Dilemmas in Water and Wastewater Pricing:
The Case of Bangkok, Thailand

by

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ABSTRACT

The thesis explores two problems of water and wastewater pricing which currently confront the metropolitan area of Bangkok, Thailand: the need to create a pricing system for the city's first wastewater services, and the problem of excessive groundwater use. Following an overview of the theory of public service pricing as it applies to water and wastewater services, the thesis discusses these two dilemmas in detail and explores the options and constraints in developing effective policies.

Bangkok is confronted with exponential increases in water pollution as a result of untreated sewage and wastewater discharge into the Chao Phraya River and the city's network of klongs. The extent to which Bangkok can successfully meet its needs for clean water and adequate sewage treatment will have a profound effect on the city's capacity to continue its economic growth and reverse the environmental degradation which is now occurring. Fortunately, the Bangkok Metropolitan Administration is now planning a comprehensive wastewater treatment system. A pricing system and rate structure for this service, however, has yet to be developed. A rate structure for wastewater services is recommended which incorporates considerations of efficiency, demand management, revenue needs, and administrative feasibility.

The second problem is excessive groundwater use and the widespread practice of illegal well drilling, which has caused depletion of the aquifers, ground subsidence, water contamination, and flooding. Many developers and industrialists choose to tap groundwater supplies to obtain cheaper and higher quality water service than is available from the public system. Government attempts to reduce groundwater consumption have been stymied by limited institutional capacity for enforcement, insufficient piped water supplies, and a rate structure for groundwater which provides strong economic incentives to developers to drill private wells rather than purchase more expensive piped water. Pricing recommendations for groundwater are made which address the current distortions in water pricing policies, and management techniques to improve enforcement and public education are suggested.

Thesis Supervisor: Paul F. Levy
Title: Visiting Lecturer

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I. Introduction

There are no perfect answers to the task of financing public services. While economic theory provides policy makers with templates for determining and allocating the costs of infrastructure services, economists also recognize the tension between conflicting policy objectives in developing a pricing program. The goal of achieving economic efficiency is countered by equity objectives; attempts to create a program which is allocatively efficient are stymied by the realities of administrative capacity. Political considerations may seem to lead to financing plans and pricing regimes which are irrational from an economic perspective.

It is precisely these conflicts in objectives that lead some practitioners to dismiss economic theories of pricing as largely irrelevant to the real world of policy making, and lead some economic theorists to treat political and administrative issues as "not part of their job". I believe, however, that designing a financing program which will work -- both economically and logistically -- is the most intriguing aspect of public finance. Traversing the complexities of politics, public opinion, societal values, environment, bureaucratic capacity, and fiscal requirements is the challenge of financing public service which translates economic theory into the art of public policy.

In this thesis I focus on specific problems in financing that well illustrate this challenge: two issues in infrastructure pricing which currently face the metropolitan area of Bangkok, Thailand. While both problems involve the water and wastewater sector, each presents a different set of issues that Thai policy makers are addressing.

A Pricing System for Wastewater Services

The first problem, that of creating a pricing system for Bangkok's first sewage service, requires policy makers to grapple with the fundamental dilemmas of public service pricing. A system of wastewater management in Bangkok is long overdue; this "City of Angels" is confronted with exponential increases in water pollution as a result of untreated sewage and wastewater discharge into the Chao Phraya River and its network of canals. Describing the current condtion of the Chao Phraya, a 1990 study soberly reported:

> ...the river has lost virtually all of its beneficial uses except for waste disposal. The former beneficial river water uses within the urbanizing region for community water supply, fisheries, and recreation have been lost, and in addition the discharge of pollutants to the upper gulf has no doubt been a major factor in progressive loss in the upper gulf fisheries (estimated at about 50 percent over the past half-century).[1]

The extent to which Bangkok can successfully meet its needs for clean water and adequate sewage treatment will have a profound effect on the city's capacity to continue its economic growth and reverse the environmental degradation now occurring in the Bangkok metropolitan area. A pricing system and rate structure for this service, however, has yet to be developed. One key piece of future work, therefore, is to design a wastewater pricing system that can best meet the economic objectives detailed in this report, while being politically and administratively feasible.

Reducing Groundwater Consumption

The second problem is that of excessive groundwater use and the widespread practice of illegal well drilling. Many developers and industrialists in the Bangkok Metropolitan Area

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[1]/ Associated Engineering, June, 1990, Accelerated Water Supply and Sewerage Program Final Study Report, Volume 1, report to the Asian Development Bank and the National Economic and Social Development Board of Thailand, p. 79.

choose to tap groundwater supplies to obtain cheaper and higher quality water service than is available from the public system. This practice, however, has caused serious depletion of the aquifers and ground subsidence in the Bangkok region. Bangkok is, literally, sinking. As a striking example of service substitution, the problem of uncontrolled groundwater use demonstrates both the unintended effects of poorly designed pricing policy, and the limits of pricing policy alone in regulating illegal and environmentally-damaging activities.

To discuss these two dilemmas in Bangkok's water and wastewater pricing policies, I will first give an overview of the theory of pricing public services, focusing on its application to water and wastewater services. I will then describe the context of water and wastewater service in the Bangkok Metropolitan Region. Next, I will discuss the two problems in detail, consider the policy objectives involved in each issue, and explore the options and constraints in developing effective policies. Finally, I will recommend strategies to develop effective solutions for these two dilemmas.

II. Theory of Water and Wastewater Pricing

A. Purposes of Water and Wastewater Pricing Policy

The level and structure of fees for water and wastewater services have consequences far beyond the amount of revenue generated from these charges. Therefore, in developing a pricing system it is useful to identify explicitly the objectives of this system, so that pricing policies can be designed which best meet the intended purposes and do not undercut other activities of the management program. Four key concerns are typically considered in establishing a pricing system: revenue generation, efficiency and demand management, economic development, and public welfare and equity.

1. Revenue Generation

Clearly the most central purpose of any pricing system is the generation of income to finance the costs of building and managing the delivery system. As suggested by Herrington, these costs include:

- customer costs: those costs incurred by connecting a customer to the water supply and sewage systems and providing ongoing service irrespective of subsequent level of use
- commodity (or volume) costs: costs which vary according to the volume of water consumed and sewage treated
- capacity costs: costs incurred to accommodate total usage (both base-load and peak demand)
- common costs: overhead/administrative costs which are necessarily incurred through operation.[2]

2/ Herrington, Paul, 1987, Pricing of Water Services, Organisation for Economic Co-operation and Development (OECD), Paris, France, pp. 37-38.

In addition, an agency's financial objectives may include a rate of return on its investment to finance future capacity costs.

The percentage of costs financed by user tariffs versus other revenue sources will vary according to the policy objectives of the agencies managing water and wastewater services and the extent to which other sources of revenue are available. The range of potential revenue sources is discussed in a later section.

Insufficient revenues to pay for full costs is a common problem of water management agencies throughout the world. For example, a study of the Federation of Canadian Municipalities in 1985 found that Canadian cities -- where historically consumer charges generate 63 per cent of total water utility revenue, taxes provide 27 per cent of revenue, and other sources account for the remaining 10 per cent of revenue -- had approximately a $6 billion shortage in funds for water system repair and upgrading. Subsequently, the Canadian federal government developed federal policies calling for "...'realistic water pricing' as a central measure to encourage both water conservation and the user-pay philosophy of valuing water resources."[3]

The problem of insufficient revenues is compounded by the spiraling increases in the costs of developing new or expanded water supply and wastewater treatment systems. Bhatia and Falkenmark estimate that the cost of an additional unit of water from the next water supply project for urban areas of developing countries is often two to three times the cost of a unit of water from the current project. Such dramatic cost increases are a result of

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3/ McNeill, Roger and Donald Tate, 1991, Guidelines for Municipal Water Pricing, Social Science Series No. 25, Inland Waters Directorate, Water Planning and Management Branch, Minister of the Environment, p. 1.

many factors, including the investment required to transport water greater distances and the expense of treating lower quality water supplies. Mexico City's experience provides a case in point. The city's water supply costs increased by 55 per cent when the original source, the Mexico Valley Aquifer, became inadequate due to land subsidence, a lowering of the water table, and deteriorating water quality. The subsequent project was required -- at great expense -- to pump water over an elevation of 1,000 meters through 180 kilometers of pipeline from the Cutzamala river.[4]

Most traditional pricing systems have not come close to covering the actual costs of service. Bhatia and Falkenmark estimate that, for water projects initiated in urban areas of developing countries between 1966 and 1981, the effective price charged to users was only about one third of the actual incremental cost of the water produced.[5] This undervaluing of water and water service, economists argue, not only results in insufficient revenues but also distorts the market by encouraging inefficient allocation of a valuable resource. Saunders and Warford argue that:

> ...recognition of the concept of consumers' willingness to pay as a guide to resource allocation is absolutely essential... Price...plays the roles of (a) obtaining efficient utilization of resources when operating at less than full capacity, and (b) providing a signal to invest.[6]

4/ Bhatia, Ramesh and Malin Falkenmark, 1992, Water Resource Policies and the Urban Poor: Innovative Approaches and Policy Imperatives, background paper for the Working Group on "Water and Sustainable Urban Development", International Conference on Water and the Environment: Development Issues for the 21st Century, January 26-31, 1992, Dublin, Ireland, p. 10.

5/ Bhatia and Falkenmark, p. 6.

6/ Saunders, Robert J. and Jeremy J. Warford, 1976, Village Water Supply: Economics and Policy in the Developing World, pp. 165-6.

2. Efficiency and Demand Management

Pricing policy can encourage or discourage efficient water use. Unrealistically low pricing contributes to an inefficient use of water resources; this can in turn lead to seriously detrimental environmental effects. As Herrington notes, the unnecessarily high demand levels which result from wasteful use may result in the construction of unnecessary facilities and the depletion of underground aquifers. Inefficient use of water for irrigation purposes can "result in increased nitrate, phosphate and pesticide contamination of aquifers and increased soil degradation through compaction and salinisation." In industrial use, low prices can lead to the misuse of water to dilute sewage to compliance levels.[7]

Recognizing the true economic value of water resources can be central to efforts to achieve a long term balance between water supply and demand. As Peter Rogers states, "...conservation for its own sake is not a realistic or advisable goal: it only makes sense within a correct pricing policy for water."[8] Careful attention to water pricing can both reinforce conservation measures and provide a reliable and sufficient source of revenues to the water management agency. Hanke found, in a study of Perth, Australia (1982) which compared pricing policies with non-price policies (leakage control, metering and mandated water restrictions) that "the most economically efficient [policy] was leakage control, followed by metering and annual marginal cost pricing."[9] A background paper prepared for the International Conference on Water and the Environment: Development Issues for the 21st Century concluded that:

7/ Herrington, p. 13.

8/ Rogers, Peter, 1992, "Integrated Urban Water Resources Management," International Conference on Water and the Environment: Development Issues for the 21st century, Keynote Papers, Chapter 7, p. 7.37.

9/ Rogers, p. 7.33.

> About 20% to 30% of the current water used in households and industries can be saved by adopting appropriate policy instruments such as regulations, water tariffs, quotas, and groundwater extraction charges. Further, twin benefits of clean water and reduced demand can be obtained if recycling/reuse of water is encouraged in industries through pollution control legislation and economic incentives (water tariffs based on economic costs, effluent charges and low-interest loans for effluent/sewage treatment plants).[10]

Pricing policy therefore is a critical component of demand management which can have a dramatic effect on the supplies required. As Rogers points out:

> The joint effect of price and income effects need to be taken into account in making forecasts of future demand. ...depending upon the rate of price increase projected, a planner can forecast a crisis in water supply or a modest increase in demand. ...The choice is up to governmental policy makers. 'Needs' forecasts do not reflect the restraining effects of price. If the regulators leave water sellers free to make water prices more nearly represent the marginal cost of supply and, in those cases where the supply has to be controlled by government, realistic pricing policies are pursued, then the forecast crisis will never take place.[11]

Rogers notes that, in gauging the effect price increases will have on demand, planners should recognize that changes in consumer habits will occur over time, rather than immediately. He says:

> ...short run elasticities are more inelastic than long run ones because the adjustment to conserving water often requires planning and capital investment on the part of the consumers ... and planners should not be mislead by them into believing that the demand for water is very price-inelastic.[12]

10/ Bhatia and Falkenmark, Executive Summary, p. 1.
11/ Rogers, p. 7.25.
12/ Rogers, p. 7.25.

By calibrating water prices to the market's full willingness to pay, water resource managers have the opportunity to shape water consumption practices to best meet the agency's financial and societal objectives.

3. Economic Development

Pricing policy is sometimes used as a mechanism to encourage economic development in specific regions, by offering lower rates as incentives to commercial or industrial enterprises. Such an approach can be tempting to municipalities competing for strong business development. However, unrealistic pricing to promote economic development can lead to unsustainable levels of subsidization -- either by the water resource agency or through general government revenues -- and at the same time encourage inefficient water use by businesses. Furthermore, there is little evidence that such subsidies actually are persuasive in affecting businesses' locational choices.

Saunders and Warford argue that full-cost pricing according to geographic area helps to ensure that future development occurs in locations which are sensible from the perspective of efficient water resource allocation. Uniform water pricing irrespective of local costs of service, on the other hand, might contribute to inefficient development patterns by masking the real costs to society of providing water and sewer services to that location. [13]

4. Public Welfare and Equity

The provision of water and wastewater services affects more than the individual consumer. The necessity of potable water and adequate sanitation to promote public

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13/ Saunders and Warford, p. 177.

health is the primary example of benefits which extend to the broader society from the widespread availability of these services.

Many countries incorporate their public utility pricing policies into larger policy objectives related to income distribution and concern for the access of lower income citizens to fundamental services. In this view, access to safe drinking water and adequate sanitation is considered a basic right of the poor, as well as a necessary and practical component of a public health strategy. To achieve universal access to water and sewage services, pricing policies are designed to provide services on a low- or no-charge basis to residents below certain income standards. Other countries achieve comprehensive access to water through direct income redistribution programs which provide poor consumers with the economic means to purchase service at unsubsidized market rates. Boland comments that in practice financing plans are rarely distribution-neutral, but rather are generally constructed to favor some consumer groups over others. He suggests that "...the question is whether the resulting redistribution is consistent with social goals, or whether it produces unwanted shifts of net benefits or net costs."[14]

To ensure the access of poor households to water and sewerage services, a common recommendation is to set most prices to reflect the marginal cost of supply, while providing a "lifeline" base rate for a low volume of residential consumption.[15] This approach can be relatively economically efficient and ensure sufficient revenues, if rates for higher volume use are actually set at full-cost levels.

14/ Boland, John J., 1983, Water and Wastewater Pricing and Financial Practices in the United States, Washington, DC: AID Technical Report 1, Metametrics Inc., p. 2.6.

15/ Sethaputra, Sacha, Theodore Panayotou, and Vute Wangwacharakul, 1990, Research Report No. 3: Water Shortages: Managing Demand to Expand Supply, presented at the 1990 TDRI Year-End Conference: "Industrializing Thailand: It's Impact on the Environment", December 8-9, 1990, p. 82.

The use of a pricing system to support the provision of services to lower-income groups is a legitimate policy technique to promote public health and equitable access of all citizens to public services. If the decision to provide subsidized rates leaves the utility unable to extend service to low-income communities, however, it may well be preferable for these consumers to have their rates increased so that public services can be provided. Studies have demonstrated that, when no public water service is available to the urban poor, they are often forced to purchase water from private market vendors. In these instances their resultant cost of water is generally significantly more expensive than that of public water. Bhatia and Falkenmark conclude that "...the urban poor have to bear the brunt of shortages by paying high prices or through adverse health effects".[16] Whittington et. al. found that in Onitsha, Nigeria, poor households forced to obtain their water privately were spending up to 18 per cent of their income on water.[17]

For reasons both humanitarian and political, policy makers have strong instincts to charge residents low rates for service. But, as Bahl and Linn stress, a utility needs to carefully evaluate the appropriateness of subsidization of specific customer classes:

> ...it is not sufficient merely to cite the likelihood of external benefits in arguing for subsidized provision of services. One also needs to know which dimension of service provision is conveying the externalities; the extent of externalities, in at least rough quantitative terms; and whether there are capacity constraints which require price rationing. Because of these practical difficulties and because of the natural tendency of actual and potential users or their political representatives to clamor for service charges below marginal costs, one should be very cautious in accepting arguments for a digression from marginal cost pricing of urban services on account of external benefits.[18]

16/ Bhatia and Falkenmark 1992, p. 33.
17/ Whittington, Dale, Donald T. Lauria, and Xinming Mu, March, 1989, Paying for Urban Services: A Study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria, World Bank, Report INU 40, p. 17.
18/ Bahl, Roy W. and Johannes F. Linn, 1992, Urban Public Finance in Developing Countries, Oxford University Press, p. 259

B. Sources of Revenue for Water Management

As discussed by Boland, most water and wastewater agencies have multiple sources of revenue which may be considered to finance the agency's work. In addition to user charges, these include tax revenues (either transfer of general government revenues or dedicated funds), bonds and loans (both long and short-term), equity capital, intergovernmental grants and subsidies, and investor ownership.

Boland cautions against the possible pitfalls of financing schemes which are overly dependent on transfers, grants or subsidies:

> Whenever the full cost of utility service is not borne by the entity responsible for setting rates and charges, the likelihood of misallocation of economic resources is increased. Because only a fraction of construction cost must be provided locally, utilities may be motivated to construct excess facilities. The federal program [in the United States] includes complex and often burdensome conditions and regulations to avoid this problem. Also, since the subsidy is available for construction only, and operating costs must continue to be fully borne by local users, incentives are created for the design of high capital cost/low maintenance cost facilities, even at the risk of substantially higher life cycle costs.[19]

A further concern about financing strategies which rely on external sources is the loss of fiscal independence of the agency responsible for services. Utilities which depend on general tax revenues, for example, may find themselves in competition with other government priorities. The degree to which a water or wastewater agency is self-financed is likely to affect greatly its ability to pursue its multi-year strategic resource management programs without interruption.

19/ Boland, p. 2.22.

There are several potential sources of user-based revenues in addition to volume-based user charges. The use of "system development charges" may sometimes be appropriate. These charges are levied on new customers to help support the expansion of facilities, on the premise that existing customers should not be expected to bear an equal share of expansion expense. Revenue offsets can include specific service charges (such as fees for service connections, delinquent disconnections and reconnections, service installations, engineering services, and meter testing) as well as non-operational revenues (interest income, special assessments, impact fees, sale of assets, franchise fees). These revenues should be applied against the costs of the relevant customer class, reducing the net revenue required from user charges.

C. Models of Cost-Based Water and Wastewater Pricing

Two approaches to cost-based pricing are full cost recovery pricing and marginal cost pricing.

1. Full Cost Recovery Pricing

Full cost recovery pricing is intended to recapture adequate revenues through user fees and charges to cover the agency's full costs of developing and management services. Full cost recovery pricing responds to some of the key requirements of a sound water pricing policy. It generates adequate revenues to maintain agency stability and to meet payment obligations to debtors and investors. In addition, to the extent that full cost recovery pricing establishes user charges at rates higher than previously charged, it will provide incentives for consumers to conserve. However, full cost recovery pricing may not provide appropriate signals for future investment, because it "...reflects historic costs rather than the actual cost of providing service under expected future conditions."[20]

2. Marginal Cost Pricing

A marginal cost pricing system is designed to achieve maximum economic efficiency in the allocation of resources throughout a society by setting per unit prices which reflect the costs to the system of producing an additional unit of water or treating an additional unit of wastewater. In this way, marginal cost pricing incorporates market mechanisms to ensure that the appropriate cost of service to consumers is reflected in service prices, that water resources are therefore efficiently allocated to "highest and best economic uses", and that additional, more expensive water supply and treatment systems are not developed unless consumers are willing to pay the higher costs of those future projects. Boland explains that marginal cost-based pricing practices "insure that the good is allocated to only those consumers whose marginal valuation is at least equal to the incremental cost of production."[21]

As Rogers stresses,

> In evaluating water investments it is important to remember that the value of water to a user is the cost of obtaining the water plus the opportunity cost. Ignoring the opportunity cost part of value will undervalue water, lead to failures to invest, and cause serious mis-allocations of the resource between users.[22]

20/ Rogers, p. 7.30.
21/ Boland, p. 2.5.
22/ Rogers, p. 7.15.

Rogers summarizes the distinction between marginal cost pricing and cost recovery pricing systems as it applies to water services:

> Marginal cost pricing is the pricing of water at the cost of supplying an additional unit of water....The marginal cost must include the opportunity cost of the water. Cost recovery refers to pricing of water to recover the costs of providing it. Typically, cost recovery is based on accounting procedures that are based on historical costs. Cost recovery pricing can be close to marginal cost pricing when the costs of new projects are similar to the costs of past projects. Unfortunately, in water resources development historical costs are typically much lower than current or projected costs of projects.
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> Many water planners confuse cost recovery with marginal cost pricing, the economists' 'golden rule.' Most water utility officials consider marginal cost pricing as leading to unrealistically high tariffs. Unfortunately, economists often try to mandate strict marginal cost pricing, ignoring practical problems faced by utility managers. In fact, there are many different tariff structures that would allow full cost recovery without marginal cost pricing....While tariffs have financial, economic, and political dimensions, it should be remembered that marginal cost pricing relies only on the economic dimension. The best approach probably lies somewhere between the two extremes.[23]

The calculation of short-run marginal cost is used to determine the cost to the utility of providing an additional unit of service to the consumer. However, the sole use of short-run marginal cost calculations are problematic. Because the expansion of water and wastewater services is capital intensive, short-run marginal costs are likely to fluctuate greatly, being high immediately prior to an expansion project and decreasing sharply during the period of excess capacity following a major capital project. The problem of "capital indivisibility" therefore produces uneven short-run marginal costs which are likely to put financial and efficiency requirements out of phase. Relying solely on short-run marginal costs will send consumers incorrect pricing signals, encouraging excessive consumption. To correct this problem Bahl and Linn recommend the use of the average

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[23]/ Rogers, p. 7.28.

incremental cost (AIC) approach, which provides a more accurate, long-run marginal cost calculation.[24]

D. Designing a Cost-Based Pricing System

The following briefly summarizes the steps involved in developing a financially efficient and equitable self-sustaining pricing system for water and wastewater services.

