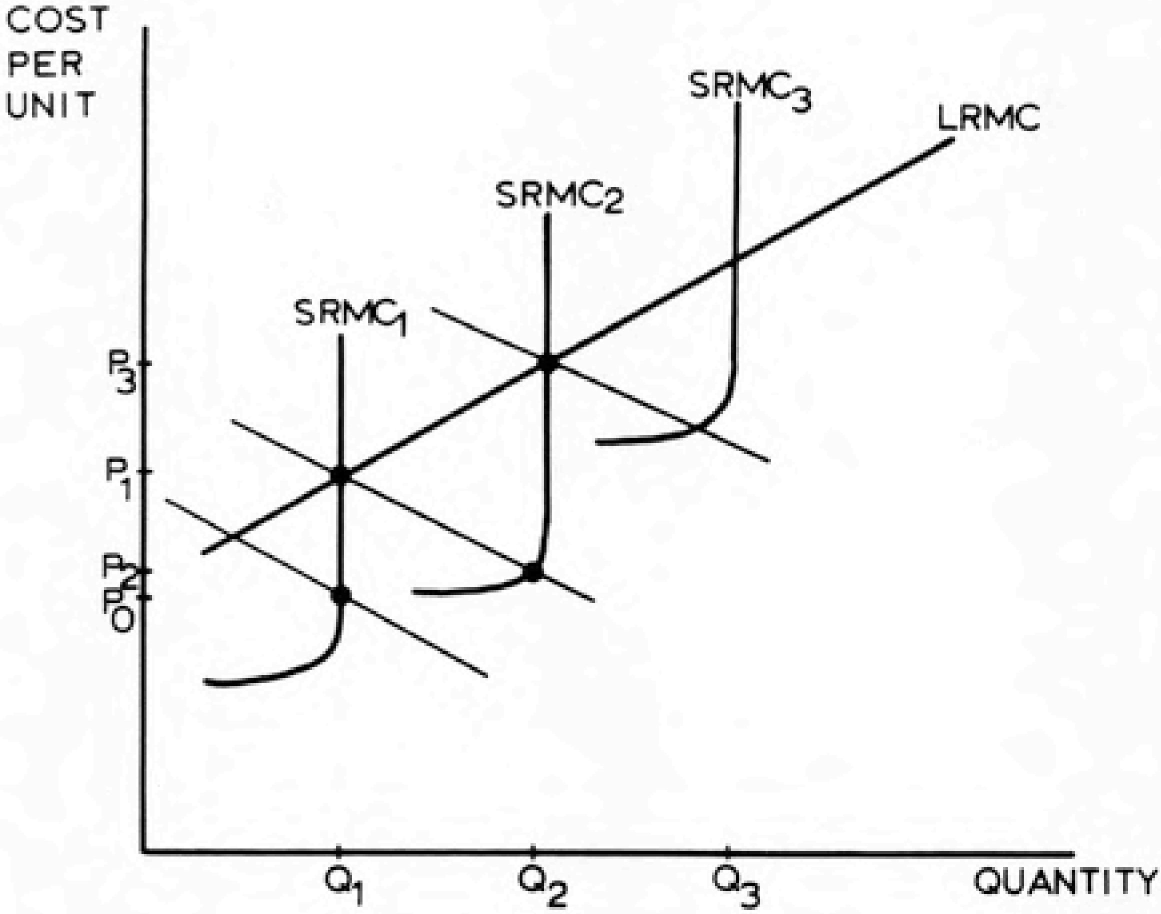
P_1 = Lifeline Rate (for all customer)

P_2 = True Marginal Cost

Figure III-2 Lifeline Rate

When, after successive increases, the price equals long run marginal cost, a capacity expansion is justified. After the expansion is made, however, the price of water should drop to equal the new short run marginal cost that corresponds to the new scale of plant, and the process is repeated again (see Figure III-3). The jumping from one short run marginal cost curve to the next creates a fluctuation in the water price. This fluctuation is accentuated by the big difference that generally exists between the short run costs (operation and maintenance) and long run costs (operation, maintenance and capital). Under these circumstances, consumers will usually be confused because they will not know how to respond to the variation in prices.