1. Identifying and Allocating Costs

a) Identifying Costs

The first step in developing a cost-based pricing system is to identify the costs of service provision. These include both capital costs and operating and maintenance (O&M) costs. Capital costs will include debt service, revenue financed capital outlays, and reserve fund contributions.[25]

In addition to a full accounting of costs incurred, economists urge that projections of anticipated future expenses -- both to manage the existing system and to expand services -- also be developed. Rogers advocates for particular focus on future capital requirements rather than historic cost accounting:

> Unfortunately, most regulatory commissions have tended to take a 'backwards' accounting stance allowing pricing based only upon average costs and the revenue needs to meet them. ...This stance is not appropriate in situations where the

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24/ Bahl and Linn, pp. 265-269.

25/ While most O&M costs are treated as expenses for accounting purposes, some O&M costs may be capitalized. Likewise the agency may choose to expense some capital costs.

> utilities are facing increasing marginal costs (all the best projects have been built and now it becomes increasingly difficult to supply the same amounts of water at the historical costs). Under these conditions a 'forward' looking accounting stance is indicated. If this policy were pursued, the emphasis on revenue requirements of utilities would be replaced by establishing adequate future investment funds.[26]

Allocation of costs according to the organization's full chart of accounts helps to identify all costs and to distribute costs by functional categories. Typical functional categories for water service will include: source of supply; pumping and conveyance, water treatment, transmission and distribution, customer accounts (including billing and collection, and customer service) and administrative. Wastewater functional categories will include: collection, pumping, treatment and disposal, customer accounts, and administrative. It is preferable to break out separately operating costs and maintenance costs under each functional category to achieve the clearest understanding of the agency's profile of expenses.[27]

The process of identifying costs is not merely an accounting exercise, but the basis of further project evaluation and refinement. In a self-financing system, one must assume that the costs of service development can be borne by the revenues available to the agency. Therefore, if the costs of a particular capital approach to service delivery exceed the revenues which can be realistically projected, alternative approaches should be considered. As Unkulvasapaul and Seidel discuss:

> A thorough financial analysis should be conducted before technical solutions to water pollution are selected. The analysis should address the issues of (1) costs and benefits of alternative solutions, (2) methods and source of funding, (3) level of central government's contribution, (4) ability and willingness of a community

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26/ Rogers, p. 7.33.

27/ Raftelis, George A., 1993, Comprehensive Guide to Water and Wastewater Finance and Pricing, pp. 148-150.

and its residents to pay, and (5) allocation of costs on an equitable basis among the polluters and other beneficiaries of a project.[28]

b) Allocating Costs by Customer Classes

The next step in developing the pricing system is to determine customer classes and to allocate costs by these customer categories. Customers classes are established according to customer characteristics which affect the cost of providing service. Such factors include different levels of demand, location, and the type and condition of the distribution system. Sewage and wastewater customers may be further differentiated according to the strength of pollutants in their discharge, which affects the cost of sewage treatment. Common examples of customer classes are: residential, commercial, industrial, institutional, other governmental utilities, and customers outside the local boundaries. Each of these categories can be further differentiated according to volume of use, strength of discharge, or other consumer variables. The decision of how may customer classes to establish is a matter of balancing the administrative complications of managing multiple classifications with the potential of increasingly refined efficiency in pricing. When customer classes have been established, the costs identified earlier can be allocated by class.

One issue in designing the rate structure relates to the optimal number of customer classes, usage blocks, and rates which should be established. The consumption needs of consumers will obviously vary; the water and wastewater service use of a restaurant, for example, will be completely different from that of a family household. Raftelis notes that: "In a well-designed rate structure, each block will have primarily the cost of service

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28/ Unkulvasapaul, Manida and Harris F. Seidel, 1991, Thailand: Urban Sewage and Wastewater Management, report to UNDP / World Bank, ASIA Water Supply and Sanitaiton Sector Development Project, Bangkok, p. 10.

characteristics of one class of customer".[29] The implementation of multiple usage blocks enables the rate structure to be more finely adjusted. However, this increasing refinement brings increasing levels of administrative complexity to the billing, collection, and accounting processes of the agency. A balance must be struck, therefore, between administrative simplicity and economic efficiency.

c) Common Types of User Charges

Once costs have been determined and customer classes established, a structure of user charges can be developed. There are two basic types of user charges employed by water management agencies: periodic fixed charges and commodity charges.

(1) Periodic Fixed Charges

Periodic fixed charges are charges billed at a constant level irrespective of the volume of water consumed. Such charges include: a) service charges -- charges made in addition to a commodity charge for all units of service which covers expenses related to access, capacity, and overhead; b) connection fees -- charges for connecting a new customer to the distribution or collection system; c) a minimum charge -- a fixed charge for a specified minimum quantity of service, used in combination with a commodity charge for units consumed above that quantity; and d) flat rate charges -- a fixed charge for service with no commodity charge.

Ideally, rates for services other than volume use should be established individually, by service component; charges for use, connection, and access need to be separately considered because the price elasticities will be different for these different services. Lower-income residential customers, for example, may have a high elasticity of demand

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29/ Raftelis, p. 188.

for connection fees (that is, their willingness to connect to the public water system will be greatly affected by the cost of service), but a low demand elasticity for low volumes of use once connected to the piped service. To encourage widespread connection to the public service, therefore, the agency may want to set a low connection fee rate for these consumers. Upper-income residential customers, on the other hand, are likely to have a low connection fee elasticity of demand, and may therefore be charged a full-cost or higher rate to compensate for the subsidized connection fee to poor consumers.

(2) Commodity Charges

Commodity charges are based upon the number of units of service consumed. Most variations in pricing models relate to the choices made of the different rate models for these commodity charges.

2. Consumer Types and Pricing

It is common practice in many countries to set different prices for different consumer groups or type of consumption. Analysts find that such distinctions can either support or undermine the water and wastewater agency's objectives.

a) Uniform Versus Differential Rates by Consumer Type

(1) Agricultural and Urban Uses

The most common distinction among consumer groups is between agricultural and urban users. Water prices for irrigation use are often substantially lower than prices charged for other purposes. According to Rogers, on a global basis consumption of irrigation water accounts for about two thirds of total water withdrawn and for more than 80 per cent of the water consumed.[30] As cities have expanded, there has been increasing competition between agricultural and urban water users in many developing countries. Many authors argue that the lower rates charged for water used for irrigation have resulted in an inefficient allocation of valuable water resources, and have discouraged the development of more efficient irrigation techniques and selection of water-efficient crops.

(2) Types of Urban Consumers

Distinctions in pricing policy may also be made based upon the type of urban consumer -- domestic, industrial, commercial, and institutional -- consistent with the agency's policy objectives. In an analysis of water consumption patterns in one East African city, Warford and Julius note that 60 per cent of the water sold is consumed by businesses and institutions, although they represent only 11 per cent of the total number of customers. Lower income households, in contrast, represented 60 per cent of the connections (excluding public standposts) yet consumed less than 20 per cent of the water.[31] The disproportionate consumption of most of the water supply by a minority of users argues for a focus on appropriate pricing and regulation of these high-volume consumers, particularly in situations of limited administrative capacity. The advantages of such an approach are several: the costs of metering and administration for fewer connections will be lower; the revenue generated per customer will be obviously far greater; and the gains in allocative efficiency can be expected to be significantly more.

Warford and Julius advocate a water tariff structure which meets both the financial requirements of the water agency and the social benefit of access to safe water for the poor. They argue that:

30/ Rogers, p. 7.11.

31/ Warford, Jeremy J. and DeAnne S. Julius, 1977, "The Multiple Objectives of Water Rate Policy in Less Developed Countries," Water Supply and Management, Vol. 1, Pergamon Press, pp. 335-342, p. 338.

> ...the financial requirements can generally be met even if only the large consumers are charged the full marginal supply cost for their water. Thus a typical tariff structure would consist of a social or "lifeline" block which would be sufficient to meet basic sanitation needs supplied at a very low price per cubic meter, and one or more larger consumption blocks where unit prices would approach or equal the incremental supply cost. ... It is important to note that the emphasis in designing this increasing block ... tariff structure is not one of charging higher unit costs to larger users but rather one of pricing most of the water at its full marginal cost while offering a subsidy for the first few liters consumed on social grounds.[32]

According to Warford and Julius in 1977 this type of increasing block tariff structure had been adopted by a majority of developing countries to whom the World Bank had lent for water supply projects.[33]

b) Differential Rates by Quality of Water

In instances where a significant portion of water demand is for uses which do not require high quality water, it may be appropriate to consider a dual-supply system which provides consumers the option of purchasing lower-quality water at a lower price. Saline water or partially treated wastewater may be adequate for some industrial purposes, and its use may relieve peak capacity demand upon potable water resources. Herrington reports that four regional water agencies in England and Wales offer "low-quality non-potable piped supplies in certain industrial ... [regions]; in recent years these have accounted for between 2 per cent and 22 per cent of overall public water supplies in individual authorities."[34] As Rogers notes,

> ...when water is provided for urban and industrial uses most of it is not consumed but is returned contaminated to the water source. This is particularly significant when it is realized that the cost of wastewater disposal in cities in developing

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32/ Warford and Julius, p. 339.
33/ Warford and Julius, p. 339.
34/ Herrington, p. 50.

countries is estimated at five to six times as much as the cost of supplying the water.[35]

c) Differential Rates by Quality and Percentage of Water Returned to System

Charges based upon the quality of water discharged should also be considered. As discussed by Herrington, "The chemical qualities of water-borne wastes may differ enormously from one discharger to another and in this situation a charging system reflecting differentiated charges for specialised treatment of different characteristics of wastes may well be justified."[36] A survey conducted of OECD nations found several examples of differential pricing based on both quality and volume changes in water returned. In the Delaware River Basin in the United States, for example, water consumed was charged at 100 times the charge for water abstracted and returned; additional charges were levied for salinization of the water based upon the zone of the river basin (fresh versus salt water) in which the water was discharged.[37] The Yorkshire Water Authority in England sets abstraction charges based upon season (with summer use charged at the highest rate), source (with first class inland water charged at the highest rate and tidal water at the lowest), and amount of loss of the water abstracted (the greater the loss, the higher the price of abstraction). Water returned unchanged in temperature, quality or quantity was considered "zero loss"; low loss uses included circulated cooling, gravel washing, and fish farming; high loss and complete loss uses included spray irrigation and evaporative cooling.[38] Such pricing mechanisms provide incentives for industrial users to develop more efficient water use systems, such as recirculation of cooling water.

35/ Rogers, p. 7.8.
36/ Herrington, p. 71.
37/ Herrington, p. 83.
38/ Herrington, p. 82.

3. Rate Models for Water and Wastewater Use Charges

A variety of rate models exist for water and wastewater pricing. A survey of OECD member countries found that residential charges in Australia, Canada, Norway, and the United Kingdom are primarily based upon property values; in Europe, the United States, Japan, and most of Scandinavia, on the other hand, rates are a combination of fixed and volume-based charges. Industrial consumers are generally billed on a volume basis; rates for commercial sector users vary considerably among different countries. The various rate models in use are as follows:[39]

a) Flat Rate

A flat rate system charges each consumer a constant charge irrespective of the volume of service used. Rates can be set on a per-connection basis, or according to household size, number and type of fixtures and appliances, size of property, value of property, or size of inflow or outflow pipe. Flat rate systems are criticized because they provide no incentive to consumers for efficient water use, as consumers' bills are unaffected by their level of consumption. Flat rate systems generally are used when metering is not in place or when an administratively simple system is required. Despite the economic inefficiency of flat rate pricing, some agencies maintain this system because the costs of switching to an alternative system -- generally involving metering -- are perceived to be too high.

b) Average Cost Pricing

Average cost rates are determined by totaling the agency's net costs and dividing by the projected number of units of water to be sold to establish a consolidated cost per unit. Customers then are billed at that per unit rate according to the volume each customer

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39/ Descriptions of pricing systems and rate models are largely based upon information provided in Herrington, 1987.

consumes. This system is viable if demand levels are stable (or accurately projected). If actual use is lower than projected, however, revenues will be insufficient to cover agency expenses. A further criticism of average cost pricing is that peak demand users are not charged at higher rates to pay for the capacity demands placed upon the water system by their usage.

c) Declining Block Tariff

Declining block tariff schemes usually involve a fixed or minimum charge, plus a per unit commodity charge. The rate per unit declines as the volume of water consumed increases. The declining block tariff has been the dominant rate structure in countries which have unit-based pricing, despite the obvious conclusion that this pricing system encourages inefficient water use and is less equitable for lower-level consumers. In 1982, a sample of 90 utilities in the United States found that 56 per cent of the water supply rate schedules were based upon a minimum charge with a decreasing block rate; 33 per cent of the utilities used a minimum or fixed charge in combination with a volume charge.[40]

Water planners and municipalities are increasingly concluding, however, that the declining block tariff produces negative water use patterns. For example, Herrington cites a study done of Brisbane, Australia, where a decreasing block tariff for commercial and industrial consumers was established to induce businesses from other states to develop in the Brisbane area. Herrington writes:

> The report noted the waste of resources and overinvestment in new capacity that can result, as well as the inequity (in Brisbane) to small domestic consumers who all pay the same large fixed annual charge....Declining-block rate structures are therefore not to be recommended since they encourage inefficient resource allocation and they are frequently inequitable. .... Paradoxical results may emerge,

40/ Herrington, p. 40.

> e.g., very large domestic users of water ...may end up facing a significantly lower marginal (and average) price than the low-volume user who makes very few claims on peak capacity. If the large consumer has, as is more than likely... a much higher income, the resulting cross-subsidisation will be at variance with all conceivable notions of equity as well as reflecting serious distortions in the use of resources.[41]

d) Increasing Block Tariff

In direct contrast to declining block tariffs, increasing block tariffs increase the charge per unit as the volume of consumption per user increases. Such "progressive" tariffs often involve a below-cost rate for a minimum volume of service -- as discussed above -- on the grounds that this subsidization enables the poor to have access to water and sanitation service and promotes public health. For example, in Brussels, 110 liters per household/per day were allowed at a reduced rate. Belgian municipalities often have special tariffs for certain groups, such as pensioners or families with children.

Japan has been in the forefront in the use of progressive tariffs. Herrington reports that by 1978, 52 per cent of water projects in Japan were using increasing block rate systems.[42] The Japanese report to the OECD survey explained that the Japanese had two objectives in instituting this tariff policy: 1) "to reflect the increased cost of the development of new water resources etc. on the charge imposed on consumers demanding a great amount of water", and 2) "to promote the consumption reducing effect".[43] In 1980 the Osaka Municipal Waterworks Bureau was charging a basic charge of 340 yen, with a charge per cubic meter of water which increased -- in an elaborate pricing system of ten tariff tranches -- through a price range from 50 yen/ m^3 for consumption between 11-20 m^3, to 117 yen/ m^3 for consumption between 41-50 m^3, to a high of 240 yen/ m^3 for consumption in excess of 1,000 cubic meters.

41/ Herrington, p. 43.
42/ Herrington, p. 44.
43/ As quoted by Herrington, p. 44.

Between 1968 to 1975, Zurich, Switzerland converted from a declining block tariff to a version of the increasing block tariff rate structure which is much simpler than that used by Japan. Zurich now has a two-tranch increasing block tariff system. All consumers are charged one rate for a basic level of consumption (the volume of which is determined according to the size of the user); water consumption in excess of this level is priced at double the basic level rate. While noting that consumption changes may also have been induced by industrial recession and restructuring, Herrington reports that:

> The trends over the period since 1970 are clear: a substantial reduction in excess consumption, stability in the consumption of normal users and a 14 per cent reduction in the consumption of large users. Zurich Water Department [officials] are confident that these trends result from the tariff change described and similar changes in the wastewater tariff in 1968 and 1971 which effectively abolished a highly regressive declining-block structure.[44]

Italy also has introduced an increasing block rating system, with basic and low-volume use priced considerably lower that higher consumption blocks. Annual reduction in per capita consumption between 1974 -1978 was reported to be 5.2 per cent in Turin and 2.8 per cent in Naples.[45]

e) Two-part Tariffs

The two-part tariff combines flat-rate and average cost pricing. A base rate is charged according to type of consumer or service connection; an additional fee is charged based upon volume of usage. The flat rate charge is often low and presented as a "meter rent"; other flat rate charges represent a higher proportion of total charges and are linked to capacity expenses of the water agency.

44/ Herrington, p. 44-5.
45/ Herrington, p. 47.

f) Peak Demand and/or Seasonal Rates for Water

Higher rate charges for water consumption during peak use periods -- variations in consumption which may occur on either a daily or seasonal basis -- are sometimes instituted by water management agencies. The rationale for these surcharges is that it encourages consumers to reduce their consumption during these periods and/or defer their consumption to a lower-use period, and that it more accurately represents the marginal cost of water consumed during that period. For example, a report on water conservation in the Regional Municipality of Waterloo, Canada, recommended that the city implement summer pricing rates to reflect the higher use -- and therefore value -- of water during those months.[46]

4. Special Issues in Pricing Sewerage and Wastewater Services

User charges for sewerage and sewerage disposal (S&SD) for residential users are most commonly linked to the tariff system for water service, both because of the direct relationship between volumes of water consumed and sewerage produced, and because of the difficulty and cost of separate measuring systems. Issues of pricing S&SD for industrial users, however, are more complex due to the wide variation in content and toxicity of water borne wastes discharged by different industries, and to the high percentage of total sewage industrial users produce. Many analysts therefore recommend that non-residential consumers be charged by both volume and concentration of pollutants in the effluent discharged.

Rogers argues that:

46/ Water Consevation in the Regional Muncipality of Waterloo, 1992, p. 37.

> ...consideration of the role of industry in the management of the ambient quality of the water resources is vital....[because] industrial processes pollute a disproportionate amount of water... Developing countries should learn from the experience of industrialised nations: it is much more expensive to clean up polluted water than it is to avoid polluting in the first place. Economic incentives against industrial pollution need to be established. Currently the 'polluter pays' principle is becoming widely accepted around the world. Under this principle policy instruments, such as effluent fees, are established so that companies will have an incentive to control their effluents at the source. In addition to the usual regulatory methods, innovative approaches such as tradeable permits and privatisation of facilities should also be explored.[47]

Because the costs of sewerage service can be exponentially greater than that of water service, it is particularly important that sewerage service be realistically priced. As Rogers points out:

> If, as is often the case, the price of environmental resources such as municipal wastewater treatment is held unrealistically low, the demand grows very large. As consumption grows, the real costs of treatment increase, necessitating an increase in the public subsidy that often exists because the utilities price their treatment upon historical average costs which are much lower than the future marginal costs for expanding treatment.[48]

A polluter-pays system may in fact reduce the amount of services demanded from the utility, as industries are motivated to develop independent strategies for minimizing costs.

> ...Industry can choose to pretreat its waste, decrease its water use, improve housekeeping, change either the production process or products, or it can choose to pay the effluent fee. The industrial charges are typically related to the quantity of water used and the 'strength' of the effluent measured in terms of the oxygen-demand organic waste load (BOD) and total suspended solids. These charges can give an incentive to industries to change the amounts and strength of their sewage effluents.[49]

47/ Rogers, p. 7.11.
48/ Rogers, p. 7.24.
49/ Rogers, p. 7.30.

5. Discussion of Different Rate Systems

The choice of a pricing system for a particular water or wastewater system will vary, based upon both the policy objectives and the administrative capacity of the management agency. Key considerations in developing a pricing policy will include the policy's effect on allocative efficiency, the costs and projected savings of implementing the system, its ability to promote consumer conservation, and its effect upon agency revenues.

a) Allocative Efficiency

The importance of rate structures in promoting allocative efficiency is clear. As Boland discusses, "Commodity charges, properly designed and set, are capable of promoting the efficient allocation of services within the water/wastewater utility sector. They may also provide the utility with some market signals regarding customers' willingness to pay for new capacity, although they do not insure that cost minimizing investment decisions are made."[50] As discussed above, in theory a marginal cost pricing system promotes highest allocative efficiency of water resources. In this regard, Boland notes that "...some rate designs are inconsistent with marginal cost pricing principles. In particular, block-type structures...and increasing rate structures preclude the use of marginal cost pricing for at least some customers."[51]

b) Costs and Benefits of Metering

It is appropriate to consider both the cost-benefit ratio of different pricing systems as well as an agency's administrative capacity to initiate and maintain each system. The most significant initial expense in each pricing system -- except the flat rate system -- is the

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50/ Boland, p. 2.15.
51/ Boland, p. 2.13.

capital outlay required for introducing meters. The benefit of metering may vary by consumer type. As Saunders and Warford note,

> ...implementation of use-related pricing [through metering]...for water supply is a costly exercise, and its introduction or continuation should ideally be subject to cost-benefit analysis. Briefly, the benefits of metering are the cost-savings brought about by reducing consumption....The case for metering industrial consumers in urban and many rural areas is usually not a matter for serious dispute; the cost of metering is normally insignificant in relation to the cost of water consumed. The real question is whether or not to meter domestic and small commercial consumers, and here the need for some sort of cost-benefit calculation is clear.[52]

An additional benefit of universal metering for water service is that it enables a water management agency to document discrepancies between water supplied and water consumed, thereby identifying waste, leakage, and pirated supply. Accurate data obtained through metering can provide support for other waste prevention measures undertaken by the agency.

The use and manner of metering varies considerably around the world. Herrington's survey of OECD member nations found that domestic metering was least prevalent in Britain, while fairly comprehensive in France, Finland, Japan, and Switzerland. Other countries have a mix of metered and non-metered households; some provide metering as an optional service.[53] The decision to institute metering is based on an assessment of both its economic efficiency (e.g. its effect on water supply and demand) and its financial efficiency (its effect on agency revenue and expenses). Herrington's summary of studies conducted on the effects of metering, however, strongly indicates that metering in some form results in savings in water use. Time series studies in 13 locations found after

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52/ Saunders and Warford, pp. 172-3.
53/ Herrington, p. 104.

metering water savings ranging from 5 per cent in Helsinki, Finland, to 45 per cent in Philadelphia, U.S.A.[54]

c) Consumer Incentives to Conserve

Different price structures for both water and wastewater will affect the degree to which consumers are encouraged to conserve water. This is most obvious in the case of high volume commercial and industrial consumer groups. It sometimes has been argued that price increases in water service do not significantly affect domestic consumption patterns. However, as was discussed above, Bhatia and Falkenmark note that "in a number of developed countries...researchers have found that household water demand drops by 3 per cent to 7 per cent when prices rise by 10 per cent."[55] In developing countries, measuring demand elasticity is difficult if metering is not in place and price increases are small. When sharp price increases are introduced, however, consumption does decline, as demonstrated by the price restructuring implemented by the Water Supply Enterprise of Bogor, PDAM, in Indonesia. In this case a tariff increase of between 200 and 300 per cent (comprised both of water rate increases and higher fixed charges) resulted in a 28 per cent to 30 per cent decrease in water consumption.[56]

In the event that metering is not extended to domestic consumers, Saunders and Warford suggest other methods of regulating consumption, some of which make use of economic incentives to conserve. These include the regulated use of different capacity household water tank reservoirs with different water tariffs charged according to tank capacity, higher flat rates for households with multiple plumbing fixtures or appliances, and differential rates based on size of the supply pipe to the household.[57]

54/ Herrington, p. 11.
55/ Bhatia and Falkenmark, p. 18.
56/ Bhatia and Falkenmark, p. 19.
57/ Saunders and Warford, pp. 179-184.

Although appropriate water pricing can induce industrial consumers to conserve, pricing policy alone will not always be sufficient to persuade businesses to implement more efficient water use practices. Bhatia and Falkenmark note that a combination of regulatory controls and economic incentives along with true-cost pricing are often necessary to achieve efficiencies in the industrial sector. They provide the case example of a fertilizer plant in Goa, India (Zurai Agro-Chemical Limited, ZACL) where "...over a six-year period (1982-1988), water consumption was reduced by 50 per cent (i.e. from designed 22,000 m^3 per day to 11,000 m^3 per day) as a response to high price of raw water...and government pressure regarding reducing industrial effluent discharged in the sea."[58]

d) Revenue Stability

Agency stability is directly affected by the reliability of fee revenues. In this regard, it is important to note that decreases in consumption in response to price increases can actually result in a decreased revenue stream, depending on the demand elasticity. For example, Rogers cites a study of industrial water use in Sao Paulo, Brazil, which documented the effect of a wastewater tariff upon consumption. Water demand dropped by 30 per cent, which resulted in a 37 per cent shortfall in revenues for the water utility.[59] In another example provided by Rogers: "The Tucson Water Department [Arizona, U.S.A.] estimated that the water rates would have to be increased by 17.6 per cent in order to pay for the increasing cost of the city supply from the Central Arizona Project, but Billings and Day (1983) pointed out that this would be too low by a factor of three when the price elasticity was taken into account. Billings and Day estimated a rate increase of 59 per cent

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58/ Bhatia and Falkenmark, p. 20.
59/ Rogers, p. 7.25.

would be necessary to increase the total revenue by 17.6 per cent."[60] Such reductions in volume of demand must be considered in calculating rate levels which will generate adequate revenues for both full cost recovery and agency stability.

e) Customer Acceptance

A common problem in establishing a full cost pricing system is that of negative customer response. This is particularly likely to be a concern in regions where water service has been traditionally considered a "right" or consistently under-priced, where service has been of poor or inconsistent quality, and of course, in areas where there has been no public sewage service and therefore no fees at all for the discharge of wastewaters. A process of consumer education is likely to be necessary to counteract this potential undervaluing of service by consumers. Bahl and Linn suggest the possibility of a "promotional service" period with lower-cost initial rates as a means of attracting customers and introducing consumers to the quality and importance of the water and wastewater services.[61]

A report by Unkulvasapaul and Seidel also considers the issue of customer acceptance. They suggest that: "Ideally, the goal should be to collect sufficient revenues directly from users to pay O&M costs....Realistically, it may be necessary to start with user tariffs that represent only a fraction of running costs and increase that fraction with successful experience. The remaining portion will then have to come from local government grants, local property taxes, or special taxes until the system can become self-supporting."[62] This may be a politically pragmatic approach to complete the financing of services in existing municipalities; however, it obviously poses the problem of how best to phase in increasingly higher rates.

60/ Rogers, p. 7.29.
61/ Bahl and Linn, p. 262.
62/ Unkulvasapaul and Seidel, p. 65.

6. Organizational Structure and Capacity

Sufficient organizational capacity is required for a water and wastewater utility to design and implement a self-financing enterprise. A skilled accounting division and financial planning staff are obviously necessary, for example, in order to design and evaluate a pricing system. Beyond the initial expense of meter installation, an agency must have the administrative capacity to manage routine and accurate meter readings, cost accounting, billing procedures, account management, and compliance. Herrington notes that:

> Monitoring and policing the system will include ensuring that meters are not tampered with and that charges geared to the ownership or use of particular water-using appliances are not avoided by false reporting. Generally, the pursuit of more allocative efficiency implies that more precise monitoring of consumption is necessary and this in turn results in higher administrative costs.[63]

Herrington cautions that the benefits of increased administrative costs must be clear before more cost-intensive systems are implemented.

The capacities to operationalize billing systems and collections procedures and to monitor and enforce restrictions are critical to the effective implementation of rate structures; these capacities should be carefully assessed as part of the rate design process to ensure that the goals of the pricing system can be met. Finally, the technical capacity to provide customers reliable service at an acceptable standard is fundamental to the success of the enterprise.

63/ Herrington 1987, p. 32.

E. Summary

The use of full-cost pricing as a resource management tool is becoming increasingly important in the arena of public utilities as resources become more scarce and expensive, and as pressures on central government financial resources become tighter. A carefully designed full cost water and wastewater pricing system will promote a clean environment, resource conservation, economic growth, and the public welfare, while relieving the financial pressure on general public revenues. As Bahl and Linn suggest:

> Considering that user charges can raise substantial revenues in a fair and publicly acceptable manner, increase the efficiency of allocation of existing service capacity, and help guide investment decisions, it is surprising how often their role in financing urban services...is neglected.[64]

The design of an effective rate structure requires a period of trial and evaluation to establish prices which meet revenue requirements and promote optimal consumption patterns. As Raftelis puts it, "Using a demand model to develop rates is an iterative process. If proposed conservation rates do not yield the proper demand or revenue result, they must be fine-tined until they do. This is the point where conservation pricing become an art -- through experience, rate technicians develop the ability to modify rate structures to achieve desired objectives."[65]

64/ Bahl and Linn, p. 239.
65/ Raftelis, p. 211.

III. The Case Study: Bangkok, Thailand

A. An Overview of Bangkok

1. Characteristics of the Region

Thailand's capital city of Bangkok and the five provinces which surround it -- together known as the Bangkok Metropolitan Region (BMR) -- are located in the flood plain of the Chao Phraya and Tha Chin rivers. The Chao Phraya River basin is the largest drainage basin in Thailand, covering about 35 per cent of the total area of the country. Its lower portion winds its way through the western side of metropolitan Bangkok before emptying into the Gulf of Thailand. Bangkok's extensive system of canals -- called klongs -- are fed by and empty into the Chao Phraya.

The BMR covers 7,616 square kilometers. Most of this entire area is a mere 1.0 to 1.5 meters above sea level. About 90 per cent of the region's annual rainfall of approximately 1,500 mm. falls during Thailand's rainy season, which runs from mid-May to October. The groundwater table is very high, beginning only 1.0 to 1.5 meters below ground level. Aquifers below the region descend through eight layers, reaching to some 650 meters below ground level. The soil in the region is primarily clay.[66]

66/ Macro Consultants Co., Ltd., March, 1993, Bangkok Metropolitan Region Wastewater Management Master Plan, Vol. 4, Executive Summary, prepared for Pollution Control Department, Ministry of Science, Technology and Environment, Thailand, in association with Thailand Institute of Scientific and Technological Research and Environmental Technology Consultants Limited, pp. 3-4.

2. Growth of the City of Bangkok and the Bangkok Metropolitan Region

a) Population Growth

Bangkok has been experiencing exponential growth, both in terms of population and in terms of economic development. In 1992, the region's population was 8,661,228, representing about 15 per cent of the country's total population of 57,788,965.[67] During the decade from 1970 to 1980, population growth in the entire region was 3.91 per cent a year, with the fastest growth, of 4.32 per cent, occurring in the Bangkok Metropolitan Area (BMA) itself. In the following decade the highest rates of growth shifted from Bangkok proper to the provinces; while the average rate of population growth in the region was 2.19 per cent a year, the rate of growth in Bangkok was only 1.44 per cent. In light of the existing population density and high land prices in Bangkok, this pattern of stronger growth in the suburbs is expected to continue. Nonetheless, population in the BMA alone is projected to increase from its 1990 level of 5,546,937 to 10,234,200 in the year 2020: an increase of 84.5 per cent in just thirty years.[68] Table 3.1 summarizes the population growth expected in the BMA and the surrounding provinces between 1990 and 2020.

67/ National Statistical office, Office of the Prime Minister, 1993, Statistical Yearbook Thailand, Number 40.

68/ Macro Consultants Co., Ltd., p. 10.

Table 3.1
Population Projections for the Bangkok Metropolitan Region, 1990 - 2020

Province	*Population* **1990**	**2000**	**2010**	**2020**
BMA	5,546,937	6,793,800	8,370,700	10,234,200
Pathum Thani	452,693	663,700	973,000	1,426,500
Nonthaburi	668,760	947,700	1,315,700	1,764,300
Samut Prakan	822,316	1,176,500	1,637,900	2,173,800
Samut Sakhon	358,155	512,300	730,300	1,036,600
Nakhon Pathom	657,182	960,200	1,393,480	2,016,100
Total	**8,506,043**	**11,054,200**	**14,421,000**	**18,651,500**

Source: Bangkok Metropolitan Region Wastewater Management Master Plan, Vol. 4, Executive Summary, p. 10, Macro Consultants Co., Ltd., March, 1993.

b) Economic Growth

The statistics on Bangkok's rate of economic development are equally impressive.

Bangkok's economy has propelled the nation into a leadership position in Southeast Asia.

As documented in a study on infrastructure and environment in Thailand:

> The number of factories (excluding rice mills) registered with the Department of Industrial Work (DIW) has rapidly increased from 600 in 1969 to 51,500 factories in 1989. Fifty-two per cent of these factories are located in the Bangkok Metropolitan and Greater Bangkok Areas (BMR). Twelve out of twenty-three industrial estates are also located in the region whereas the remaining seven are located in the central region including the Eastern Seaboard. Value added derived from these factories has accounted for 76 per cent of the country's value added in the industrial sector and thus reflects a high concentration of medium and large scale industries in the region.[69]

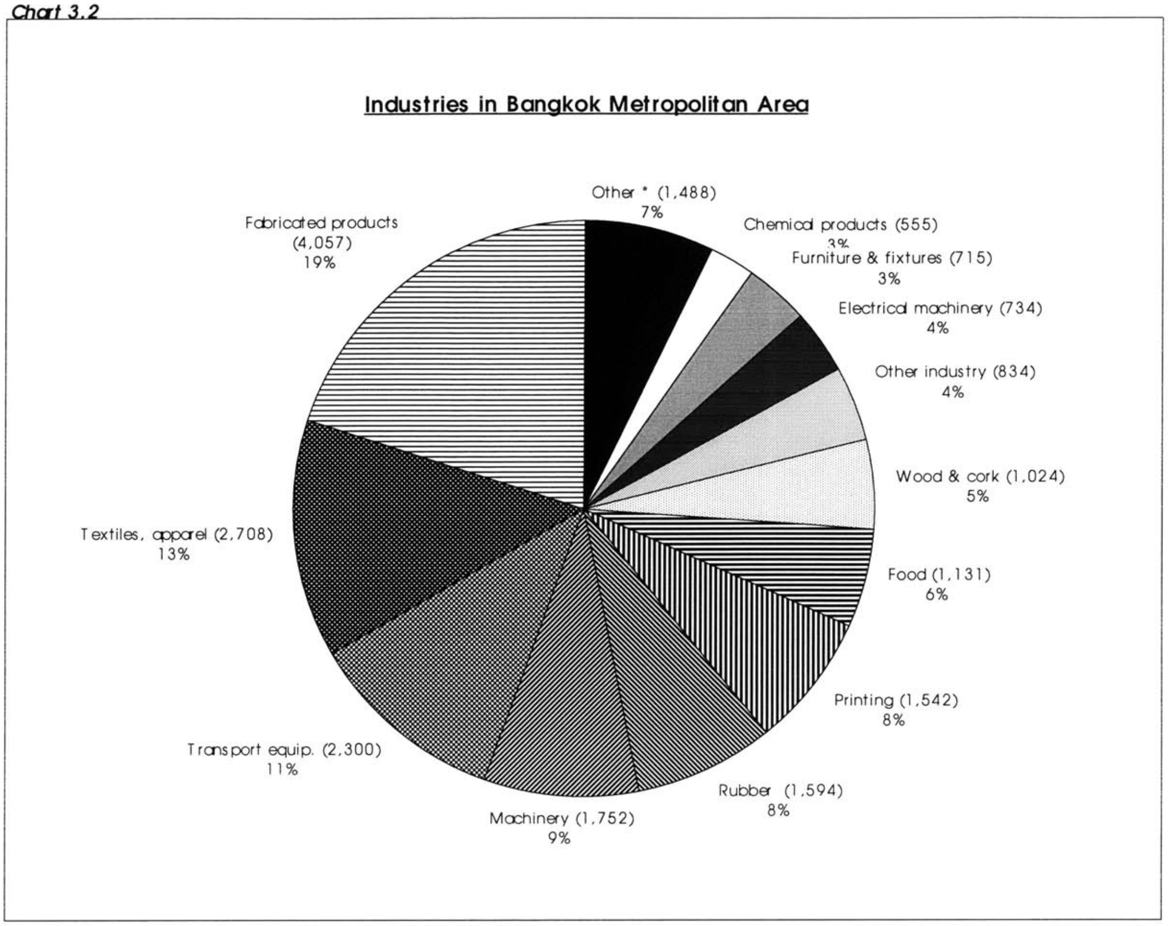
[69]/ Wattananukit, Atchana and Phanu Kritiporn, no date (circa 1990), The Development of Infrastructure and Supporting Facilities and Prevention Control for Pollution and Environment, Executive Summary, Thailand Development Research Institute Foundation, p. 11.

While the rate of this industrial growth is itself significant, the nature of Bangkok's industry is changing as well. Bangkok's production focus is shifting from assembling activities and food processing to increasingly sophisticated industries in the chemical and engineering sectors. Industrial and electronic machinery, textile, fabricated metal and basic chemical industries are all projected to grow.[70] Chart 3.2 summarizes the mix of industries in the BMA in 1990.

The region's rapid pace of development is expected to continue. The overall economy is projected to grow at a rate of six to eight per cent between now and 1996. During the same period the industrial sector will grow even faster, at a rate of eight to nine per cent.[71]

70/ Wattananukit and Kritiporn, p. 2.
71/ Wattananukit and Kritiporn, p. 11.

Chart 3.2



* OTHER includes: Tobacco (8), Petroleum (13), Beverages (69), Basic metal (262), Non-metal (265), Paper & paper products (397), and Leather Footwear (474).

Source: Adapted from Table 5.2, "Number of Industrial Establishments in the BMR", which used data obtained from the Dept. of Industrial Works, Ministry of Industry, in Sethaputra et. al., "Industrializing Thailand: Its Impact on the Environment", 1990, p. 50.

As a result of this phenomenal growth, the pressure on all of Bangkok's infrastructure systems is enormous. Bangkok's water supply system currently reaches an estimated 75 per cent of its existing customer base, and is struggling to keep up with the pace of development in the region.

B. Governance of Water and Wastewater Activities

1. Overview of Structure of Governance

Thailand has a strong unitary government structure, with a beloved monarch and royal family as well as an elected government. The country is divided into provinces, of which the Bangkok Metropolitan Administration (BMA) is one. The BMA has a unique level of authority, however. The BMA's Governor is the only elected provincial head, and the Bangkok government has more autonomy than any other province in the nation. Nonetheless, most important local decisions must be approved by the relevant national ministry, and often by the nation's Cabinet itself.

Thailand's system of governance for water and wastewater services is a product of this strong central government system. Numerous national ministries are involved in water use and management, with overlapping -- and often conflicting -- management objectives. Scott Christensen and Areeya Boon-long, researchers at the Thailand Development Resource Institute, describes the confusing institutional framework for water management in Thailand. They write:

> The institutional landscape for water management is littered with some 30 departmental-level agencies under seven different ministries. Two national committees attached to the prime minister's office -- the National Water Resources Committee and the National Rural Development Committee -- are responsible for drafting water guidelines and coordinating these agencies. ....Water management agencies are not legally obligated to inform the others of their activities, and thus the existence of national committees does not guarantee coordination. Another consideration is that some agencies, e.g. the Electricity Generating Authority of Thailand (EGAT), the National Energy Administration (NEA) and the MWA, also consume water free of charge. The lack of effectively defined property rights for

the agencies leads to competing claims and bottlenecks within the government itself.[72]

On the local level in the Bangkok Metropolitan Region, this structure of governance has produced a split between water and wastewater management: the BMA's Department of Drainage and Sewage has responsibility for wastewater, while the Metropolitan Waterworks Authority is responsible for the production and delivery of piped water service with the BMA and the two provinces of Nonthaburi and Samut Prakan. In other provinces in the BMR, as in the rest of the country, the Provincial Waterworks Authority (PWA) is the primary agency responsible for water services, although local governments and municipalities play a significant role. In addition, groundwater use and pricing throughout the region is separately governed by the Department of Mineral Resources. Political and administrative constraints complicate any attempt to restructure Bangkok's water pricing policies.

2. Key Government Institutions Involved in Water and Wastewater Management

The following summarizes the primary government agencies and ministries involved in waster and wastewater management on a national and regional level.

a) National Institutions

<u>(1) Royal Irrigation Department (RID)</u>

The Royal Irrigation Department (RID) is the largest and single most important government agency involved in the development of water resources. Historically, RID's

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72/ Christensen, Scott, and Areeya Boon-long, September, 1993, "Institutional Problems in Water Allocation: Challenges for New Legislation", <u>TDRI Quarterly Review</u>, Vol. 8 No. 3, p. 5.

emphasis was on providing water for irrigation. Thailand has been largely an agricultural nation, and agriculture continues to be an important activity throughout the country. As Thailand has become increasingly industrialized -- and urban -- the Royal Irrigation Department's traditional responsibility of governing irrigation expanded into the construction of hydro-electric facilities, multi-purpose dams, and other water resource development activities serving both rural and urban populations. RID is a major supplier of raw water for water supply systems, and particularly for Bangkok, as authorized by the Royal Irrigation Act of 1942 and amended through 1975.[73]

RID's water pricing policies are a particular concern, as it charges only industrial consumers for raw water. Other customers -- including the MWA and other urban suppliers as well as agricultural users -- do not pay for RID's water, and the RID has little control over the allocation of the water it produces.[74]

(2) Provincial Waterworks Authority (PWA)

Created in 1979, the PWA has grown rapidly to become "...the largest water supply agency outside the Bangkok Metropolitan Region. Approximately 5,000 staff operate 210 water systems with 1989 gross revenue projected at 1.75 Billion Baht (US $70M)."[75] According to a 1990 report on water supply and sewage to the Asian Development Bank and the National Economic and Social Development Board of Thailand, the creation of the PWA has substantially improved water management in Thailand.

> Substantial progress has been made since the organization was created in 1979 and took over 138 water systems previously operated by PWD. Seventy-two

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73/ Associated Engineering, June, 1990, Accelerated Water Supply and Sewerage Program Final Study Report., Volume 1, Report to the Asian Development Bank and the National Economic and Social Development Board of Thailand, Appendix B, p. 7.
74/ Associated Engineering, p. 74.
75/ Associated Engineering, p. 2.

> additional waterworks have since been taken over, the number of connections has increased by 350,000, the operating loss changed to a substantial profit, the number of employees per water connection reduced and improvements have been made in personnel management, finance, accounting, and training.[76]

The PWA has significant constraints on its authority, however. For example, without Cabinet approval the PWA is not allowed to invest in projects costing over 5 million baht, borrow or lend more than that amount, or enter into partnerships. Most importantly, the PWA is prohibited from independently setting the price rates for the water it provides.

(3) Ministry of Industry (MOI) / Department of Mineral Resources (DMR)

Because groundwater is considered a "national resource" responsibility for its management has been given to the Department of Mineral Resources under the Ministry of Industry. The management of groundwater is exercised by DMR's "Groundwater Division" under the national Groundwater Act of 1977, amended in 1985. "The Ministry of Industry issues guidelines for well drilling and digging, charges fees for the use of groundwater, carries out surveys of groundwater and provides technical assistance to other organizations and people, both public and private on the use of groundwater. An important responsibility is the prevention of groundwater contamination."[77] Along with the National Environment Board, the Ministry of Industry sets industrial wastewater standards.

(4) National Environment Board (NEB)

The Improvement and Conservation of National Environmental Quality Act, which was passed in 1975 and amended in 1978 and 1979, established the National Environmental Board (NEB). NEB is primarily a policy-making body which sets standards and guidelines

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76/ Associated Engineering, p. 2.
77/ Associated Engineering, p. 74.

for environmental quality but has no operating authority or enforcement powers. Both the NEB and the Ministry of Industries set wastewater standards for industries, and the NEB requires environmental impact studies for certain industries.[78]

Laws governing industries are considered weak, however.

> The law provides for factories to have waste water treatment plants, and standards for discharging waste water into drains. The law also provides for exemptions, which are determined by the Minister and announced in the Government Gazette. There are extensive provisions regulating industrial plants. Provisions on water pollution are, however, less extensive. Further, the Minister is given wide latitude to issue rules and proclamations which have the force of law. Punishment for violation is light and could not be considered to be a major deterrent to willful violators.[79]

(5) Ministry of Public Health / Department of Health

The agency primarily involved with rural sanitation is the Department of Health (DOH) of the Ministry of Public Health. Through the national Public Health law, the DOH is responsible for establishing standards of water use to protect the public health. Enforcement authority, however, is held by local governments.

> Although the Public Health law is national legislation, actual authority to control and enforce the provisions of the law is vested in local authorities. The DOH [Department of Health] performs the technical functions of establishing standards and providing general oversight to assure the standards are observed. If DOH observes a violation, it is the local authority that must take the action against the violator. There is a fine of 50 Baht for a violation. Despite the comprehensive coverage of the law and its intent to protect the people by assuring a clean and healthy environment in their communities, the law has little value because of the lack of meaningful sanctions against violators (large fine, imprisonment, etc.). The ability of local authorities to provide sufficient, qualified staff to implement and enforce the provisions of the Law must also be questioned.[80]

78/ Associated Engineering, p. 8.
79/ Associated Engineering, p. 9.
80/ Associated Engineering, Appendix B., pp. 6-7.