Another problem with strict application of marginal cost pricing where there is capital indivisibility is in the definition of marginal cost. When there is capital invisibility, it is difficult to define the cost of producing an additional unit of output. Several definitions of marginal cost have been proposed to deal with this problem, and for the most part they include some notion of incremental cost. A definition used by the World Bank is Average Incremental cost, which is calculated by discounting all future costs (operation and capital) related to the supply of water over a given period of time, and dividing this amount by the discounted value of the incremental output that is generated



- Price is raised from P_0 to P_1 to ration capacity Q_1.
- A P_1, price = LRMC, signaling need for an expansion to capacity Q_2.
- Following expansion, price should drop to P_2, where price = $SRMC_2$.
- Gradually, price is raised to P_3, signaling the need for another expansion, to Q_3.

Figure III-3 Price/Capacity Change Over Time during the same period. Mathematically, the Average Incremental Cost can be written as:

$$AIC_t = \frac{\sum_{x=1}^{T} \left[\frac{R_{t+x} - R_t + I_{t+x-1}}{(1 + i)^{t-1}} \right]}{\sum_{x=1}^{T} \left[\frac{Q_{t+x} - Q_t}{(1 + r)^{x-1}} \right]}$$

Where

t = Base year for which AIC is calculated

R_t = Operation and maintenance expenditures in year t

Q_t = Water produced in year t.

I_t = Capital expenditure in year t.

T = Period of time considered in the analysis

i = Opportunity cost of capital

r = Time preference rate for consumption

The AIC represents a compromise between the need to avoid price fluctuation, the need to signal capacity expansions, and the need to allocate resources efficiently. With the use of AIC, water price (equal to the incremental cost) changes smoothly over time when there are increasing units of cost and has little fluctuation compared to other marginal cost definitions (Warford 1977). When AIC is used, a capacity expansion is signaled when demand equals the capacity of the system.

AIC is considered appropriate by the World Bank when capital indivisibility is significant, as is generally the case in the water supply sector, and especially in developing countries where due to difficulties in getting finance, planners consider longer time horizons for their projects.

CHAPTER IV

APPLICATION OF METERING TO HONDURAS

Previous chapters have presented the theory of using metering along with marginal cost pricing. Additionally, the practical aspects of running a metering system as done by a well organized utility in the United States have been discussed. This chapter analyzes the practicability of implementing a metering system in the small communities of Honduras in light of the theory and U.S. practice. This chapter consists of four sections: a) metering, b) reading, billing and collecting revenue, c) setting price levels, and d) conclusions.

4.1 Metering

From the perspective of Honduras, the three main aspects of metering include: 1) purchase, 2) testing, and 3) maintenance of meters.

4.1.1 Purchase of Meters

In Honduras, the purchase of meters would be done under very different conditions than in the United States.

The organization that purchases meters for small communities in Honduras would have to be capable of the following:

1) International Purchases There is no production of meters in Honduras; therefore, all of them would have to be imported from other countries. The organization in charge of purchasing meters and accessories must be capable of making international purchases. It must have connections with the foreign meter suppliers and manufacturers. It would have to be able to handle the procedures and conditions imposed by manufacturers and suppliers in other countries.

2) Public Bidding In purchases involving large amounts of money (as would be the case with meters), it is necessary in Honduras to follow a public bidding process. The organization that purchases meters would have to be able to conduct international bidding.

3) Government Requirements Since meter purchases would be done at the international level, it would be necessary to obtain authorization from the government to: a) import meters, b) get foreign currency to pay for them, and c) get tax exemptions, since they would be destined for public use. The purchasing organization would have to know very well governmental procedures for the three previous items, and it

would have to be able to meet all the requirements imposed by the government.