(6) Public Works Department (PWD)

The national Public Works Department (PWD) has responsibility for the development of both water and drainage systems, and has historically been involved in water resource development as well. The PWD has assumed responsibility for assisting local governments with wastewater management. Municipalities outside of Bangkok can receive technical assistance from the Sanitary Engineering Division (SED) of the PWD. They are ultimately responsible, however, for their own sewerage. The capacity of the PWD is strained to support local governments in providing support to wastewater management projects; in 1990 its engineering planning staff was comprised of merely 29 engineers for the entire country.[81]

b) Regional Institutions

(1) Metropolitan Waterworks Authority (MWA)

As described above, the Metropolitan Waterworks Authority (MWA) is responsible for the production and delivery of piped water service within the BMA and the two neighboring provinces of Nonthaburi and Samut Prakan. A large and sophisticated water management agency, in 1992 the MWA served 740 kilometers of its service area, reaching a total of 1,090,005 customers. This represents service to approximately 75 percent of the potential customers in the region. In response to spiraling demands for water, the Metropolitan Waterworks Authority is undertaking an ambitious expansion program with far-reaching economic and environmental implications. The work of the MWA is discussed in further detail in the next chapters.

81/ Associated Engineering, pp. 6, 58.

(2) Bangkok Metropolitan Administration (BMA) / Department of Drainage and Sewage (DDS)

The Bangkok Metropolitan Administration is one of few local governments specifically responsible by law not only for drainage and flood prevention but for control of wastewater as well. The BMA's Department of Drainage and Sewerage (DDS) is responsible for all of these functions within the BMA boundaries. DDS, created in 1978, is a substantial department of six divisions and with a staff of 2200 civil servants and permanent employees, 990 temporary employees, and 73 engineers.[82]

3. Problems with Existing Governance Structure

a) Overlap in Responsibilities and Insufficient Coordination

The 1990 report by Associated Engineering to the Asian Development Bank and the National Economic and Social Development Board provides an excellent summary of the institutional problems confronting Thailand in managing its increasingly complex needs for water and wastewater service. The key issue is the number of government agencies involved in similar work, without a system which enables these bureacracies to effectively coordinate efforts, distribute responsibilities, or standardize policies. As the report discusses:

> Several agencies provide the same type of water supply services. For example, four agencies drill deep wells; three agencies install piped water systems; even more agencies are involved in assisting in or providing storage tanks and jars, digging shallow wells, and constructing ponds. There is no evidence of attempts to ensure uniformity.[83]

82/ Associated Engineering, p. 64.
83/ Associated Engineering, p. 68.

The report goes on to recommend a consolidation and restructuring of agency responsiblities:

> Several agencies are now involved in providing the same type of [raw water service]. Consideration should be given to having each agency do what it does best. For example, the Department of Mineral Resources (DMR) has the most experience in deep well drilling and the maintenance of handpumps, thus DMR might be the only agency designated to drill deep wells, install and maintain handpumps. Perhaps both DMR and PWD could be designated as the deep well drilling and handpump maintenance organizations. ...Similarly, three agencies, PWA, PWD, and DOH have responsibility for piped water systems. One or perhaps two of the agencies might phase out of this service over time. DOH, for example might concentrate all of its efforts only on sanitation and water quality. PWD with staff in all provinces may be the logical agency to provide technical assistance on operation and maintenance of the small rural project systems.[84]

b) Need for Raw Water Resource Management

The problem of poor coordination becomes even more important when confronting Thailand's increasingly urgent need to develop water resource management policy on a regional and national level. As will be explored further in the next chapters, many analysts are concerned about the growing competition for water which is developing in Thailand among urban and rural uses.

> ...there is a strong consensus that a policy regarding raw water resource development and management is long overdue...there is need for a master plan for raw water resource development over the long term, a program for conservation of resources, and an equitable and enforceable water allocation policy. Present priorities of domestic, irrigation, power, and industry should be established as firm policy and management of raw water sources should include strong and enforceable sanctions on the pollution of water sources. [85]

84/ Associated Engineering, p. 71.
85/ Associated Engineering, p. 74.

The development of such sound policies is hampered by the fragmentation of authority over use and protection of Thailand's waters.

c) Different Water Pricing Policies of Water Management Institutions

As can be seen, the prices set for water consumption vary considerably in Thailand. Price differentials exist not only based upon consumer class, but based as well upon the source of water. These variations in price are not determined, however, according to the costs of supplying that water, but rather represent inconsistent valuing by different government agencies and preferential treatment of various consumer classes. A prime example of this inconsistency on a national level is the pricing of surface water by the Provincial Waterworks Authority, at prices averaging 5 baht per cubic liter, compared to the pricing of ground water, under the jurisdiction of the Department of Mineral Resources, at a price of 1 baht per cubic liter. This substantially lower cost of groundwater acts as an obvious incentive for consumers to tap groundwater supplies -- in direct contradiction to public policies which seek to rapidly reduce groundwater extraction.

It should be noted that PWA pricing policy is based on an increasing block tariff. However, the rate is set at the same level throughout all service areas despite "substantial variations in the average incremental costs of water supply." According to the 1990 report, "the uniform tariff was adopted following considerations of equity, ease of implementation, administration and the overall effect on PWA's financial position."[86]

86/ Associated Engineering, p. 14.

IV. Developing a Pricing System for Wastewater Management in Bangkok

A. The Need for Improved Wastewater Management in Bangkok

1. Levels of Water Pollution

a) Condition of the Chao Phraya River and Bangkok's Klongs

Anyone who rides a long boat down the Chao Phraya or through the klongs cannot miss the fact that Bangkok's waters are grossly polluted. Commuting workers and students cover their faces with handkerchiefs to protect themselves from the murky water splashed up by passing water "taxis"; restaurant and household effluents stream into the water from innumerable outflow pipes along the water's edge. Scientific measures confirm the conclusion reached by the casual observer: by official pollution standards, the condition of the Chao Phraya in its upper regions is classified as slightly below standard and the lower part is extremely degraded. As reported in the Metropolitan Regional Structure Planning Study commissioned by the National Economic and Social Development Board (1993):

> For the lower part of the Chao Phraya river water quality was very low especially the section between Bangkok bridge to Bangkok Harbour which is about 20 kilometers in length. The critical area has been enlarged each year upstream along the Lower Chao Phraya River. Salt water intrusion zone in the river is about 0-160 km from the sea. It was found that the major polluter was the effluent from communities.[87]

The three primary measures of water pollution are the levels of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Total Coliform Bacteria (TCB). Environmental

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87/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #7: Environmental Study, Office of the National Economic and Social Development Board, October, 1993, Bangkok, pp. 7-8.

standards are set for each indicator to gauge the environmental health of waterways. Low DO levels indicate decreased capacity of the water to sustain normal aquatic life.[88] Conversely, high BOD levels indicate the presence of high levels of organic matter which deplete oxygen content.[89] TCB levels are used to measure the degree to which the water is safe for consumption: the higher the TCB level the greater the risk of disease from drinking the bacteria-contaminated water.[90]

Thailand's National Environment Board (NEB) has monitored water quality in the entire Chao Phraya -- a total length of 379 kilometers from the river's mouth -- at 32 survey stations since 1985. NEB has set three grades of water quality standards for the Chao Phraya, based on the section of the river, with the level of pollution that is acceptable increasing as the river flows closer to the Bangkok Metropolitan Area.[91]

88/ As described in Wetzel, Robert G., 1983, Limnology, p. 176, "Dissolved oxygen is essential to the respiratory metabolism of most aquatic organisms. The dynamics of oxygen distribution ...are governed by a balance between inputs from the atmosphere and photosynthesis, and losses due to chemical and biotic oxidations. Oxygen distribution is important for the direct needs of many organisms, and affects the solubility and availability of many nutrients, and therefore the productivity of aquatic ecosystems."

89/ From Wetzel, p. 161: "The loss of oxygen...results primarily from the biological oxidation of organic matter, both in the water and especially at the sediment-water interface, where bacterial decomposition is greater. Although plant and animal respiration can consume large, often catastrophic, amounts of dissolved oxygen, major consumption...is associated with bacterial decomposition of sedimenting organic matter."

90/ Some have argued that separate measurements should be taken as well for the presence of other disease-causing organisms, particularly for enteroviruses. "The traditional indicator of the microbiological safety of drinking water has been the coliform group. The validity of the coliform group as an indicator of the virological safety of drinking water has been questioned based on several characteristics of enteroviruses including: their higher resistance to disaffection; their stability under various environmental conditions; and observations indicating that they are removed less efficiently than coliform by water treatment processes. On the other hand, coliforms...are much more numerous in contaminated waters than are enteroviruses....at present, the coliform groups remains firmly established...as an adequate indicator of the virological safety of drinking water." quoted from The Incidence, Monitoring, and Treatment of Viruses in Water-Supply Systems -- A State of the Art Review, Task Committee on Viruses in Drinking Water of the Committee on Water Supply and Resources Management of the Environmental Engineering Division, American Society of Civil Engineers, 1983, p. 24.

91/ Macro Consultants, p. 22. The lower portion of the Chao Phraya, extending from kilometers 7 to 62, is assigned a standard level of 4; the middle portion (kilometers 62-142) a standard level of 3; and the upper portion (kilometers 142-379) a standard level of 2.

> The NEB monitoring results during 1985-1990 show that there is a yearly declining trend of dissolved oxygen (D.O.) in the Chao Phraya river. D. O. in the lower portion of the Chao Phraya river is now less than the standard limit of level 4 (= 2 mg/l). Most of the time, but especially during the dry season, the D. O. in the lower Chao Phraya declines to less than 1 mg/l.
>
> The NEB monitoring data during 1975 - 1980 indicated BOD concentrations in excess of levels 2 and 4 (1.5 and 4 mg/l) in some stations of the upper and middle Chao Phraya river. The level of total coliform bacteria also has an increasing trend every year.[92]

Table 4.1 details the condition of the Chao Phraya from 1981 to 1990. As these data show, the condition of the Chao Phraya has deteriorated dramatically over the past decade. There has been marked degradation of the Tha Chin River as well: DO levels have been decreasing and BOD levels increasing in the Tha Chin since 1987 due to both higher levels of residential wastes and "...higher polluting loads from aquacultural and agricultural activities along the river."[93]

92/ Macro Consultants, p. 22.
93/ Macro Consultants, p. 23.

Table 4.1
Water Quality of the Lower Chao Phraya River: 1981-1990

	DO (mg/l)*	BOD (mg/l)**	TCB (mg/l)***
Environmental Standard	not less than 2.0	not more than 4.0	no standard
1981	0.5	0.5	92,400
1982	0.3	2.4	164,750
1983	0.4	2.9	4,970
1984	0.4	2.8	221,650
1985	0.2	3.8	243,000
1986	0.4	3.1	355,000
1987	0.4	4.1	171,000
1988	0.9	1.9	242,000
1989	0.3	2.2	705,000
1990	0.5	3.0	1,002,600

* DO = Dissolved Oxygen
** BOD = Biochemical Oxygen Demand
*** TCB = Total Coliform Bacteria
Source: Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #7, pp. 55-56.

The decreased oxygen levels and high BOD content have profound effects on the ecosystems of these rivers. Researchers have documented sharp increases in phytoplankton and sharp decreases in the numbers and diversity of benthos, both key indicators of a river in trouble. The numbers of fish species in the Chao Phraya has dropped dramatically from 127 species identified in 1955 to 18 identified in 1991. In addition, nearly 90 per cent of shrimp production has ceased due to coastal water pollution.[94]

94/ Macro Consultants, pp. 24, 25. The report states: "Monitoring results over the period 1976-1991 reveal that there was a remarkable reduction of benthic organisms, in terms of species, abundance and diversity index, in both the Chao Phraya and Tha Chin rivers. For example, the species of benthic organisms at Bangkok Bridge decreased from 4 to 1 and their numbers from 21,303 to 1,000 organisms per sq. m. During the 1976 - 1991 period, the diversity index changed from 0.11 to zero. Comparing the existing conditions with ten years ago, the diversity of benthic organisms in the downstream reach of the Chao Phraya river (km. 0-82) have decreased from 8-14 species in 1980 to 0-4 species in 1990. The value of the species diversity index has decreased from 0.68 - 1.87 to 0 - 1.457 over the same period. These figures indicate a serious deterioration in quality over the period.... Monitoring of the species of fish in

The condition of the klongs themselves is as disastrous as that of the rivers. The NESDB study summarizes the plight of the klongs:

> Traditionally, these klongs have been used for transportation, water supply, flood drainage and sewerage. However, during the past 20 years, sewerage has been a dominant use. Such use should be discouraged by gradually replacing direct disposal of wastewater by a suitable pretreatment process. Instead, the klongs should be restored to their original elegance and treated as a national heritage.[95]

b) Solid Wastes and Water Pollution

The problems of water pollution are exacerbated by Bangkok's insufficient capacity to manage its solid wastes. Bangkok's garbage is mounting. Cairncross estimates that "In 1987, around a quarter of solid wastes generated in the city [of Bangkok] remained uncollected and were dumped, mostly onto vacant land or in canals and rivers."[96] An official report estimated that in 1992, 5,600 tons per day of solid waste was produced in Bangkok, while only 4,500 - 5,000 tons per day was collected, representing between 80 - 90 per cent of total solid waste. The total amount collected is expected to increase to 9,500 tons per day by the year 2000.[97] The Metropolitan Regional Structure Planning Study summarizes the problems faced by the BMA in managing its solid waste: a) inadequate collection due to lack of equipment and manpower; b) solid waste pollution due to unsanitary treatment and disposal; c) inadequate treatment areas and technology.[98]

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the Chao Phraya river in the years 1955, 1964, 1981, 1989 and 1991 indicate a significant reduction in diversity with 127, 90, 66, 22 and 18 species, respectively, being identified in the years indicated."

95/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #5, Waste Supply and Sewerage, Office of the National Economic and Social Development Board, October, 1993, Bangkok, p. 43.

96/ Cairncross, S., 1990, "Water Supply and the Urban Poor", The Poor Die Young: Housing and Health in Third World Cities, edited by Cairncross, Hardoy, and Satterthwaite, Chapter 5, p. 1.

97/ Suwarnarate, K. and W. Luanratana, 1993, "Waste Management and the Need for Public Participation in Bangkok," in Regional Development Dialogue, Vol. 14., No. 3, Autumn, pp. 67-68.

98/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #7, pp. 12-13.

The problem of uncollected garbage is particularly severe in Bangkok's slums, creating public health hazards for these residents and contributing to environmental problems throughout the city.

> In the absence of any operational system of garbage collection, liquid as well as solid wastes are disposed right through the gaps between floor planks, out of the windows and through the door openings. The accumulating rubbish is an eyesore during the dry season and becomes an even worse nuisance during the rainy season, when stagnant water dissolves chemical substances and accelerates rotting, causing a stench that can become nauseating, at times. Much more dangerous, stagnant water inside an old tire provides the kind of breeding ground for mosquitoes that cause...haemorrhagic fever, which slum dwellers conscientiously try to eradicate through keeping their water storage jars covered.[99]

> Municipal garbage collection services could only be effective, if they had convenient access to the users' houses. The narrow walkways, in many cases resembling wooden bridges raised over swamps, do not allow garbage trucks to get into the slums. The residents thus, have no choice, but to dump the waste into the swamps or to pile it upon any vacant land...[100] The ground beneath [the elevated walkways] is littered with rubbish to such extent that water cannot be drained off and remains stagnant.[101]

c) Drainage and Water Pollution

Because Bangkok is only slightly above sea level and is subject to torrential monsoons, the drainage system for the city is particularly important, and the klongs have been a critical component of this system. Inadequate drainage is a particular problem for lower income communities, which are often built along klongs and in low-lying and swampy areas. A 1986 study described the debilitating effects of poor drainage on the residents of two slums in Bangkok:

99/ Shahand, A., M. A. Tekie, and K. E. Weber, 1986, The Role of Women in Slum Improvement: A Comparative Study of the Squatter Settlements at Klong Toey and Wat Yai Sri Supan in Bangkok, Human Settlements Development Report #10, Division of Human Settlements Development, Asian Institute of Technology, Bangkok, p. 126.
100/ Shahand, et. al., pp. 36-39.
101/ Shahand, et. al., p. 148.

> The presence of large smelly swamps and ponds make for unhealthy conditions that create a favourable environment for insect and rodent breeding. ...Although mosquitoes and other insects are abundant in every part of the city, what is particular about slums is the presence of large numbers and varieties of insects and pests, and the inability of the people to take protective measures against them. Consequently, it is probable that these insects have been causing serious endemic diseases and epidemics.
>
> There are no particular drainage systems in most of the slums of Bangkok. Houses are built over swamps, into which the refuse and wastes are thrown. There are neither sewerage pipes to carry wastes from the houses nor reasonable outlets to which the swamps could be drained off. The wastes, therefore accumulate, and in some places they emit an annoying stench.[102]

The filling of klongs with garbage -- in addition to filling done by public "improvement" projects -- further jeopardizes flood-prone areas in the city. The continuing problems of inadequate solid waste collection and poor drainage represent significant health hazards to slum residents and further exacerbate Bangkok's environmental crisis of water pollution.

d) Effects on Water Supply

The high levels of pollution in the Chao Phraya and klongs affect Bangkok's water supply in three ways. First, the degradation of surface supplies of raw water increase the costs of treatment necessary before the water can be safely consumed. Second, groundwater may be contaminated through the leaching of polluted wastewaters into the aquifers. Finally, the quality of the treated water itself is threatened. Water distribution pipes -- which run along and through the klongs and drainage ditches as well as under ground -- are subject to numerous breaks, leaks, and unauthorized and poorly executed taps. These maintenance problems, compounded by low water pressure, lead not only to the loss of valuable water but as well to the intrusion of polluted water into the public delivery

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102/ Shahand, et. al., pp. 36-39.

system. This jeopardizes the piped water which is provided to all Bangkok residents, and particularly the water supplied to those who live in lower income neighborhoods or at the ends of distribution lines. This problem is not unique to Bangkok, as Cairncross describes:

> One of the reasons for the shortfall in capacity of many a city's water supply is the high rate of leakage from the distribution system. Typically, 30 per cent of the water treated and pumped into the water supply of a tropical town, and commonly as much as 60 per cent, is lost in this way. It may result from incompetent pipe-laying, from exposure of mains pipes due to soil erosion, from construction of houses over mains due to poor physical planning, or from sheer age of the system. Leaky distribution mains present an additional hazard with intermittent supplies or where there are low pressures, as pollution from drains and sewers may enter through the leaks when the pressure drops. ...The leakage is frequently exacerbated by the numerous unauthorized connections to the water mains made by private individuals. They are often improvised out of inappropriate materials such as old motor tyres and wire. They may result from high water charges, from delays and corruption in the allocation of water connections, or from a refusal to provide connections to squatters.[103]

In conclusion, the high levels of pollution in the Chao Phraya and klongs represent a serious problem for the people of Bangkok. The 1990 report on water supply and sewerage in Bangkok has summarized well the negative effects of water pollution:

> A variety of existing and potential environmental impacts from wastewater pollution have been identified. These include:
>
> - Pollution of the ground and surface water resources used to supply community potable water systems.
> - Infiltration of polluted groundwater into water supply distribution pipes.
> - Degradation of irrigation water quality.
> - Loss of fishery resources in receiving waters.
> - Loss of aesthetic values and direct health risks from polluted klongs and other open waters in urban areas.[104]

103/ Cairncross, S., p. 116.
104/ Associated Engineering, p. 9.

2. Sources of Water Pollution

The sources of Bangkok's wastewater are estimated to be 75 per cent residential and commercial and 25 per cent industrial.[105]

a) Domestic Wastes

While the sources of water pollution include chemical wastes from both agriculture and industry, Bangkok's main problem in water degradation is organic waste. As discussed by Phantumvanit and Liengcharernsit:

> Although materials such as heavy metals and pesticides are clearly important as far as water quality is concerned, the main problem in most of Thailand's rivers is the biochemical oxygen demand (BOD) imposed by organic effluents. In terms of water quality, the dissolved oxygen (DO) level is probably the best single indicator of the state of the river's health. The recorded DO levels of the Chao Phraya river have shown depressed sag curves for nearly 20 years, with the area affected showing a tendency to spread. Despite the somewhat higher DO curves recorded for 1979 and 1980, the evidence suggests that DO levels will remain depressed during low flow conditions for the foreseeable future. During high flow conditions, the area of depressed DO levels is shifted downstream.[106]

The main cause of this high BOD level is the discharge of untreated and partially treated sewage and other residential wastes directly into the waterways. Cairncross et. al. report that:

> Only two percent of the population is connected to a sewer system; human wastes are generally disposed of through septic tanks and cess pools and their effluents --

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105/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #7, p. 7.
106/ Phantumvanit, Dhira and Winai Liengcharernsit, 1989, "Coming to Terms with Bangkok's Environmental Problems", Environment and Urbanization, Vol. 1, No. 1, April, p. 33. The term "sag curve" refers to the curve on a graph which documents changes in dissolved oxygen levels in a waterway over time. A "depressed sag curve" indicates that the measured amounts of DO have dipped into negative levels -- indicating anerobic conditions.

> as well as waste water from sinks, laundries, baths and kitchens -- are discharged into stormwater drains or canals.[107]

Most households do have some individual system for sewage disposal. However, the effectiveness of these systems is inadequate, due in part to the geology of the region.

> Over the past decades Bangkok has depended upon the use of onsite individual subsurface leaching systems (usually septic tanks with leaching pits) for disposal of excreta and other sanitary wastes. However, little downward leaching actually takes place because the soils are generally tight clays... and as a result the septic tank effluents find their way to the surface and flow to street gutters, to klongs and then to the Chao Phraya river. In addition solid wastes are commonly thrown into the klongs. Consequently the klongs and the river are very severely polluted during the dry season.... The klongs are often septic (black colored) and filled with water lilies and other vegetation, and the "sanitation environment" along the klongs can only be described as a sanitation "mess," hardly suitable as a community setting.
>
> ...Despite the constraint on leaching, the septic tanks do serve to treat the waste and do generally produce a clear effluent which, while hardly acceptable for exposure to playing children, nevertheless is believed to be considerably less dangerous than the raw sewage. [108]

Sanitary conditions for lower income residents are a particular concern. Some poor households have latrines which consist of concrete septic tanks topped with a concrete frame with a squat platform, and stored water and water scoop for pour flushing.[109] Others rely on unlined pit toilets, wastes from which are likely to leech into surface waters. Still others have no sanitary facilities at all, depositing feces and urine directly into the drainage ditches and klongs.

107/ Cairncross, S., Jorge E. Hardoy, and David Satterthwaite, 1990, "The Urban Context", The Poor Die Young: Housing and Health in Third World Cities, edited by Cairncross, Hardoy, and Satterthwaite, Chapter 1, pp. 1-24, p. 1.
108/ Associated Engineering, June, 1990, Accelerated Water Supply and Sewerage Program Final Study Report., Volume 1, Report to the Asian Development Bank and the National Economic and Social Development Board of Thailand., p. 79.
109/ Shahand, et. al., p. 124.

There are some indications that, despite the increasing residential waste load in the BMA, progress in controlling industrial BOD discharges have helped to stave off even worse water conditions.

> Since the 1960s, there has been concern that these low DO levels would finally result in the formation of anaerobic conditions along extended lengths of the river. In fact, it is likely that anaerobic conditions already occur in the river, after the first major rainfall following the dry season flushes organic deposits into the river from the canals and drains. But the DO records suggest that there may have been a number of competing trends at work. Since the river has not yet become anaerobic for significant periods of time, it might be that the increasing treatment of high BOD industrial effluents has, to some extent, compensated for the growing volumes of untreated sewage discharged by Bangkok's rapidly growing population.[110]

The BMR Wastewater Management Master Plan concurs with the assessment of Bangkok's residential wastewater problem:

> Household wastewater contributes to the major share in Bangkok and its vicinity provinces. Most of the households use the septic tank and leaching pit as their treatment method which is a low treatment efficiency system. The effluent BOD can be reduced at only approximately 30-35 percent of the influent BOD. Moreover, soil characteristics in the BMR area are composed mainly of clay with low permeability value... The groundwater table is typically high, as a result the leaching pit does not work efficiently. It is commonly found that the local residents illegally connect their wastes from the leaching pit to the street drains which causes water pollution. Therefore it is necessary to provide the central wastewater treatment system for the BMR area.[111]

b) Commercial Wastewater

Bangkok's vibrant commercial sector -- with its markets, restaurants, sidewalk food stalls, and massage parlors -- produces a significant amount of organic waste which ends up in

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110/ Phantumvanit and Liengcharernsit, pp. 33-34.
111/ Macro Consultants, p. 27-28.

the city's surface waters. This pollution includes not only wastewaters which are commonly discharged directly into the klongs or the Chao Phraya, but also garbage which is illegally dumped into drainage ditches and klongs. Because of the heavy concentration of organic matter in these wastes, commercial wastewater contributes BOD loads of roughly twice the concentration of residential and industrial wastewater.[112]

c) Industrial Wastewater

While approximately 75 per cent of the Chao Phraya's current pollution is due to non-industrial sources, the incidence of industrial water pollution has been on the rise. Industrial wastes include BOD loading, and also discharges of chemicals and other toxic wastes.

(1) Industrial BOD Discharges

Wattananukit and Kritiporn provide an estimate of current levels of industrial BOD loading, and predict that these levels will grow substantially in the coming years.

> Industrial wastewater in the form of BOD was estimated to be 0.5 million tons per annum in 1991, the equivalent of wastewater generated by an urban population of 27.2 million. About 29.3 percent of the wastewater is generated by sugar-related industries with 17.4 and 19.6 percent being generated by beverage and pulp and paper industries. Under current economic and industrial growth, it is projected that wastewater in BOD form will grow to 0.68 million tons per annum in 1996. This figure would be equivalent to the wastewater generated by an urban population of 35.3 million.[113]

112/ Macro Consultants, Vol. 5, Main Report, Tables 2-9 to 2-13, pp. 2-70 to 2-79.
113/ Wattananukit and Kritiporn, p. 16.

(2) Chemical Wastes

The percentage of hazardous-waste-generating factories in Thailand has increased from 29 percent in 1979 to 58 percent in 1989.[114] The Office of Industrial Services and Wastes Management of the Industrial Works Department (IWD) "has initiated a job hazardous waste treatment programme for handling industrial liquid, sludge, and solid hazardous wastes from all factories situated in and around Bangkok and the eastern seaboard region."[115] Staff of the IWD and the private company managing the treatment facility note that the efforts to date are insufficient:

> ...Due to our licensing procedures and monitoring programs, water pollution problems for industry have been considerably reduced, especially from those discharging wastewater containing significant BOD loads. There are still some small scale backyard family-type industries located amongst commercial or residential areas which do not regularly operate treatment plants, and there is still no municipal sewage treatment facility. As a result, two major rivers, the Chao Phraya and the Thachin are badly polluted with a very low level of dissolved oxygen concentration (DO - 1.0 mg 1^{-1} or less). ...Although the IWD has succeeded in controlling industrial pollutant discharges especially from medium and large-scale factories, the treatment is limited to organic wastewaters and some toxic wastes... In addition, a number of small electroplating factories which are scattered in commercial or residential areas ... [have] solid residues containing toxic wastes [which] are disposed of along with household refuse or without proper disposal facilities. As a result, hazardous pollutants are being accumulated in our environment and are being concentrated in fish and aquatic plants to the extent that these may become dangerous for human consumption.[116]

The Office of the National Environmental Board has identified heavy metal-contaminated wastewater -- principally produced by "about 200 medium and small scale registered

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114/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #7, p. 14.
115/ Lohwongwatana, B., et. al., April, 1990, "Industrial Hazardous Waste Treatment Facilities in Thailand", in Waste Management & Research, Vol. 8, No. 2, p. 129.
116/ Lohwongwatana, B. et. al., p. 130.

electroplating factories scattered around the Bangkok area" -- as one of the major hazardous waste problems in Thailand.[117]

3. Existing Wastewater Treatment Facilities in Bangkok

Standards for water quality of the Chao Phraya River were issued by the National Environment Board in April, 1986. The Seventh National Economic and Social Development Plan (1992-1996) established specific guidelines for environmental pollution control in all sectors. The target for reduced water pollution is to reduce BOD discharges to levels not exceeding 4 mg/l in the lower part of the river. In addition, the National Environmental Quality Act which was announced in March, 1992, attempts to focus on stronger enforcement of pollution controls and penalties.[118]

In addition to on-site septic systems, there are a few treatment facilities currently in operation in the Bangkok Metropolitan Region. As described by the Metropolitan Regional Structure Planning Study:

> The BMA [Bangkok Metropolitan Administration] has a few small plants that cover a small percentage of the total waste load generation... The NHA [National Housing Authority] has installed a number of activated sludge treatment type plants in some new housing projects. Wastewater from factories and plants located in industrial estates usually receive treatment. Many plants outside of the parks, although forbidden by law, continue to discharge their wastewater into public water bodies due to ineffective enforcement. Agricultural farms are also contributing significantly to the untreated wastewater load. Most hospitals install their own treatment plants.[119]

117/ Soponkanaporn, T. and A. Sophonsridsuk, April, 1990, "Commissioning and Operating an Inorganic Waste Treatment Facility in Bangkok", in Waste Management & Research, Vol. 8, No. 2, p. 135.
118/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #7, pp. 20-34.
119/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #5, p. 40.

Phantumvanit and Liengcharernsit describe the current requirements for industrial pollution control, as governed by the Ministry of Industry (MOI):

> All private polluting factories have to install suitable waste-water treatment facilities in order to obtain their annual operating permits from the Industrial Works Department (IWD). Proposed treatment facilities of new factories must be approved by the department prior to the issuance of permits. Waste-water plants must treat effluents to a standard defined by the Ministry of Industry. Some government-owned factories are also in the process of installing treatment facilities. Smaller factories typically do not have their own treatment facilities, due to a lack of space, a lack of funds, or both.[120]

The Ministry of Industry (MOI) has planned four additional hazardous waste treatment centers, two of which were slated to begin operation in 1993. Another site is under investigation. According to the Metropolitan Regional Structure Planning Study, however, "it is expected that the whole capacity of these center[s] is inadequate to dispose all hazardous waste in Thailand. High capacity disposal plant is thus urgently needed."[121] To protect the Chao Phraya river, a restricted zone of 350 square kilometers has been established in the catchment area of the Sam Lae pumping station. New buildings and factories which discharge wastewater exceeding one kilogram of BOD per day are prohibited.[122]

A 1990 TDRI report suggests that industrial water use -- and therefore wastewater treatment requirements -- will be increasing at a faster rate as Thailand's economy continues to grow.

> Water is used for industrial requirements including cooling, processing, cleaning, and waste removal. About 85 percent of the industrial water becomes highly polluted wastewater. The total quantity of water required for industrial use is roughly equal to that for domestic. Industrial users with high levels of water

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120/ Phantumvanit and Liengcharernsit, p. 33.
121/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #7, p. 15.
122/ Metropolitan Regional Structure Planning Study, Interim Report, Sector Study #7, p. 18.

> consumption are the iron and steel, food, and textile industries. Wastewater from industries usually requires special treatment to remove harmful materials such as heavy metals. It is expected that industrial water requirements will grow at a higher rate in the future...because of economic growth, structural change and rapid industrialization. The amount of water used will grow at about the same rate as that of the domestic sector.[123]

The report also warns of the increasing costs of protecting Thailand's water supply from industrial contamination.

> In addition, an increase in the water quantity required for the sectoral uses described above implies increased wastewater generation, and without proper treatment and control, the wastewater could contaminant the buffer stock, making it unsuitable for further use. From an economic point of view, the increase in withdrawal and the necessity to deal with wastewater will increase the costs of treatment at the expense of other benefits such as the environment.[124]

Wattananukit and Kritiporn discuss the changes in the industrial sector which have made it difficult for waste management programs to keep pace with industry. They write:

> ...factors such as the change in industrial structure (shifts from small scale industries generating organic waste to large scale industries with sophisticated production processes and technologies which generate waste that is more difficult to treat), rapid industrial growth at the rate of 10 percent per annum in the past decade, and the cumbersome procedures required to change laws and regulations, have made environmental management less efficient and effective.[125]

The Wastewater Management Master Plan also recognizes the seriousness of the problem of inadequate enforcement capacity:

> Legally, every wastewater-producing industry should provide a treatment system for its wastewaters and the discharged effluent quality should be within the

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123/ Sethaputra, Sacha, Theodore Panayotou, and Vute Wangwacharakul, 1990, Research Report No. 3: Water Shortages: Managing Demand to Expand Supply, presented at the 1990 TDRI Year-End Conference: "Industrializing Thailand Its Impact on the Environment", December 8-9, 1990, p. 5.
124/ Sethaputra and Wangwacharakul, p. 10.
125/ Wattananukit and Kritiporn, p. 15.

standard limits of the Ministry of Industry (MOI). Practically, a lot of industries have avoided operation of their wastewater treatment plants, since the MOI has insufficient resources to pay for effective monitoring and control. Many industries directly discharge their wastewater to canals and rivers without any treatment.[126]

The master plan discussed below recommends specific mitigation guidelines to help manage industrial wastewater. These include construction of a central treatment plan financed by participating industries, limits on the concentration of BOD in effluent which industries are permitted to discharge directly into the public collection system, increasing the monitoring capacity of the Ministry of Industry through more staff and funding, and stricter laws and penalties governing industries which violate wastewater control regulations.[127]

B. The Proposed Master Plan For Wastewater Management

1. Description of the Master Plan

In 1993 a master plan for wastewater management in the Bangkok Metropolitan Region (BMR) was completed for the Pollution Control Department of Thailand's Ministry of Science, Technology and Environment. The report, prepared by Macro Consultants Co., Ltd. in association with the Thailand Institute of Scientific and Technological Research and Environmental Technology Consultants Limited, presents a plan for comprehensive wastewater services throughout the BMA and the five surrounding provinces. While this thesis focuses on the recommended plan for the BMA, the recommendations made for the broader region have important implications for the city of Bangkok itself.

126/ Macro Consultants, pp. 31-33.
127/ Macro Consultants, pp. 31-33.

The master plan lists five objectives for wastewater management in the BMR. They are:

- i. To reduce water pollution loads into the Chao Phraya and Tha Chin rivers so that the water quality in both rivers can be improved to meet the required standards within a suitable period of 10-15 years.
- ii. To control the water quality in both rivers so as to meet the expected quality of every reach to serve the needs of long term water use.
- iii. To reduce water pollution loads discharged to the main canals within the BMR which drain to the Chao Phraya and Tha Chin rivers.
- iv. To allow the long term multipurpose use of the rivers and canals for fisheries, navigation, etc.
- v. To improve the general quality of life, with emphasis on public health, sanitation, environment and aesthetic aspects.[128]

The report candidly acknowledges that it is a significant challenge to develop a feasible plan for the area:

> Production of a Master Plan for the BMR is a complex problem. The study covers a very large area, 76,580 sq. km., in the provinces of Bangkok, Pathum Thani, Nonthaburi, Samut Prakan, Samut Sakhon, and Nakhon Pathom, with a total number of residents up to 8.5 million.
>
> Existing water pollution control measures are minimal in most areas and massive infrastructure development is required throughout the region. The main constraints in defining an appropriate plan capable of implementation in the required time scale are:
>
> - i. The study area is quite large and composed of different development zones requiring different management strategies.
> - ii. Existing uncontrolled land use creates a mix of land uses in the same area, including the existence of non-registered industries.
> - iii. The wastewater problem has been completely ignored for a long time and there is a large quantity of untreated wastewater passing through the storm drains and drainage canal systems.

128/ Macro Consultants, p. 26.

iv. High land values and restricted site locations create difficulties in providing suitable wastewater treatment plants.
v. The invasion of resettlement sites over drainage canal rights of way will cause problems in expanding the system and become another line pollution discharge source.
vi. Some locations in the study are low lying, causing design difficulties for wet season drainage systems.
vii. The differences in income among communities requires a mechanism for the fair allocation of wastewater treatment plant investment.[129]

The BMA already has approved plans for sewage development projects in six areas of the city. The master plan calls for eighteen additional zones of wastewater service to provide service to the entire BMA. These zones were selected based upon several criteria, including the possibility of securing sites for treatment plants, population level, size of treatment area, feasibility of laying the collection system, existing layout of roads and canals, future land use plans, and existing legislative zones.[130] Because of these multiple considerations, the geographic area and volume of wastewater treatment required varies considerably among the twenty-four zones.

Due to Bangkok's extreme density and lack of space for new lines, the collection system recommended for most of the BMA is a system of intercepting sewers, with main interceptors located along the main drainage canals. The report recommends that a separate collection system be installed along main and branch roads in areas which are still under development. The treatment system recommended for all zones in the BMA is an activated sludge system.

129/ Macro Consultants, pp. 26-27.
130/ Macro Consultants, pp. 44-45.

2. Projected Costs

Table 4.2 details the costs and treatment capacity of all twenty-four planned and proposed projects in the BMA.[131] The six projects which have already been approved will have a daily treatment capacity of 1,028,660 cubic meters and serve a total population of 2,048,000. The total capital cost of the six projects is expected to be 18,290 million baht. The eighteen projects proposed by the master plan will have a combined daily treatment capacity of 1,817,430 cubic meters and cost an estimated 21,027.23 million baht to build.[132] Therefore, the total projected costs for full wastewater management in the BMA is estimated to be 39,317.23 million baht.[133]

Incorporated in this aggregate cost, however, are unit construction costs which vary widely depending on the size of facility, technical complexity, and land costs of each project.[134] Costs range from a low of 1.40 baht per cubic meter of capacity to a high of 6.70 baht per cubic meter, with an average construction cost of 2.27 baht per cubic meter.

131/ The proposed costs of facilities in the five other provinces is summarized in Table 4.3 below.

132/ Macro Consultants, pp. 47, 52.

133/ Suggestions have been made that Bangkok's costs of wastewater management could be reduced through demand management programs. See for example Levy and Potter, February, 1994, "Financial Savings in BMA's Wastewater Treatment Plans From Water Conservation Programs," in Strategic Planning for Metropolitan Bangkok, Phase III, Final Report, pp. 72-82.

Likewise, Sethaputra et. al. comment about the importance of water conservation to wastewater management: "The optimization of water supply and demand has substantial implications for the generation of water pollution. The industrial sector, although not the largest polluter, is a major one. The conservation of water not only reduces the cost of supply, but also reduces wastewater generated and, hence, environmental impacts. Except for certain types of manufacturing, wastewater from domestic sources and from many types of industry is discharged freely to public waterways and creates social costs." (p. 59).

This report assumes the cost projections provided by the master plan. However, the pricing and financing recommendations are fully applicable to BMA's wastewater management plan even if project costs change.

134/ The proposed master plan assumes that projects which can be built on land which is owned by a government agency will have zero land costs. If the actual values of land parcels were included in the projected costs of these projects they would be likely to have significantly increased costs. The fact that this cost is not included represents a hidden subsidy by the government agencies involved.

Projected operating and maintenance costs are less variable, ranging from 1.84 to 2.56 baht and with an average of 2.05 baht per cubic meter of capacity. Total costs per cubic meter are higher for the initial six projects than for the proposed projects; the six projects cost an average of 4.97 baht and the proposed projects cost 3.95 baht per cubic meter. The average combined cost of construction and operation and maintenance is 4.32 baht per cubic meter.[135]

[135]/ The following assumptions were used in the master plan for cost estimations. All costs are based on 1992 prices. Capital costs include 20% physical contingency and 10% engineering design and construction supervision. For O&M projections, civil work is projected at 0.5% per year of construction cost; mechanical and electrical is projected at 1.5% per year of M&E cost; electricity charge is assumed at 2.0 baht/kw-h. Administrative overhead for both construction and O&M was assumed to be 20% of costs.

Table 4.2

SUMMARY OF CONSTRUCTION, OPERATION AND MAINTENANCE COSTS FOR BMA'S 6 PLANNED WASTE MANAGEMENT PROJECTS AND 18 PROPOSED WASTE MANAGEMENT ZONES (1992 PRICES)

Waste Management Zone	Waste Quantity (cu.m/d)	Construction Cost Incl. Land cost (million baht)	Unit Constr. Cost (B/cu.m)	Total Unit Constr. Cost Incl. 20% admin*** (B/cu.m)	Operation and Maint. Cost** (MB/yr)	(B/cu.m)	Total O&M Cost Incl. 20% admin*** (B/cu.m)	Total Costs (B/cu.m)
Planned Projects								
1. Sir Phraya	30,000	320.00	1.46	1.75				
2. Ko Ratanakosin	40,000	900.00	3.08	3.70				
3. Yannawa	390,000	3,560.00	1.25	1.50				
4. Nong Khaem - Phasi Charoen	157,360	3,160.00	2.75	3.30				
5. Rat Burana	65,000	2,650.00	5.58	6.70				
6. Turn Key Project, Phase 1	346,300	7,700.00	3.05	3.66				
Subtotal	1,028,660	18,290.00	2.44	2.92		1.71	2.05	4.97
Proposed Projects								
1. *	191,200	1,630.27	1.17	1.40	116.41	1.67	2.00	3.40
2.	41,800	838.11	2.75	3.30	29.72	1.95	2.34	5.63
3.	47,500	666.39	1.92	2.31	28.14	1.62	1.95	4.25
4. *	159,240	1,296.54	1.12	1.34	88.99	1.53	1.84	3.18
5. *	152,400	1,964.56	1.77	2.12	100.02	1.80	2.16	4.28
6. *	91,000	1,085.13	1.63	1.96	62.13	1.87	2.24	4.20
7. *	124,940	1,411.06	1.55	1.86	77.10	1.69	2.03	3.89
8. *	125,400	1,051.64	1.15	1.38	75.19	1.64	1.97	3.35
9. *	87,800	902.84	1.41	1.69	53.53	1.67	2.00	3.69
10.	149,300	1,873.89	1.72	2.06	92.51	1.70	2.04	4.10
11.	73,800	826.22	1.53	1.84	45.89	1.70	2.04	3.88
12.	34,060	370.67	1.49	1.79	21.54	1.73	2.08	3.87
13.	29,600	376.79	1.74	2.09	21.84	2.02	2.43	4.52
14.	173,350	1,875.05	1.48	1.78	105.81	1.67	2.01	3.78
15.	168,740	2,379.32	1.93	2.32	101.68	1.65	1.98	4.30
16.	88,600	1,157.00	1.79	2.15	54.23	1.68	2.01	4.16
17.	49,900	885.17	2.43	2.92	35.60	1.95	2.35	5.26
18.	28,800	436.58	2.08	2.49	22.44	2.13	2.56	5.05
Subtotal	1,817,430	21,027.23	1.58	1.90	1,132.77	1.71	2.05	3.95
Total	2,846,090	39,317.23	1.89	2.27		1.71	2.05	4.32

Source: Table 1, "Summary of Construction, Operation and Maintenance Costs for BMA 18 Waste Management Zones (1992 Prices) p. 52, and table, p. 47, in Bangkok Metropolitan Region Wastewater Management Master Plan, Vol. 4, Executive Summary Macro Consultants Co., Ltd March, 1993.

Notes:

*These projects will be built on government-owned parcels. Land costs are assumed to be zero.

**The O&M cost for the 6 planned projects is estimated to equal the projected average O&M cost of the 18 proposed projects.

***Administrative costs of 20% based upon estimate provided in Master Plan, pp. 51-52.

Some calculated totals vary slightly from totals in the source table due to rounding.

3. Proposed Sources of Financing

The master plan proposes that local governments be fully responsible for the costs of operation and maintenance, and that the capital costs of project development be covered through a cost sharing arrangement between the local and central governments. Depending upon the revenue capacity of each province, it is proposed that the national government finance between 75 and 87 per cent of the land and construction expense through a combination of loans and grants, and that the local governments be responsible for generating the remaining 25 to 13 per cent of the capital cost. A summary of the proposed capital investment shares by central and local governments is provided in Table 4.3 below.

The master plan recommends that the terms of loans from the central government be for twenty years, at a suggested subsidized rate of five per cent. This below-market cost of debt represents an additional contribution from the central government that -- depending on the sources and costs of this capital to the central government -- is likely to be significant. Furthermore, the master plan recommends that the amount of annual loan repayments should not exceed ten per cent of local government income.