4) Standards and Specifications Currently in Honduras, there are no standards for meters, and the specifications for purchasing meters are very general. The organization purchasing meters would have to develop standards and specifications for the kinds of meters most appropriate for Honduras. Additionally, in order to reduce repair costs and facilitate maintenance, the organization would have to be able to limit selection to just a few brands. Politically, this would be difficult to accomplish since many government officials would expect this to result in higher prices.

5) Testing for Quality Control For all practical purposes, there would be no warranty from the manufacturer because of the high cost of shipping. Consequently, it would be extremely important to test the meters before final acceptance and payment. The purchasing organization would have to be able to test the meters during the purchasing process.

Small communities cannot make purchases of meters. At present, they do not have the organization for performing any of the required tasks mentioned above. It would be very difficult and expensive to develop an organization in each community capable of making purchases, and it is very unlikely that such organizations, even if it were possible to create them, could work efficiently.

To fulfil all the above requirements, the purchase of meters would have to be done at the national level. There would have to be an organization responsible for purchasing all the meters needed by all the communities in the country. The only organization in Honduras that could conceivably implement such purchasing is the national water supply agency, SANAA.

4.1.2 Testing of Meters

The meter testing conditions for OWASA and the water authorities in Honduras are very different. In Chapter III, it was reported that meter testing as done by OWASA involves the use of well trained personnel, with appropriate equipment standards and procedures for testing. In the case of Honduras, there is no experience with meter testing, trained personnel are limited, there is no equipment for testing, nor are there standards and procedures.

It would be difficult or impossible to create testing workshops in each small community in Honduras; there are several reasons for this. First, there is a tremendous lack of qualified personnel, especially at the local community level. This means that it would be necessary to either train the personnel in the community or to bring personnel from other parts of the country. Second, there is little incentive for trained personnel to work in local communities. Third, there would be a tremendous lack of technical and administrative support for meter testing activities because there is no organization in small communities. Finally, the training of personnel would be difficult since the community would lack an organization with qualified personnel capable of deciding who needs to be trained and what kind of training is needed.

The problems of meter testing point to the need for regional testing centers. By having regional offices, the operation would be done at a larger scale which would allow the concentration of enough funds to purchase equipment and spare parts and to pay salaries. In a regional office, it would be easier to attract specialized personnel, especially if the office were located in a relatively large town. Additionally, the establishment of regional testing centers would have the advantage of full utilization of equipment and personnel.

Although regional testing centers might include many advantages, there would also be disadvantages that might make implementation difficult. One is that testing on a regional scale would require good coordination between the regional center and the local water offices in the communities. The regional office would depend upon actions taken by the local offices; therefore, no matter how well equipped or how well qualified the personnel in the regional center, if the local water offices do not cooperate or have organizations capable of supporting the regional office, the system would not work. Difficulties in obtaining agreement and coordination among the institutions in charge of local water supply systems would be another obstacle to regional testing centers.

4.1.3 Maintenance of Meters

Essentially all meter maintenance in Honduras would have to be performed by the central water authority. Practically speaking, it would be impossible to obtain warranty from manufacturers. Additionally, there are no private companies for servicing large meters as in the United States. Therefore, water authorities in Honduras would have to be prepared to maintain all sizes and types of meters. A second characteristic of maintenance in Honduras is that the authority would have to maintain a much larger number of meters than a typical utility in the United States because of the need to serve the entire country. In addition, because in Honduras it would generally be cheaper to repair old meters than to buy new ones (due to the relatively high cost of new meters, plus the cost of shipping, the relatively lower salaries in Honduras, and the need for hard currency to make purchases), the water authority would have to be prepared to repair a very large number of meters.

Small communities in Honduras simply do not have the capacity to run a metering system. There is no organization to support maintenance activities, and it is very unlikely that such a support organization could be created. As with testing, the communities do not have trained personnel nor technical support.

It would be more likely to organize the maintenance of meters at the regional level. As with a meter testing system, regional maintenance would enable concentration of resources and better utilization of them. Additionally, a regional meter maintenance system would enhance the quality of work compared to individual maintenance organizations at the local community level.