For the BMA, the master plan proposes that the central government finance 75.1 per cent of the capital cost of the proposed eighteen projects, and that the BMA assume 24.9 per cent of this investment. This level of local responsibility -- which is higher than that proposed for any of the vicinity provinces -- is based upon the BMA's greater relative revenue capacity. Assuming that the central government also finances 75 per cent of the initial six projects in the BMA, the total shares of the central government and of the BMA would be approximately 29,514 million baht and 9,803 million baht, respectively.

Table 4.3
Capital Investment Shares of Central and Local Government For Wastewater Management Projects

Proposed Capital Investments in BMR

Area / Province	**Total Investment** (million baht)	**Central Government Share** (million baht)	**Central Government Percent**	**Local Government Share** (million baht)	**Local Government Percent**
BMA*	21,027.2	15,796.7	75.1%	5,230.5	24.9%
Pathum Thani	1,472.8	1,279.5	86.9%	193.3	13.1%
Nonthaburi	2,678.6	2,264.2	84.5%	414.4	15.5%
Samut Prakan	1,695.9	1,445.0	85.2%	250.9	14.8%
Samut Sakhon	441.0	332.1	75.3%	108.9	24.7%
Nakhon Pathom	546.0	460.5	84.3%	85.5	15.7%
Total	27,861.5	21,578.0	77.4%	6,283.5	22.6%

Estimated Capital Investment for All BMA Projects

BMA - proposed 18	21,027.23	15,796.70	75.1%	5,230.53	24.9%
BMA - planned 6	18,290.00	13,717.50	75.0%	4,572.50	25.0%
Total	39,317.23	29,514.20	75.1%	9,803.03	24.9%

Source: Bangkok Metropolitan Region Wastewater Management Plan,
Vol. 4, Executive Summary, p. 90, Macro Consultants Co., Ltd. March, 1993.
Notes:
* Costs are for 18 proposed projects only.
Some calculated totals vary slightly from totals in the source table due to rounding.

4. Proposed Fee Structure

A fee structure is proposed in the master plan to apply the "user pays" principle to the costs of operation and maintenance. Allocation of costs is based on the average level of BOD loading by each customer class, and the revenue requirements are based on the projected costs of operation and maintenance in the entire region. The proposed system of wastewater fees would charge residential customers an annual flat fee per household of 995.55 baht. Non-residential customers would be charged a fixed annual charge per unit. The unit basis of these fees for offices, industries, commercial, and retail customers would be square meters of floor area; hospitals would be charged on a per bed basis; and hotels would be charged according to the number of rooms. The master plan's proposed fee structure is shown in Table 4.4.

Table 4.4
Proposed Wastewater Fees By Customer Category

Customer Category	Average BOD Loading (kg/day)	Percent Total BOD Load	Operating Expenses (million baht/yr)	Percent Operating Expenses	Unit	Proposed Fee (baht/unit/year)
Household	251,140	65%	757	65%	household	995.55
Office	1,735	0%	5	0%	sq. metre	0.53
Hospital	3,440	1%	10	1%	bed	549.28
Hotel	5,645	1%	17	1%	room	719.87
Shopping Centre	190	0%	1	0%	sq. metre	1.60
Market	10,170	3%	31	3%	sq. metre	20.48
Restaurant	29,260	8%	88	8%	sq. metre	5169.00
Factory	83,380	22%	251	22%	sq. metre	2.99
Total	384,960	100%	1,160	100%		

Source: Bangkok Metropolitan Region Wastewater Management Plan,
Vol. 4, Executive Summary, p. 90, and Vol. 5 p. 8-42, Macro Consultants Co., Ltd. March, 1993.

C. Discussion of Financial Plan

The financing plan proposed by the master plan is consistent with Thailand's historic approach to infrastructure development, in that the bulk of the capital costs are borne by the national government. The report states that without central government support, local governments would not be able to raise sufficient revenues to develop expensive wastewater treatment systems and asserts that joint responsibility between central and local government is appropriate because "it serves government policies of decentralization and redistribution of wealth".[136] The report suggests that lack of central government support in the past has been the main reason that wastewater systems have not been developed in the region.

> In the past, the central government has not assisted local governments in the Bangkok Metropolitan Region to introduce the function of wastewater management. Only recently, during the study period, some assistance has been given. However, there is still no policy on finance. In order to break this deadlock, the consultants suggest a government subsidy for investment planning and construction. The subsidy should not be 100% and should require a small contribution from each local government, which will instill a sense of financial responsibility into the latter agency. The local government contribution may range from 25% for large authorities, such as the BMA, to 5% in the case of smaller authorities.[137]

The report further notes that independent revenues of local governments in Thailand -- approximately 3 - 4 per cent of the national budget -- are substantially lower than in many other countries, restricting the capacity of local governments to assume more financial responsibility.[138]

Other analysts have observed, however, that a high level of central government subsidy can be counterproductive. As Unkulvasapaul and Seidel note, even a 70:30 per cent cost sharing between central and local governments may be difficult for the national government to sustain, and "...may result in only partial implementation of the investment program...."[139] The combination of below-market interest rates and outright grant support from the central government represents a substantial draw on national revenues, which will ultimately be reflected in higher levels of general taxation. Supporting local projects with national revenues is an appropriate strategy for projects which enhance the public welfare,

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136/ Macro Consultants, p. 93.
137/ Macro Consultants, p. 94.
138/ Macro Consultants, p. 96.
139/ Unkulvasapaul and Seidel, p. 10.

and strong arguments certainly can be made that sanitation infrastructure projects meet this criterion of a public good in many respects. This distribution of public resources spreads the burden of local improvements across a broader tax base, thereby helping to make services more affordable in specific localities and taxing the general public for improvements which may well promote the national economy as well as benefit local citizens.

However, in light of the opportunity costs of central government funds, it is becoming increasingly necessary for local governments to develop more creative mechanisms to shoulder a greater portion of their capital requirements for local infrastructure development in addition to assuming recurrent costs. Furthermore, as Bahl and Linn point out, distortion of investment decisions is likely if the practice of general fund subsidies is commonplace because it does not provide consumers with accurate price signals, and thus encourages excessive consumption. They stress that the use of general fund transfers should only be considered as a last resort, after a pricing system as close as possible to average incremental cost pricing, based on total costs, has been implemented.

Therefore, financial planners should carefully examine the full range of potential revenue sources at the local level. Knowing that local general revenues are limited, a number of project-specific revenue mechanisms can be employed to cover not only operation and maintenance costs but capital expense as well. In addition to volume-based user charges, these mechanisms include development fees, connection fees, and effluent surcharges.

The master plan does not specify the revenue sources for the BMA's proposed capital investment share of 25 per cent, nor does it detail the amount of loan versus grant funds recommended to be provided by the central government or the resultant loan repayment plan. Discussions with BMA officials, however, indicate that the BMA expects to be required to repay the full amount of the central government's investment over time.[140] For the purposes of this thesis, therefore, I assume that the BMA will repay 100 per cent of the projects' capital investment. It should be noted that the assumption of all cash costs, however, still does represent the full costs of the projects; the donation of government-owned land parcels to seven of the projects at no cost is a considerable in-kind subsidy. Regardless of the specific amount of capital costs for which the BMA will become responsible, the following recommendations for a structure of user fees represent an appropriate approach.

One issue which arises in the allocation of capital costs to customers is the fact that the total projected investment cost for the BMA system is an aggregation of costs which vary considerably across zones. One could argue on grounds of economic efficiency that customers living or operating in each zone should bear the costs of service for that area. This would result in large variations in wastewater service fees within the BMA. While theoretically more efficient, I do not recommend such price distinctions for three reasons. First, managing separate billing and collection systems for twenty-four zones would be administratively cumbersome. Secondly, differences in fees could contribute to unintended distortions in the location decisions of firms within a relatively small area. Finally, even though the master plan has recommended a decentralized system of zones for collection and treatment of wastewater, the BMA is obviously a closely integrated service area. Because the treatment system has ben designed to minimize total costs across all zones rather than costs specific to any individual zone, it is logical to distribute equally the costs of all twenty-four systems among all BMA customers.

140/ Meeting of the Bangkok Research Team on January 18, 1994, represented by Paul Levy and the author with Mr. Mana Noppun, Director General, Department of Drainage and Sewerage of the BMA, and other DDS and BMA officials.

D. Discussion of Fee Structure

The fee structure as proposed in the master plan represents a useful attempt to allocate costs to customers according to average level of service among customers classes and to recognize issues of customers' ability and willingness to pay for service. However, there are serious deficiencies with the proposed fee structure. The first concern, as discussed above, is that the revenues generated by fees are intended to cover only operation and maintenance costs. The revenue goals should be revised to include debt payments on at least some portion of capital expense, as negotiated with the central government.

A second major concern with the proposed fee structure is that the allocation of a flat fee per customer based on average service use within each customer class masks wide variations in the level of service which will be consumed by individual customers. Use by households, for example, will vary according to the number of persons in the household and by the type and number of fixtures in the residence. A uniform charge for all households therefore would not equitably allocate costs according to the level of service received. Furthermore, a fixed annual fee for residential customers would pose a particular hardship for lower income residential consumers, who are likely to require lower levels of wastewater service because of their lower average rates of water consumption, and for whom the fixed fee represents a higher percentage of household income compared to households with higher incomes.

Industrial use also will vary considerably based on the type of production, volume of water consumed, and amount and type of discharges produced by the production process. Because industrial facilities of the same size will place vastly different demands on the wastewater treatment system, a flat fee according to square meters of floor area is not an efficient way to allocate costs. Therefore, the proposed fee structure violates the principle of allocative efficiency by charging users based upon their general customer class rather than by the level of service consumed.

There are two ways to address this problem for industrial users. The first method is to develop more specific sub-classes of industries with common production, water use, and wastewater service needs. A more accurate average service charge could be calculated then based on average presumptive use within each subgroup.[141] While this would be an improvement, the development of standardized fees for industrial subgroups -- or for any other customer categories -- still would not provide economic incentives for users to minimize the amount of their discharged effluent. Therefore the second and recommended approach is to institute a volumetric base charge.

1. Volumetric Charges

Because the volume of wastewater produced is a direct function of the amount of water consumed, it is common practice to base volumetric charges for wastewater service on volume of water intake.[142] The master plan assumes that 80 per cent of water consumption is discharged as wastewater.[143] There are four basic options for the BMA in designing a volumetric base charge. These options are:

141/ The standardized proposed rates for hospitals, offices, and hotels are an example of presumptive pricing which is probably relatively equitable, because service needs by institutions in these customer categories are less likely to vary widely than do industrial service needs. Nonetheless, charging by size of facility is less efficient than charging by volume of actual use.

142/ Some jurisdictions do have separate meters to measure sewage discharge directly. I do not recommend this approach for Bangkok at this time because of the additional time and effort required to develop this capacity. If dual metering is considered in the future, a careful cost-benefit analysis should be conducted to determine the net value of such an approach. As discussed in Chapter II, the benefit of metering may vary by customer group.

143/ Macro Consultants, p. 13.

1. *Charge a flat base rate per cubic meter of water for all users based on the total cost of service.* A flat charge for all users is simply calculated, easily understood by customers, and gives the same "price signals" to all users. Because it does not shift costs to higher volume consumers or non-residential customers, however, it may be considered less equitable for residential users, particularly for residents with lower-incomes. A variation on this approach would be to introduce a "lifeline" rate for small volumes of service, after which a flat charge per cubic meter would take effect.

2. *Set the sewerage fee at a fixed percentage of the MWA's charge for water.* Because the MWA has already established different rates for three different customer categories and instituted an increasing block rate structure in each category, this method would allow the DDS to simply apply the same rate assumptions to its own service. The increasing rate structure provides incentives for consumers to use service efficiently, and provides low-cost service for low-volume users. This method also has the advantage of being easily understood by customers.

3. *Charge an increasing base rate for increasing blocks of service consumption.* This method, like the MWA rate structure, would charge a progressively higher rate per cubic meter for higher volumes of service. It would not, however, establish different rates for different customer categories, but charge all users a consistent rate varying only by volume of consumption. This approach would not give preference to some categories of customers over others, but it would retain the advantage of an increasing rate structure in providing incentives for conservation and ensuring low-cost service for low-volume users.

4. *Charge a flat charge per cubic meter of use, with charges varying by customer class.* This approach would enable the BMA to give preference to some categories of customers, while maintaining allocative efficiency among customers in each class.

2. Treatment Charges

Any selected system of volumetric charges can be used to meet all or a portion of the total revenue goal. It can be argued, however, that charging 100 per cent of costs on a volumetric basis is not an efficient allocation of costs among customers because some customers will place greater burdens on the system due to the higher costs of treating the effluent they produce. To appropriately assign these costs, I recommend that a surcharge be applied which reflects customers' rates of BOD loading and their rates and types of chemical pollutant discharges.

Table 4.5 and Chart 4.5 summarize the projected amounts of BOD loading by residential, industrial, and commercial customers from 1990 to 2020. According to data in the master plan, BOD loading from residential users is expected to be about 65 per cent of the total BOD load, while the volume of wastewater from residential users will be about 70 per cent of total volume. Industrial users will contribute about 22 per cent of the total BOD load, and be the source of roughly the same percentage of total volume of wastewater. In contrast, the BOD loading of commercial users is projected to be about twice the percentage of their volume discharge: while commercial users represent only 6 to 7 per cent of the total quantity of wastewater, they will contribute about 13 per cent of the BOD load in the BMA.[144]

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[144]/ Macro Consultants, Vol. 5, Main Report, Tables 2-9 to 2-13, pp. 2-70 to 2-79.

Table 4.5

Estimated BOD Loading in BMA, 1990, by Customer Class

Wastewater Volume (cu. m/d)

Customer Class / Year	1990		2000		2010		2020	
Residential	1,109,387	72.2%	1,494,630	70.4%	2,009,140	70.6%	2,660,890	71.8%
Commercial	122,004	7.9%	152,440	7.2%	191,302	6.7%	223,020	6.0%
Industrial	305,120	19.9%	475,980	22.4%	646,850	22.7%	820,770	22.2%
Total	1,536,511	100.0%	2,123,050	100.0%	2,847,292	100.0%	3,704,680	100.0%

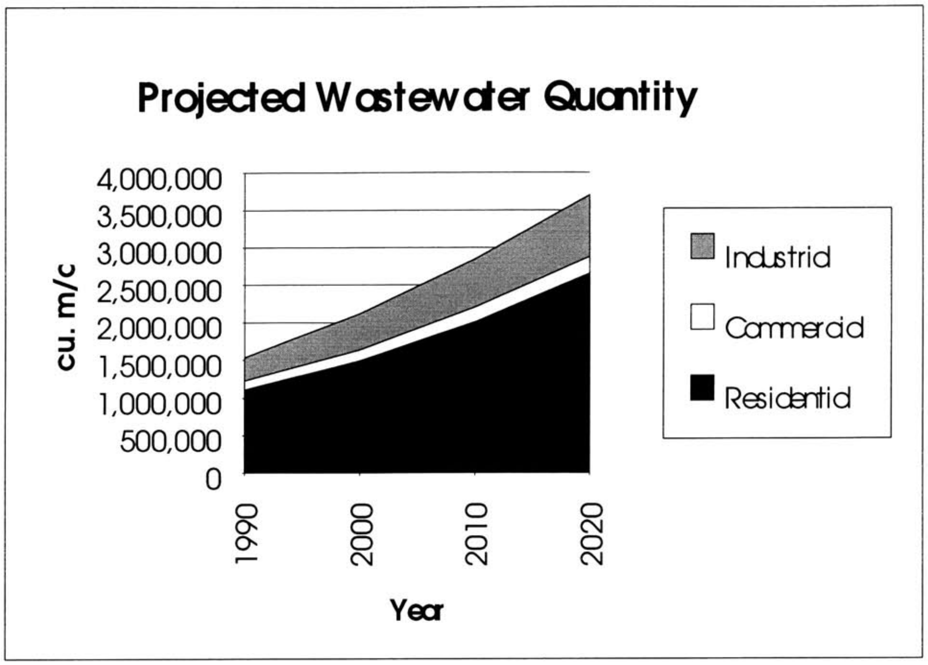
BOD Loading (kg/d)

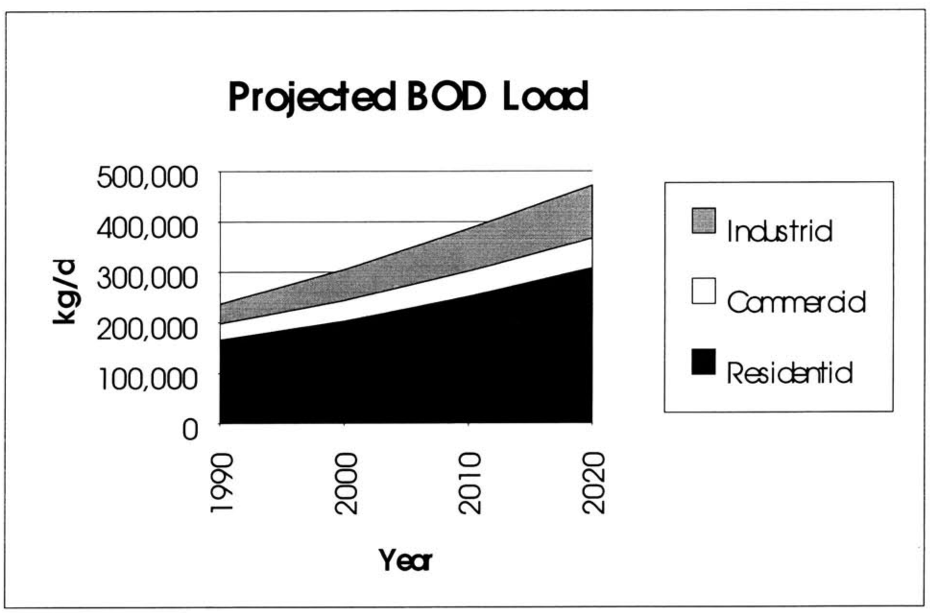
Customer Class / Year	1990		2000		2010		2020	
Residential	166,409	69.9%	203,810	66.7%	251,140	65.2%	307,030	65.1%
Commercial	32,167	13.5%	40,190	13.2%	50,437	13.1%	58,800	12.5%
Industrial	39,330	16.5%	61,360	20.1%	83,380	21.7%	105,790	22.4%
Total	237,906	100.0%	305,360	100.0%	384,957	100.0%	471,620	100.0%

Source: Data drawn from Tables 2-9 to 2-13, Bangkok Metropolitan Region Wastewater Management Master Plan, Vol. 5, Main Report, pp. 2-70 to 2-79, Macro Consultants Co., Ltd., March, 1993.

Chart 4.5

Estimated BOD Loading in BMA, 1990, by Customer Class





Source: Data drawn from Tables 2-9 to 2-13, Bangkok Metropolitan Region Wastewater Management Master Plan, Vol. 5, Main Report, pp. 2-70 to 2-79, Macro Consultants Co., Ltd., March 1993.

It should be noted that, while the aggregate percentage of BOD loading by industrial users is roughly equivalent to their percentage of volume discharged, this calculation, once again, is very likely to mask wide differences among specific industries. Food processing industries, for example, have much higher rates of BOD loading than some other enterprises.[145] Furthermore, in the case of industrial customers, rates of discharge of chemical pollutants in addition to BOD loading needs to be considered.

We can conclude that commercial enterprises and some classes of industries will be responsible for a rate of BOD loading which is greater than their percentage of wastewater volume, while the percentage of BOD loading from residential users will be roughly equivalent to their percentage of total volume. It is appropriate, therefore, to apply a weighted charge to customers to reflect the relative burdens they place on the wastewater treatment system. The fee for these costs of treatment surcharge should also be applied volumetrically, however, because the treatment expenses incurred by each customer increases as the volume of more highly polluted wastewater they discharge increases.

While variations in BOD loading among individual customers within residential and commercial classes are not significant, we expect considerable variation in BOD discharges among industrial customers. Ideally, the discharge of each industrial user would be monitored, and a specific rate based on that facility's levels of BOD loading would be applied. Developing the capacity for this level of monitoring, however, will take time. In the interim, I recommend that sub-classes of industrial users be identified, and that a distinct treatment surcharge rate be calculated for each class. Industries which generate higher levels of BOD loading would be charged more per cubic meter than

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145/ Unkulvasapaul and Seidel, Table 9.2, p. 87. Unkulvasapaul and Seidel document a nationwide projected annual growth rate of 7 per cent between 1991 and 2001 in agriculturally-based industries, producing a BOD load of 1,075,824 -- a BOD load equivalent to that produced by a residential population of 55.5 million.

industries which are less polluting. The specific classes of industries can be determined by the DDS in cooperation with the Ministry of Industry, the Ministry of Science, Technology and Environment, and other relevant government agencies.

Once industrial subgroups have been established, costs can then be distributed among all customer classes. To calculate the specific distribution, the BMA will need to determine the percentages of total costs which are incurred by the treatment of BOD. While these specific data are not available for this report, Table 4.6 provides a model which demonstrates the proposed approach to the allocation of waste management treatment costs. In this table, we assume that of the total average projected cost of 4.32 baht per cubic meter, 40 per cent (1.73 baht) is incurred by BOD treatment, and the remaining 60 per cent (2.59 baht) reflects the general costs of operation.[146] Assuming this cost distribution, the costs of treatment are then distributed among customer classes proportionate to each group's contribution to BOD loading. The rate per cubic meter calculated for each customer class is then applied to the total volume of use by individual customers. As the master plan suggests, volume of use can be calculated at 80 per cent of metered water consumption.

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[146]/ This estimate of percentages of cost is taken from a recent study by the Massachusetts Water Resource Authority (MWRA), which concluded that approximately 40 per cent of its combined capital and operating costs were incurred by BOD treatment. Information from a conversation with Richard Tribiano, Sanitary Engineer, MWRA, on May 5, 1994. For further detail, see Ernst & Young, February, 1994, Sewer Rate Methodology Data Collection Study, Final Report, report to the Massachusetts Water Resources Authority.

Table 4.6
Model for Allocation of Waste Management Treatment Costs*

	% Volume	% BOD Load	Average Costs (Baht/cubic meter) General Costs** 2.59	BOD Treatment** 1.73	Total Charge (per cubic meter) For Each Customer Class
Residential	71.0%	65.0%	2.59	1.58	4.17
Commercial	7.0%	13.0%	2.59	3.21	5.80
Industrial	22.0%	22.0%	2.59	1.73	4.32
Total	100.0%	100.0%			

Notes:
* Actual treatment cost data were not available; cost allocations are for illustrative purposes only.
** Total average costs are given as 4.32 baht/cubic meter. General costs are calculated as those not related to specific treatment. BOD treatment costs are calculated at 40% of total costs. No separate costs for chemical treatment are included.

This proposed method of cost allocation does not include fees for chemical pollutants which are discharged by some industries. Most sewage treatment facilities are not equipped to treat these industrial pollutants and therefore do not incur extra costs due to these chemicals. However, to the extent that toxic substances are retained in the sludge produced by secondary treatment, the waste management facility will have increased costs in sludge disposal. The BMA may therefore choose to also impose a chemical pollutant charge on industrial customers to reflect these expenses. If this is done, the total costs per cubic meter which would be distributed using the above methodology would be accordingly reduced. Industrial waste management is a complex and important issue for Bangkok, however, and further recommendations for control of these pollutants need to be developed.

3. Connection Fees and Development Fees

Two final sources of revenue should be instituted. Connection fees should be charged for all new customers. As with piped water service, connection to the system should be mandatory for all industrial and commercial establishments, and fees should be set to cover the full costs of these connections. Unkulvasapaul and Seidel have recommended that to avoid collection problems, the connection fee could be collected as a surcharge to the routine service bill.[147] Others have suggested that to encourage compliance with the mandatory connection requirement, a deposit for twice the amount of the connection fee be collected at the time a building permit is issued, and the amount of excess payment refunded to the developer when the new facility is actually connected to the wastewater collection system. The effectiveness of such a deposit would of course depend on the relative costs of the fee to the developer.

Secondly, development fees should be levied in areas under development. Fees should be charged for all types of development: residential, industrial, or commercial. These fees should be set according to the capital costs of extending collection networks to newly developed areas. Development fees are one appropriate source for the BMA's local capital investment share of the initial projects construction costs. Once the initial wastewater management plan is complete, revenues generated by these fees should be directly applied to the costs of capacity expansion as the city continues to grow. Development fees are a mechanism to equitably charge the developers who will benefit from improved infrastructure for the costs of this service.

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[147]/ Unkulvasapaul and Seidel, p. 14.

4. Administrative Considerations: Contracting Billing and Collection Services

The approach under consideration by the BMA of contracting with the Metropolitan Waterworks Authority (MWA) for billing and collection services is reasonable. The majority of wastewater customers are already served by the MWA, and the MWA's service can be expected to become more comprehensive during the twenty-year development phase of the full wastewater management system.[148]

Furthermore, the MWA has developed an increasingly efficient system for meter reading, billing, and collections. Administrative innovations which have been implemented by the MWA include the use of hand-held computers for meter reading, an expanded network of locations for water bill payments, including branch offices and the use of banks and ATMs, and the deployment of neighborhood based bill collectors. In 1992, bill collectors collected 60.8 per cent of total payments. The resulting rate of collections is impressive: in 1992 unpaid bills by private users averaged only 0.67 per cent per month, and Government unpaid bills averaged 6.29 per cent per month.[149] Given the logical relationship between wastewater management and water supply services and the fact that an effective collections system is already in place, contracting with the MWA for billing and collections represents an alternative which would be administratively efficient for the BMA as well as convenient for customers.

As is noted in the discussion on groundwater consumption, however, there are a number of industrial users who do not receive piped water service from the MWA. All efforts

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148/ The MWA currently serves about 75 per cent of its potential customer base in its total service area (MWA 1992 Annual Report, p. 17). Although specific data regarding the percentage of customers served in the BMA itself were not available, it is reasonable to assume that piped water service is provided at a higher rate in the BMA than it is to customers in the more distant parts of the service area.
149/ MWA 1992 Annual Report, pp. 45-46.

should be made to connect these customers to the MWA system. For those facilities which are not connected, a separate monitoring and billing system will be required. A flat rate based on a presumptive use schedule is the most feasible approach to user fees in the short term.[150] Billing and collections could be managed by the DDS, or contracted to the MWA as an additional service.

150/ As described in Chapter V, presumptive use rates are determined by establishing customer subclasses with common water use characteristics, and estimating a standard level of water consumption for each group. Customers are then charged based on this presumed level of water use.

E. Summary of Recommendations for a Fee Structure for BMA Wastewater Management Services

1. *Charge a volumetric flat rate fee per cubic meter of use, with charges varying by customer class.*

2. *Establish customer subclasses for industrial users based on levels of BOD loading.*

3. *Calculate rates for each customer class based on general system costs and on the specific costs of BOD treatment.*

4. *Contract with the Metropolitan Waterworks Authority for meter reading, billing, and collections.*

5. *Establish a presumptive pricing system for users not connected to the MWA service.*

6. *Require mandatory connection to the sewerage system.*

7. *Charge a connection fee concurrent with the issuing of each building permit. Calculate costs based on the actual capital and administrative costs of connection.*

8. *Impose development fees for all new development projects. Apply revenues to the capital costs of systems development.*

V. *The Problem of Service Substitution: Reducing Groundwater Consumption in the BMA*

A. Extent and Implications of Groundwater Use

While estimates of the extent of groundwater use vary, experts agree that the high level of groundwater consumption in the BMR is a serious problem. The Bangkok Metropolitan Region Wastewater Management Master Plan, published in 1993, says:

> It is estimated that, in 1990, the total volume of groundwater utilized in the BMR area was approximately 1,732,780 cubic metres per day, of which 84% was consumed by the private sector, the remaining portion being used for public water supply and for government offices.[151]

These figures are roughly consistent with the government data provided by a 1990 TDRI report, which calculates that groundwater consumption in 1987 by licensed private consumers alone in the BMR was 1,137,255 cubic meters per day. About 43 per cent of this amount was consumed within the BMA. The data in Table 5.1 summarizes the official record of private sector groundwater consumption in the BMR from 1978 to 1987.

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[151]/ Macro Consultants, p. 12.

Table 5.1
Private Groundwater Consumption in the BMA and BMR

	BMA		Other BMR Provinces		BMR Total	
	Volume (Cu. m./day)	Percent Change	Volume (Cu. m./day)	Percent Change	Volume (Cu. m./day)	Percent Change
Year						
1978	339,496		342,341		681,837	
1979	363,164	7.0%	363,651	6.2%	726,815	6.6%
1980	418,354	15.2%	409,194	12.5%	827,548	13.9%
1981	465,361	11.2%	443,245	8.3%	908,606	9.8%
1982	495,837	6.5%	500,474	12.9%	996,311	9.7%
1983	522,299	5.3%	529,824	5.9%	1,052,123	5.6%
1984	542,894	3.9%	584,472	10.3%	1,127,366	7.2%
1985	499,566	-8.0%	543,907	-6.9%	1,043,473	-7.4%
1986	476,941	-4.5%	607,223	11.6%	1,084,164	3.9%
1987	485,331	1.8%	651,924	7.4%	1,137,255	4.9%

Source: Adapted from Table 5.3, "Private Groundwater Consumption in the BMR", in Sethaputra et. al.,"Water Shortages: Managing Demand to Expand Supply", 1990, p. 52.
Note: BMR data does not include groundwater consumption in Nakhon Pathom, which was not considered to be at risk of excess groundwater use.

However, the TDRI report concludes that the actual volume of groundwater extracted is much greater than these official figures due to extensive unlicensed consumption.

> According to the Department of Mineral Resources' (DMR) records of registered wells, between 1.2 million cubic meters per day and 1.4 million cubic meters per day of well water are extracted in the BMR by more than 9,000 wells, and more than 80 percent of the total amount is consumed by the private sector, mainly factories and housing estates.... Our estimated amount of nearly 3 million cubic meters per day or more than 1 billion cubic meters per year of industrial use is corroborated by independent estimates of industrial wastewater discharge.... difference in numbers are a result of unreported groundwater pumping.[152]

The problem of *unlicensed* groundwater extraction is therefore a significant part of the overall groundwater problem. Some analysts estimate that unlicensed use may be as much as 50 per cent of licensed usage.[153]

152/ Sethaputra et. al., p. 51.
153/ Phantumvanit, Dhira and Winai Liengcharernsit, April, 1989, "Coming to Terms with Bangkok's Environmental Problems", Environment and Urbanization, Vol. 1, No. 1, p. 32.

The amount of groundwater which can be safely pumped out of aquifers is based on the recharge rate -- the rate at which extracted groundwater is replenished. It is estimated that in 1985 the total figure of 1.29 million cubic meters a day consumed by the MWA and the private sector exceeded the safe extraction rate by over 60 per cent.[154] Over time, the negative effects of excessive groundwater use are dramatic. As the aquifers are depleted, the land subsides, causing increased flooding and structural damage to buildings, roads, and infrastructure. In addition to subsidence, groundwater extraction which exceeds the rate of recharge leads to the infiltration of saline waters -- particularly in areas nearest the coast -- as well as to degradation of the aquifer by other contaminants.

Phantumvanit and Sathirathai report that subsidence is most severe in Bangkok's eastern suburbs, where the highest levels of groundwater usage occur. In this area, subsidence rates of more than ten centimeters a year have been measured.[155] Data provided by the Army Survey Department indicate that subsidence rates vary from place to place, and currently range from 0.6 to 5.1 centimeters per year.[156] A study by the Japan International Cooperation Agency (JICA) released in 1986 projected that a considerable portion of Bangkok would lie below sea level by the year 2000, projecting a total subsidence of one area in downtown Bangkok of about 1.4 meters between 1977 and 2000.[157]

The problem of excessive groundwater use is expected to get worse as the demand for water continues to grow. As seen in Table 5.1, efforts to reduce groundwater

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154/ Phantumvanit, Dhira and Khunying Suthawan Sathirathai, 1988, "Thailand: Degradation and Development in a Resource-Rich Land," Environment, Vol. 30 No., 1, pp. 10-15 and 30-36, pp. 15, 30.
155/ Phantumvanit and Sathirathai, p. 30.
156/ Phantumvanit and Liengcharernsit, p. 32. Data from Thailand Institute of Scientific and Technological Research (1987), "Master Plan of Flood Protection and Drainage System of Eastern Samut Prakan", a report prepared for the Public Works Department, July, 1987.
157/ Japan International Cooperation Agency (JICA), February, 1986, Feasibility Study On Flood Protection / Drainage Project in Eastern Suburban-Bangkok, Main Report, Appendix, Figure 2-3.

consumption were successful in 1985 and 1986, when the per cent of consumption was reduced by 8.0 per cent and 4.5 per cent, respectively. However, consumption levels began to grow again in 1987. The TDRI report concluded:

> In the BMA, Samut Prakan and Nonthaburi, it is estimated that water consumption will increase from 1,072 million cubic meters per year in 1989 to 1,482 million cubic meters in 1992 and 1,860 million cubic meters in 1997, representing a growth rate of 11.6 percent per year during 1989-1992 and 14.6 percent during 1992-1997. The major problem area for water shortage is forecast to be Western Bangkok. It is also expected that this problem will become increasingly serious since this area has been rapidly urbanized and industrialized. At present, groundwater is its major source of supply. It has been estimated that the quantity [of] groundwater pumped up in the BMA is over 1.2 million cubic meters/day, but the quantity permissible without causing land subsidence is said to be 600,000 - 800,000 cubic meters /day. *One should, therefore, aim at reducing groundwater use by 400,000 - 600,000 cubic meters / day.*[158]

While government agencies and the MWA withdraw some groundwater, the burgeoning industrial sector carries the bulk of the responsibility for groundwater use in the BMA. Sethaputra et. al. estimate that piped water to manufacturing industries in the BMR represents less than 1 per cent of their total water consumption.[159] As shown in Table 5.2, the MWA had only 158 industrial customers in 1992, and water sales to these industries represented only 1.5 per cent of the MWA's total sales.[160] Furthermore, it appears that many of the industries that are using groundwater are not doing so because of lack of access to piped supply, but because they prefer private well use.

> The information collected by the MWA on private groundwater well owners shows that for every ten owners of groundwater wells, about nine are located within the MWA distribution system and six are MWA customers (MWA 1987).

158/ Wattananukit and Kritiporn, p. 4. Italics added.
159/ Sethaputra et. al., p. 55.
160/ MWA Annual Report, 1992, p. 20.

This fact indicates the significance of the cost advantage of a groundwater supply over a system water supply.[161]

Table 5.2
MWA Customer Profiles

Customer Category	Number of Customers	% of Total Customers	Volume Water Sale (million cu m)	% Total Sales	Avg Water Consumption (cu m/ connect./month)	Revenues From Water Sale (million baht)	% of Total Revenues	Effective Rate (Baht/cu m)
Residences	810,404	74.3%	405,341	49.2%	42.62	1,895.739	38.3%	4.68
Business	275,736	25.3%	301,329	36.6%	93.6	2,213.051	44.7%	7.34
Governments	4,659	0.4%	101,262	12.3%	1825.33	746.748	15.1%	7.37
Industries	158	0.0%	12,249	1.5%	6550.27	82.824	1.7%	6.76
Retail	38	0.0%	1,577	0.2%	2958.72	7.032	0.1%	4.46
Public service/other			1,631	0.2%	–	0.000	0.0%	0.00
Total	1,090,995	100.0%	823,389	100.0%	64.27	4,945.394	100.0%	6.02

Source: MWA Annual Report 1992, p 20.

There are several reasons underlying the extensive practice by industries in the BMA of drilling their own wells. First, the MWA has not had sufficient capacity to expand its service to new customers fast enough to keep up with the rapid pace of development. Second, despite aggressive MWA efforts, the distribution system still suffers from leaks, breakage, and unauthorized tapping which results in unreliable service and insufficient water pressure, especially in the outlying sections of the distribution network. The MWA's campaign to improve service and reduce unaccounted for water loss is making good progress each year.[162] Nevertheless, industries still opt for private wells as a more secure water source. The most important factor in industries' choice of private wells is the significant difference in the costs of groundwater compared to piped water.

161/ Sethaputra et. al., p. 55.
162/ According to the MWA Annual Report, 1992, unaccounted for water loss (UFW) was reduced to 33.39 per cent in 1992, and the agency's goal was to reduce UFW to 28.5 per cent in 1993.

The price rate for groundwater consumption is set by the national Groundwater Act to be no more than 1 baht per meter, which is to be collected by the Department of Mineral Resources. Costs of drilling and pumping for an industry are estimated at an additional baht per meter, resulting in a combined estimated cost of 2 baht per cubic meter.[163] In contrast, the costs of MWA piped water to an industrial customer in 1992 averaged an effective rate of 6.76 baht per cubic meter.[164]

Water tariffs for MWA customers in 1992 are detailed in Table 5.3. The MWA's tariff structure divides water customers into three groups: residential, business and government, and industrial. The rate structures for all three customer groups have a low rate for low levels of consumption, and rates for residential and business and government customer classes are progressive: the cost per cubic meter increases as the level of consumption increases.

Industrial water rates increase for consumption up to 2,000 cubic meters, ranging from 6.20 baht per cubic meter for consumption between 11-20 cubic meters to a high of 11.18 baht per cubic meter for consumption between 201-2,000 cubic meters. Rates for consumption above 2,000 cubic meters, however, begin to decline. Consumption over 50,001 cubic meters is priced at only 6.50 baht per cubic meter. With the cost of piped water at least three times the cost of well water, the price advantage to an industry of developing a private supply of groundwater is obvious.

163/ Sethaputra, et. al. p. 58.
164/ <u>MWA Annual Report</u>, 1992. p. 20.

Table 5.3
MWA Water Tariffs, 1992*

Category 1: Residence		Category 2: Business State Enterprise Government Agencies & Others		Category 3: Industrial	
Volume (Cu. M.)	Rates (Baht/Cu. M.)	Volume (Cu. M.)	Rates (Baht/Cu. M.)	Volume (Cu. M.)	Rates (Baht/Cu. M.)
0 - 30	4.00 (but not less than 20 Baht)	0 - 10	50 Baht (Package rate)	0 - 10	50 Baht (Package rate)
		11 - 20	6.20	11 - 20	6.20
		21 - 30	6.45	21 - 30	6.45
31 - 40	5.53	31 - 40	8.71	31 - 40	8.71
41 - 50	5.85	41 - 50	9.04	41 - 50	9.04
51 - 60	6.18	51 - 60	9.36	51 - 60	9.36
61 - 70	6.50	61 - 80	9.69	61 - 80	9.69
71 - 80	6.83				
81 - 90	8.00	81 - 100	10.01	81 - 100	10.01
91 - 100	8.32				
101 - 120	8.65	101 - 120	10.34	101 - 120	10.34
121 - 160	8.97	121 - 160	10.66	121 - 160	10.66
161 - 200	9.30	161 - 200	10.99	161 - 200	10.99
Over 201	9.95	Over 201	11.31	201 - 2,000	11.18
				2,001 - 4,000	10.92
				4,001 - 6,000	10.40
				6,001 - 10,000	9.73
				10,001 - 20,000	7.10
				20,001 - 30,000	8.45
				30,001 - 40,000	7.80
				40,001 - 50,000	7.15
				Over 50,001	6.50

Source: MWA Annual Report, 1992, p. 80.
Note: * Tariffs effective October 1, 1992

B. Policies Initiated to Reduce Groundwater Consumption

The problem of groundwater depletion and subsidence has been recognized since the 1950's, and some action has been taken to control groundwater consumption. The Groundwater Act was passed by the national government in 1969 and amended in 1977. This act gives the Department of Mineral Resources (DMR) authority to manage both the quantity and quality of groundwater supplies. An amended Groundwater Act, passed in 1985, mandates that pumping be phased out in the BMR by 1998.[165] As described by a 1990 report to the Asian Development Bank (ADB) and the National Economic and Social Development Board (NESDB):

> The act gives the minister power to set technical standards for drilling, to cancel drilling, to develop rules of conservation, disposal of water into water wells, abandonment of wells, and environmental protection. He can also set the price for water by certain methods, so long as it does not cost more than one Baht per cubic meter. A key provision sets the requirement for the issuing of permits by the Director-General in accordance with prescribed rules and regulations. There are three permits: (1) for groundwater drilling; (2) for the use of groundwater; (3) for the disposal of water into water wells.[166]

Despite these regulatory powers, the effectiveness of DMR in monitoring private well drilling and groundwater extraction has been limited. While the water use of well owners is supposed to be recorded by meters, Sethaputra et. al. note that inadequate staffing at DMR has led to "erratic and inefficient" meter reading and fee collection.[167] This lack of agency capacity means not only that agency revenues are less than they should be, but also that users are further encouraged to ignore all regulations which restrict well drilling or pumping rates.

The Thai government has approved measures to solve the problem of excessive groundwater extraction through increasing the supply of piped water and better regulating the use of aquifers. As summarized by Sethaputra et. al., these measures include:

1. A supply of raw surface water would be available to the MWA and the private sector in the most critical areas by 1986.

165/ Christensen and Boon-long, p. 6.
166/ Associated Engineering, Appendix B., p. 7.
167/ Sethaputra, et. al., pp. 57-58.

2. The support and acceleration of pipe water development would be done... particularly in the critical areas.
3. The MWA's pumping of groundwater in the critical areas would be stopped by 1987.
4. The enforcement of the Ground Water Act (1977) would be supported.
5. The groundwater rates would be adjusted to approximate the pipe water rate.
6. The Urban Master Plan would be improved to fully consider the land subsidence problems.[168]

These objectives, however, have not been fully met. The MWA's own consumption of groundwater has been reduced significantly but it continues to rely on groundwater sources to supplement its surface supply.[169] Droughts experienced in recent years have added an increased sense of urgency to the MWA's extensive plans for supply expansion, which include inter basin water transfers. The MWA's thirty year supply expansion plan (1987-2017) will bring water to the BMR from the Mae Klong River basin via a new canal from the Vajiralongkorn Dam. Several shorter-term measures for supply expansion are also underway, including the construction of new treatment plants and the diversion of raw water supplies from the Tha Chin River.[170]

Despite the MWA's steady progress in expanding its service, the pace of development in the region has exceeded MWA's service capacity, and even those industrial customers with access to MWA service continue to use private wells. As a result, far from seeing a reduction in the rates of groundwater extraction, an increase in groundwater use is projected. Phantumvanit and Liegncharernsit state that:

> According to the DMR, until 1987, groundwater extraction had been controlled to expand at a rate of only 2.3 per cent per year, compared to the maximum allowable 5 per cent per year. Since 1988, however, instead of the targeted 5 per cent per

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168/ Sethaputra et. al., p. 56.
169/ MWA Annual Report, 1992, p. 34.
170/ MWA Annual Report, 1992, pp. 41-42.

year reduction rate, the use of groundwater has conversely increased at a rate of 5 per cent per year.[171]

C. Options to Control Groundwater Consumption More Successfully

There are four general approaches which can be taken to reduce the problem of excess groundwater consumption: 1) expand the supply of surface water provided through the piped network; 2) reduce the levels of water consumption through water conservation programs; 3) improve the enforcement of groundwater use regulations; and 4) introduce economic incentives for desired consumption patterns through a revised pricing program.

1. Expansion of Piped Supply

The expansion of piped water obtained from surface supply sources is the most apparent solution to the problem of groundwater use. However, as discussed above, the soaring demand for water in the BMR has challenged the MWA's ability to eliminate its own reliance on groundwater, let alone replace the groundwater used by its private customers.[172] In 1992, the MWA produced an average of 3.22 million cubic meters per day, and targeted a production level averaging 3.48 million cubic meters per day in 1993 -- an increase in production of 8.1 per cent.[173] However, Sethaputra et. al. estimate that the replacement of all groundwater used in the MWA would require at least an *additional* 4 million cubic meters per day of water. They state:

171/ Phantumvanit and Liengcharernsit, p. 32.
172/ In 1989 "the MWA pumped about 43.8 million cubic meters...or 4.7 per cent of the Authority's total production, from ground wells," according to Christensen and Boon-long, p. 4.
173/ MWA Annual Report, 1992, pp. 6-7.