The only organization in Honduras that has the potential for performing regional maintenance is the national water supply agency, SANAA. SANAA manages many of the community water systems throughout the country and has established offices that could serve as a basis for starting a regional organization for meter maintenance. Other institutions in Honduras that also manage community water systems include municipalities and community groups, but they work only at the local level and do not have capacity to create regional offices.

In practice, there may be difficulties for implementing regional meter maintenance workshops. Meter maintenance at the regional level would require excellent coordination between local water supply offices in each community and the regional office. Such coordination may be difficult to accomplish, if local offices are managed by municipalities and the regional office is managed by a governmental institution such as SANAA.

4.2 Reading, Billing and Collecting Revenue

The activities of reading, billing and collecting revenue constitute a process that includes the following key factors: 1) the billing period, 2) organization and technology, and 3) cost.

The billing period is the time between when the customer receives two successive bills. The length of the billing period is an important factor. Long billing periods do not inform customers of their consumption with sufficient frequency to allow them to adapt their demand to the amount charged. Long periods result in large bills which adversely affect the budgets of consumers. Short billing periods have the advantage of lesser effect on customers' budgets, especially for the poor. From this point of view, it is better to have short billing periods (one month or less); the poor have trouble planning or paying bills for periods longer than one month because their income is usually on a daily, weekly or possibly a bi-weekly basis. On the other hand, shorter billing periods require a more sophisticated organization and greater expense.

The lack of resources in Honduras, especially capital and qualified personnel, requires that organization of the water utility be simple and that the technology be easy to implement and use. Such organization and technology might be impossible with the kind of frequent billings required in Honduras. Also, the cost of such frequent billing would probably be relatively high, and strong possibility might exist for clerical and other error.

The billing period, organization and technology, and cost must be considered and weighed against each other to create the most effective and appropriate system for the small communities of Honduras. If these three considerations cannot be optimally combined, then it may be impossible to develop an effective system. The rest of this section analyze each of these components within the context of small communities in Honduras.

4.2.1 Reading

In the case of OWASA, 235 meters are read daily per reader with the help of a vehicle and radio communication system. In Honduras, the reading of meters would have to be done under very different conditions. In small communities there would not be any vehicles or communication systems, and the reading would have to be carried out on foot. The performance of the readers would be low, probably no more than 50 to 70 meters per day per reader. The number of required readers for a community would depend on the number of bills per cycle, the number of cycles per month, and the performance of the readers. Training would be required for the readers in order to ensure that their information is accurate. Meter reading would be carried out by the local water supply utility.

4.2.2 Billing

The billing system in small communities would depend primarily on the quantity of bills. In the case of OWASA, 3,500 accounts are processed per cycle, and three cycles are included per month, all done through the use of a very sophisticated billing system. Table IV-1 shows the number of bills that would have to be processed every two weeks for billing frequencies of one and two months and for communities of 10,000 and 50,000 inhabitants. The table assumes that there are five inhabitants per customer account. Table IV-1 shows that in communities with 10,000 inhabitants it would be necessary to process 1,000 and 500 bills per cycle for billing periods of one and two months, respectively. This number of bills implies the need for mechanical or electronic (computerized) systems. The need for a well organized office with a computerized system is quite obvious in the case of communities with 50,000 inhabitants, where it would be required to process 5,000 and 2,500 bills per cycle for billing periods of one and two months, respectively.

It would be very difficult to implement a billing system in small communities of Honduras, the reasons for which are: a) the lack of administrative and technical support since local water authorities are lacking in the human resources to give such support, and it is unlikely that it would come from outside the community, and b) the difficulty in implementing a computerized system, especially because the electric supply is not reliable and also due to computing hardware limitations in the country.

Table IV-1

NUMBER OF BILLS PROCESSED BIWEEKLY AND

THE NUMBER OF READERS REQUIRED 1/

(Two cycles per month)

Billing Period (months)	10,000 hab. community		50,000 hab. community	
	No. of Bills	No. of Readers	No. of Bills	No. of Readers
1	1,000	2	5,000	10
2	500	1	2,500	5

1/ The assumptions made in this table are: 1) there are two cycles of billing per month, 2) there are 5 persons per customer account, and 3) each reader reads 50 meters per day.

Given present limitations in small communities of support for a billing system, the alternative could be to execute the process on a regional basis. However, there are several difficulties that make this an unlikely alternative as well. The first is lack of organization and resources in local offices with respect to collecting and sending information. The regional billing office would depend heavily on the local offices. If they did not perform well, the regional billing system would not work. Another problem would be coordination between the local and regional offices. The regional billing office would have to coordinate the reception of information with the delivery of bills. This task would be difficult because of problems with transportation and communication, especially where several institutions are involved in the process. A third difficulty would be establishment of a satisfactory billing period, especially for the poor. On one hand, it would be necessary to have short billing periods of perhaps one month or less, since many households have low incomes and are paid on a daily, weekly, or biweekly basis. On the other hand, a regional system should ideally have billing periods longer than one month in order to satisfactorily coordinate the local and regional offices, taking into account that a sophisticated system with highly qualified personnel would be very costly.

4.2.3 Collection of Revenue

The revenue collection practices of OWASA cannot be applied in the small communities of Honduras. In the case of OWASA, most of the revenue is collected through the mail. In the case of Honduras, utilization of the postal service would not work because the mail is not reliable, and the majority of people do not have checking accounts. There are some alternatives for revenue collection that could be implemented in small towns. One would be to pay bills directly to the local water authority. Another would be to go house by house collecting the money for payment. This has the drawback of putting the collector at risk of being robbed, or the collector himself might possibly steal the money. Banks could also be used to collect revenue, which is used in some places to pay electricity bills, but the authority would have to pay a fee for this service; this, however, is probably the most convenient and safest method.

4.3 Setting Price Levels

4.3.1 Average Cost Pricing

The use of average cost pricing, as in the case of OWASA, requires at least three basic conditions: 1) good records, 2) an administrative organization to manage charges and payments (i.e., accounting and customer services departments), and 3) sufficient capacity on the part of the people to pay their bills.

In the small communities of Honduras, generally there is little record keeping of costs and almost no statistical information about the system or its functioning. It would therefore be very difficult if not impossible to make a cost of service study as done in the United States. Charges would probably have to be based on estimates, with the risk that if they were not accurate, the charges might not recover costs.

The capacity of the people to pay is an important consideration in small communities where many of the people are poor. If the price of water were too high compared to income, the users would be hurt by the charge and would probably have to reduce their consumption. Additionally, if a large portion of the customers were poor, the utility might not be able to collect enough revenue to cover the cost of providing the service. The capacity of payment of the people would need to be investigate thoroughly before an average cost pricing structure could be implemented. The application of average cost pricing in small towns would also require an education campaign for the general public as well as for local authorities. Education would be important to help the people understand the price structure and how it works and to reduce opposition that might exist.

The application of average cost pricing in the small communities of Honduras would have to be analyzed on a case by case basis.

4.3.2 Average Incremental Cost

In the small communities of Honduras, it would be difficult to apply average incremental cost (AIC) pricing. It is common in the water supply industry for long run marginal costs to be greater than average costs. Therefore, the average incremental cost can be expected to exceed the average cost; the poor simply would not be able to pay the high price represented by AIC. It would be necessary to utilize lifeline rates, but if the poor constitute a large portion of the population, it might not be possible to generate sufficient revenue. Another difficulty with implementation of AIC pricing would be the political problems associated with high prices, the generation of "profit" (even in the short run), and the fact that it has traditionally been the responsibility of the government to fund theses types of projects.

4.4 Conclusions

Regarding practical application of a metering system along with an appropriate pricing policy for the small towns of Honduras, it can be concluded that:

1) The majority of activities required for metering and billing cannot be done in the community, because: a) there is a lack of basic organization to support these activities, b) there are no incentives for people to work in these communities, and c) there are no adequate public and private services required to implement the system.

2) The implementation of metering and billing on a regional basis would be very difficult because: a) there would always be dependency of the regional office on local community offices, b) there would be problems of coordination between the regional and local offices, c) there would be difficulties in obtaining agreement between the different institutions managing the water systems, and d) it would be difficult if not impossible to obtain a satisfactory compromise among billing period, level of organization and management, and cost.

CHAPTER V

RECOMMENDATIONS

To solve some of the problems associated with the water system management tasks in small towns, it will be necessary: 1) to identify those communities where metering could be implemented, 2) to develop a solution to the problem of regionalization for those communities where metering might be possible, and 3) to define a policy for those communities where metering cannot be used.

5.1 Identification of Communities

The identification of communities that can or cannot be metered, should include the following steps:

1. Identification of all the communities with population between 10,000 and 50,000 inhabitants.

2. Collection of data on the economy of every community, and particularly on the income of the people (distribution of the income), and determination of the capacity of the people to pay water charges. The practice of the World Bank, which estimates the capacity to pay of the people at a 5 to 6 percent of their income, could be used. A

economic study should be based on present economic conditions, with consideration of future conditions based on current economic trends in the region. Such information would be used for selection of communities, as described in step 4.

3. Collection of data on the water supply system, potential water resources, the local authority, and public services.

4. Classification of communities into two groups: a) those with possibilities of implementing a metering system on a regional basis, and b) those where it would not be possible to use meters. The following criteria should be used in the selection:

   a. Functioning of the water system: Since it is not possible to implement a metering system when there are water shortages or rationing, only those communities can be considered where the system is in good condition and operating adequately, preferably with excess capacity, or where it might be possible to repair the system at low cost.

   b. Water Quality: Water quality is a very important consideration in small communities, where, generally, there is no treatment. Hard water or water containing high concentrations of solids can create serious maintenance problems with meters. It would be necessary to have water quality standards for the use of meters and to investigate the quality of water in every community. Only those communities with acceptable water quality would qualify for metering.

c. Cost and Capacity to Pay: The communities where metering could be implemented must have sufficient capacity to at least pay the costs of operation, maintenance, and capital for expanding system capacity. To make this evaluation, it would be required to estimate the cost of each component for every community and compare it to capacity to pay, as determined in step 3.

5.2 Communities with Metering

Once the communities with good prospects for having metering systems have been identified, a study would be needed to establish the feasibility of creating one or more regional systems. The feasibility study would have to thoroughly address several considerations such as: a) institutional agreements, in cases where communities in the same region have different water authorities, b) the costs in each community (including the corresponding portion of the regional system cost), c) capacity of the people to pay in each community, d) organizational arrangements to make the regional system work, and e) availability of human resources and training.

If a study showed that it would be feasible to establish a regional system, it would be necessary then to establish the appropriate price level for each community (using average or average incremental cost pricing). In setting the price level, it would be necessary to take into consideration the capacity of the people to pay in each community.

5.3 Communities without metering

In those communities where it would not be possible to implement a metering system, a charge might be used that depends on the number of faucets in each house. This charge would not be directly related to water consumption as in the case of a metering, but it might make accurately match cost with consumption than a fixed charge system. This type of charge represents a compromise between a flat rate, is totally independent of the consumption, and a commodity charge, which strictly depends on the volume of water consumed.

The charge should be set at a level to generate enough revenue to cover at least the operation and maintenance costs of providing the service; depending on the capacity of the people in the community to pay, the charge might also be set to cover the capital cost of expansions to system capacity.

Master meters should be installed in these communities to help make better decisions on capacity expansions also, with master meters, it is possible to monitor total water demand thereby providing a basis for determining water losses in the distribution system. Master meters also provide the data needed for determining the rate of demand growth which is essential for deciding the scale of capacity expansions.

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