This demand already exceeds the existing supply capacity of the MWA. Thus, under the present surface water supply conditions, it is unlikely that the MWA can accomplish this task. If new sources of raw water are used, the marginal costs of the supply would continue to increase and make the replacement of groundwater by pipe water even more difficult. ...a complete phasing out of groundwater would increase the cost to the agency [MWA] by about 400,000 baht per day.[174]

...the industrial demand for pipe water is projected to grow at a rate of 5.4 percent over the next decade and to decline to 4.5 percent from 2000 to 2010. The demand for groundwater is likely to be higher than the demand for pipe water because of the increasing spread of the industry into outlying provinces (within the BMR) which are less well-served by the MWA system.[175]

MWA planners have already concluded that water will need to be drawn from other river basins in order to keep up with increasing demand. As the BMR's thirst for water grows, the costs of drawing water from further distances increases, and the metropolitan area's needs come into increasing competition with those of other regions. The supply needs of communities, agriculturists, and industries outside the BMA will have an increasing effect on the MWA's ability to obtain adequate water supplies from the Chao Phraya and Tha Chin Rivers as well as from other basins. In their analysis of infrastructure and pollution control needs in Thailand, Wattananukit and Kritiporn give an overview of water demands in the eastern seaboard and in the provinces surrounding Bangkok, and warn of increasing shortages.

In the Eastern Seaboard area, water demand should be about 575 million cubic meters / year in 1991, 64.7 million cubic meters in 1996 reaching 101.7 million cubic meters in 2001. Comparing these figures with the existing water supply in reservoirs, water supply shortages could emerge in the very near future, especially in Lam Chabang, Mab Ta Pud, Pattaya and Chachoengsao. Manufacturing firms in Chachoengsao, in particular, have recently experienced water shortages mainly because it has a total number of 137 firms needing 5 million cubic meters of water per day but the supply is limited to 1.8 million cubic meters. Groundwater can not

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174/ Sethaputra et. al., pp. 57-58. Projections based on 1987 consumption and costs.
175/ Sethaputra et. al., p. 63.

be used as a substitute because of its salt content. As a consequence, manufacturing firms have to pay high prices for transporting water supply.

The problem of water shortage also is likely to emerge in many core industrial provinces. Samut Prakan, Nakhon Rajchasima, Nakhon Pathom, Pathum Thani, Surat Thani are examples.[176]

Sethaputra and Wangwacharakul estimate that in 2010 the domestic and industrial water requirements in Thailand will be eight times the level of water need in 1990, and that the "buffer" of annually renewable water supply will be less than half its present size.[177] As regional conflicts become increasingly apparent -- both between urban and rural users and between the BMR and the rest of Thailand -- policy makers must ultimately conclude that a localized approach to supply expansion is not likely to be successful. Phantumvanit and Sathirathai observe:

> MWWA is pushing ahead with plans to extend piped-water supplies from surface waters to more areas of the city in order to cut the pressure on groundwater. This will inevitably result in growing competition for water resources, both within and between regions. There is therefore an urgent need for Thailand to adopt a more coordinated approach to water resources management, including a master plan for groundwater exploitation and for interbasin water transfer. The efficiency of water use in various sectors of the economy must also be improved. The concept of water as a free, unlimited resource may no longer be valid.[178]

2. Water Conservation

Given that the approach of providing sufficient supplies of piped water to replace the current rates of groundwater use is not highly feasible, it is appropriate to consider approaches which will reduce the overall requirements for water.[179] Strong arguments

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176/ Wattananukit and Kritiporn, p. 5.
177/ Sethaputra and Wangwacharakul, pp. 7,10.
178/ Phantumvanit and Sathirathai, p. 30.
179/ For a discussion of demand management as it might be applied to Bangkok's water service, see Levy, Hiebert, and Potter, July, 1993, "Improving the Efficiency of the Bangkok Water System Through

have been made that significant reductions in the volume of water used by industries are technically possible. Citing a 1989 study conducted by the Japan International Cooperation Agency (JICA), Sethaputra et. al. state:

> As reported by JICA, there is a great potential for water saving in the five major groups of industries... and the effective use of industrial water, as discussed by JICA (1989), can be achieved by control of water use; use of water recycling; multistaging, or cascading; reclamation of wastewater; application of water-saving apparatus; control of domestic water use; etc.[180]

The results of JICA's study are shown in Table 5.4 below. This data show that considerable savings in industrial water consumption -- averaging 22 per cent of use -- could be achieved through conservation measures, at costs ranging from 1.30 to 10.10 baht per cubic meter depending on the industrial sector. Excluding water reclamation, a more costly conservation technique, water consumption could still be reduced by 10.8 per cent, at a cost per cubic meter of 1.4 baht.

These estimates demonstrate that the cost to most industries of saving a cubic meter of water is currently *less* than the cost of purchasing water from the MWA, but *more* than the cost of groundwater use.[181] Therefore, without some change in the cost of groundwater or some other economic incentive, industries currently using groundwater have little reason to undertake water conservation activities.[182]

Demand Side Management and Repricing", Section I of Concept Plan for Bangkok Metropolitan Development, report prepared by Gakenheimer et. al. for the Bangkok Metropolitan Administration.
180/ Sethaputra, et. al., p. 59.
181/ These costs do not include the savings in sewage fees which would be realized by reduced volumes of wastewater if a volumetric sewage charge is implemented, as recommended in Chapter IV.
182/ Sethaputra et. al., p. 61.

Table 5.4
Estimated Water-saving Rate and Average Cost of Improvement

Type of Industry	Water Consumed (Cu. m/day)	Percent Savings	Per Unit Cost (Baht/cu. m)
Food	7,025	14.9%	3.40
Paper	18,845	31.0%	3.30
Textile	13,632	19.4%	10.10
Metal	8,594	18.8%	1.40
Chemical	4,799	14.8%	1.30
Total	52,895	22.2%	4.70

Source: Table 5.5, Sethaputra et. al., "Water Shortages: Managing Demand to Expand Supply", 1990, p. 61. Data from Japan International Cooperation Agency, 1989.
Note: "This includes water reclamation for certain industries. If water reclamation is excluded, the rate of saving is reduced to 10.8 percent and the cost is 1.4 baht per cubic meter."

3. Improved Monitoring and Regulation

As discussed above, the Groundwater Act empowers the Department of Mineral Resources to regulate the use and quality of groundwater through a system of permits for well drilling, groundwater use, and water disposal, and now requires that pumping be phased out in the BMR by 1998. As demonstrated by the levels of unlicensed groundwater extraction, however, the DMR has been clearly ineffective in enforcing any of the Groundwater Act regulations. Observers believe that the major reason for DMR's ineffectiveness is the lack of budget and staff capacity for adequate monitoring and enforcement.

The problem of insufficient capacity to regulate industries is not unique to the DMR. For example, Wattananukit and Kritiporn note that the Department of Industrial Works (DIW), which is responsible for environmental quality of industries, is also inadequately equipped for this responsibility. In 1989 DIW's budget for monitoring and enforcement of environmental quality was only 1,900 baht per factory, and a total of merely 679 staff was responsible for 51,500 factories (a staff to factories ratio of 1:74).[183]

Support for the DMR's efforts to enforce the existing regulations can be provided by increasing the staff and budget available for inspections and regulations, and by developing stiffer penalties for violations. However, given the reality of insufficient piped supplies and the major role industries in the BMR play in Thailand's economic development, one can assume that the level of political will to aggressively enforce groundwater pumping prohibitions is lukewarm, at best.

4. Pricing Revisions

Most analysts have concluded that changes in the pricing structure for groundwater are necessary to achieve any of the three objectives discussed above. The opinions of Wattananukit and Kritiporn express the general sentiment of water management experts.

> Policies dealing with water shortages should focus on pricing, reflecting the real social cost, especially that of groundwater. The higher price for government water supply results in more groundwater being pumped up, either legally or illegally, which leads to land subsidence causing floods. In addition, a pricing system reflecting the real social cost should encourage better demand management and especially water conservation which has not been given sufficient attention.[184]

Significant improvements have been made in water pricing in Thailand over the past several decades. Both the Provincial Water Authority (PWA) and the MWA have established increasing rate block structures for their water services. While the rate

183/ Wattananukit and Kritiporn, p. 14.
184/ Wattananukit and Kritiporn, p. 5.

structures are progressive, however, the actual rates charged for piped water do not reflect the real costs of that water, and the rates have not been changed often enough to keep pace with the growing costs of providing water service. As Sethaputra et. al. describe the problem:

> Demand management has not been widely used in Thailand, despite the tremendous growth in demand in recent years. From 1958 to 1984, pipe water prices increased only three times. Between 1976 and 1984 the real effective rates of water increased only from 2.6 baht per cubic meter to 3.7 baht per cubic meter. In 1985 water rates were allowed to increase and have been frozen ever since -- in nominal terms. As a result, the real effective rates of water have declined since 1986. This water-pricing policy...reflects the neglect of demand management as a means of meeting water shortages.[185]

While the pricing of piped water does not accurately reflect its true costs, the price structure for piped water is still much better -- from an economic perspective -- than the price structure of groundwater. The recommendation to price groundwater equivalent to piped water, if implemented, would be a vast improvement toward charging for groundwater at economically efficient rates. However, the capacity and political will of government agencies to implement this rate change is questionable.

D. Groundwater Pricing and the Dilemma of Service Substitution

Water planners and fiscal analysts confront a confounding set of issues in developing sound pricing and water management policies for water use in the BMA. The overriding dilemma is that of service substitution: consumers avoid paying the existing higher rates for piped water service because they are able to substitute well water to meet their water

185/ Sethaputra et. al., p. 65.

requirements, which they can obtain at a significantly lower cost. The availability of cheaper groundwater, in turn, inhibits suppliers of piped water from increasing their rates to charge optimal prices for their service. Economists and public policy analysts who have attempted to deal with this problem of service substitution discuss three basic strategies: "second-best" pricing, compulsory connections, and presumptive pricing.

1. Second-Best Pricing

The technique of second-best pricing is to reduce rates to below full-cost as a means of competing with service substitution.[186] In this instance, industrial rates for MWA's piped water service would be reduced to compete with industry's costs for groundwater consumption. For those customers who have the resources to by-pass the system, therefore, prices would be set to ensure their participation in the service system even if the resulting preferential rate given to those customers would be less than the long-run marginal costs of service. The main benefit to this approach is that, given a situation in which the capacity for enforcement is weak, providing economic incentives to industrial customers to stop groundwater consumption may well be more effective than attempting to enforce use restrictions. In addition, as long as short-run marginal costs are covered, the MWA would still receive some contribution to its overhead while effectively expanding its customer base.

The practice of providing preferential rates to larger customers in order to retain their participation is not uncommon among utilities. This pricing approach is problematic for several reasons, however. First, it implies that other customers -- those without the means to by-pass the public system -- will be forced to pay a larger percentage of the agency's

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186/ Bahl and Linn, p. 260.

overhead than they would have under a "fair" cost allocation scheme. Economists might argue that because most of the agency's costs are joint and common costs, any formula selected to allocate these costs is essentially arbitrary, and that all customers still benefit if industries are persuaded to participate in the system and absorb some portion of these costs. Nonetheless, there is likely to be public opposition to special treatment of industrial users. Furthermore, given the large difference between the costs of piped water and groundwater, it is questionable that the MWA could offer large enough price discounts to industries to effectively compete with their current costs of water.

It should be noted that (as seen in Table 5.3) the costs of piped water to industrial users for consumption in excess of 200 cubic meters are already below the prices charged to businesses and government agencies, and that industrial consumption in excess of 6,000 cubic meters is priced at rates lower than the residential high-volume rate. As Sethaputra et. al. observe:

> Industrial water rates are progressive up to the level of 2,000 cubic meters per month and are regressive thereafter. It is not clear whether this price structure reflects (1) an attempt at marginal cost pricing or (2) an incentive to induce large industrial groundwater users to turn to pipe water.... [187]

The alternative to charging other customers a larger portion of overhead expense is to rely on general revenues from the local or central government to compensate for the revenue loss. Because we assume that the capacity of the government to further absorb water infrastructure costs is limited, this option is not desirable.

A further complication with second best pricing is that it is difficult both to determine which customers actually require a discounted rate in order to avoid substitution, and to

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[187]/ Sethaputra et. al., p. 67.

calculate precisely how deep a discount would be required to induce them to connect to the piped system. The use of second best pricing in a public service system is therefore open to political pressure and manipulation on behalf of favored customers.

The largest concern with the use of second best pricing by the MWA, however, is that establishing even lower prices would contradict demand management efforts to promote water conservation through more accurate pricing signals to consumers. As discussed above, the existing tariff schedule -- although progressively set -- already undercuts economic efficiency by setting prices at below full economic costs.

2. Compulsory Use and Connection

A second method, compulsory use and connection, is recommended by both Bahl and Linn[188] and the World Bank.[189] This method takes exactly the opposite approach to second best pricing: Instead of the agency behaving in a competitive way by pricing to meet the market, it acts in an aggressively monopolistic fashion, forcing businesses to connect to the utility system. Obviously, strict monitoring and enforcement procedures would be required to ensure compliance with this requirement, and government agencies have yet to demonstrate the capacity for such enforcement.

The fundamental issue regarding compulsory use is how monitoring agencies can be provided with both the resources and the incentive to effectively enforce the legal regulations. The DMR's capacity to monitor industrial consumption could be improved if the rates charged for groundwater use were increased significantly and the revenues

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188/ Bahl and Linn, p. 256.
189/ Unkulvasapaul and Seidel, p. 67.

generated by this increase were applied to the agency's costs of adequate enforcement. The DMR should also be allowed to significantly increase penalties for violations.

Sufficient agency revenues to build adequate staff and technical systems would be an important start in developing improved enforcement. However, a larger budget alone will not necessary result in more rigorous monitoring. Increased revenues will need to be complemented by management changes which reward staff for aggressive enforcement of groundwater use regulations. Management incentives could include financial bonuses or promotions for staff with high success rates of violation detection and enforcement. Performance might also be improved through frequent rotations of staff to different geographic areas to reduce corruption and uneven enforcement.

In addition to these internal management reforms, enforcement activities should include a high-visibility public education campaign which discusses the crisis of excess groundwater use and publicizes both industrial violations and "good citizen" industries who transfer their water consumption to piped service and implement water conservation practices. Close cooperation among the BMA, MWA, PWA, and DMR will be necessary for such a campaign to be effective.

Finally, as noted above, some industries do not have access to piped service. Therefore, if compulsory use is to be aggressively enforced, policies also need to be implemented for groundwater users who cannot yet connect to MWA's distribution network and therefore are not able to comply with compulsory use regulations. Existing industries should be allowed to apply for a temporary waiver from the compulsory connection requirements. However, these industries ideally should be charged for their groundwater use at the same rates as for piped service, and their waiver should expire as soon as piped service is available. The costs of meter reading and inspections for these facilities should be covered through pumping permit fees. In addition, a system of development fees should be established for new industries and businesses throughout the service area to underwrite the costs of expanding the distribution network into unserved areas. These two mechanisms will help to forestall a tendency of developers to construct new factories, industrial complexes, or residential or commercial estates in areas which are currently unserved by the MWA distribution system, while providing the MWA with the capital funds it needs for infrastructure construction.

3. Presumptive Use Rates

Sethaputra et. al.'s TDRI report suggests an additional approach, recommending that "presumptive use rates" for industry be established based on the type of industry and level of production. In this system, industries would be charged for their estimated level of water use, whether or not they were connected to the piped water system. Charging industries for their presumed level of consumption discourages the use of groundwater because the cost of pumping groundwater -- up to the volume of water for which the industry is charged -- becomes an additional expense for the industry. In this way, the economic incentive for groundwater extraction is eliminated.[190]

The main benefit of the use of presumptive use rates is that -- for an institutional system with limited monitoring capacity -- it avoids the necessity of individually metering and inspecting each facility. Instead, industrial users are grouped into customer subclasses according to type and volume of production activity, and billed according to the average estimated level of water consumed by that type of facility.[191] This approach to water charges can also be used for other customer classes if adequate individual metering and

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190/ Sethaputra, et. al., p. 82.

191/ The application of presumptive use rates to sewerage fees is discussed in Chapter IV.

billing capacity is not developed. Obviously, the effectiveness of presumptive use rates depends upon the accuracy of the estimated amount of water use.

There are two major disadvantages to the reliance on a system of presumptive rates. First, because industries are billed according to their estimated water use, there is no economic incentive for industries to reduce their water consumption below the standard set for their customer subclass. This means that efforts to encourage water conservation, and thereby reduce the demand on the entire system, would be undercut. One mechanism to deal with this problem might be to allow customers a "conservation rebate" if they could document water consumption below the presumed level. Ensuring the validity of rebate applications, however, would itself require a certain level of monitoring and inspection capacity.

The second problem relates to the potential of gaining cabinet approval for this fee system. Like the compulsory connection method discussed above, charging by presumptive use relies on the statutory power of the government to avoid competition by charging for a service, whether or not that service is actually provided to the user. It is likely that most businesses would oppose a fee system which mandated costs regardless of true level of consumption. The political feasibility of establishing a presumptive use rate system, therefore, is in doubt.

E. The Role of the BMA

Most of the policy options discussed above would require action by the MWA or the DMR; some would also require changes in national legislation. While the BMA bears most of the burden of excessive groundwater use -- due to the costs of flooding and structural damage -- it has little independent authority to control this problem. It is important, therefore, that the BMA coordinate its efforts with the MWA and DMR to implement changes in pricing and monitoring groundwater use. In addition, there are some specific areas in which the BMA could take independent action.

I recommend that the BMA develop an inspection unit within the BMA to inspect industrial users for groundwater violations. If possible, the approval of annual operating permits should be linked to compliance with groundwater restrictions and compulsory connection to piped service. In addition, the issuance of building permits should be linked to BMA approval of the water service plan for the proposed development. Fees for annual inspections should be set high enough to cover the full administrative costs of these inspections.

In the previous chapter, I discussed the use of presumptive pricing for industrial sewerage fees. If this approach is used, the classification and billing of industries for both water and sewage use could be combined under the supervision of the BMA's Department of Drainage and Sewage.

F. Summary of Recommendations To Reduce Groundwater Consumption in the BMA

1. *Remove rate-setting restrictions on MWA, PWA, and DMR.*

2. *Through an inter-agency rate-setting committee, establish equivalent rates for surface and groundwater consumption, calculated according to average incremental costs. Review and revise rates annually.*

3. *Aggressively enforce groundwater use restrictions. Establish penalties at levels which will be significant deterrents to illegal use. Implement management incentives within DMR to reward aggressive enforcement.*

4. *Develop a high-visibility public relations campaign to publicize industrial users who are in and out of compliance.*

5. *Develop an inspection unit within BMA to independently inspect industrial users for groundwater violations. Link building permits and annual operating permits to compliance with groundwater restrictions and connection to piped service. Charge inspection fees adequate to cover full administrative costs.*

6. *On an interim basis (until full metering and enforcement capability is developed), institute presumptive pricing for industrial users, establishing industrial subclasses with common water consumption practices. Coordinate classification and billing of both water and sewage services.*

VI. Conclusions

Major urban centers throughout the world are confronted by the challenge of providing adequate water and wastewater service to expanding populations within the context of inadequate financial resources, increasing difficulty and expense of obtaining new supplies, and growing awareness of environmental concerns. Establishing a rationalized pricing system has been strongly advocated by economists and some water resource managers as a key strategy of demand side management which can both promote more efficient consumption, and generate adequate revenues to pay for the capital and operational costs of services. In this thesis I have explored two problems of water and wastewater pricing which currently confront the metropolitan area of Bangkok, Thailand: the need to create a pricing system for wastewater services, and the problem of excessive groundwater use.

A Pricing System for Wastewater Services

The Bangkok Metropolitan Administration (BMA) is now working to solve the city's tremendous problem of water pollution through the development of a comprehensive wastewater treatment system. A sound financing and pricing plan will be necessary to support both the construction of this system -- which is projected to cost over 39,317 million baht -- and the effective operation and maintenance of the 24 facilities. The financing plan should be designed such that the system is not overly reliant on grants or transfers from the national government. The rate structure should encourage efficient use of wastewater services, be administratively feasible, and provide sufficient revenues to support the wastewater management system.

Based on these criteria, I have made the following recommendations for a fee structure for BMA wastewater management services.

1. *Charge a volumetric flat rate fee per cubic meter of use, with charges varying by customer class.*

2. *Establish customer subclasses for industrial users based on levels of BOD loading.*

3. *Calculate rates for each customer class based on general system costs and on the specific costs of BOD treatment.*

4. *Contract with the Metropolitan Waterworks Authority for meter reading, billing, and collections.*

5. *Establish a presumptive pricing system for users not connected to the MWA service.*

6. *Require mandatory connection to the sewerage system.*

7. *Charge a connection fee concurrent with the issuing of each building permit. Calculate costs based on the actual capital and administrative costs of connection.*

8. *Impose development fees for all new development projects. Apply revenues to the capital costs of systems development.*

The implementation of these pricing recommendations would enable the proposed wastewater management system to be financially secure. At the same time the recommended rate structure would appropriately allocate the costs of service among customers according to their volume of use and the relative burden they place on the treatment system. By giving accurate price signals to customers, they would be encouraged to use both water and wastewater services efficiently.

Reducing Groundwater Consumption

The problem of excessive groundwater consumption is so severe that it is causing land subsidence, structural damage, and flooding in the greater Bangkok area. Government attempts to reduce groundwater consumption, particularly by industrial users, have been stymied by limited institutional capacity for enforcement, insufficient piped water supplies, and a rate structure for groundwater which provides strong economic incentives to developers to drill private wells rather than purchase more expensive piped water. This complex situation demonstrates the serious environmental problems which can be produced through unwise pricing policies, and the need to consider institutional and political realities when attempting to develop effective policies to better control water consumption practices.

I recommend the following strategies to reduce groundwater consumption in the BMA.

1. *Remove rate-setting restrictions on MWA, PWA, and DMR.*

2. *Through an inter-agency rate-setting committee, establish equivalent rates for surface and groundwater consumption, calculated according to average incremental costs. Review and revise rates annually.*

3. *Aggressively enforce groundwater use restrictions. Establish penalties at levels which will be significant deterrents to illegal use. Implement management incentives within DMR to reward aggressive enforcement.*

4. *Develop a high-visibility public relations campaign to publicize industrial users who are in and out of compliance.*

5. *Develop an inspection unit within BMA to independently inspect industrial users for groundwater violations. Link building permits and annual operating permits to compliance with groundwater restrictions and connection to piped service. Charge inspection fees adequate to cover full administrative costs.*

6. *On an interim basis (until full metering and enforcement capability is developed), institute presumptive pricing for industrial users, establishing industrial subclasses with common water consumption practices. Coordinate classification and billing of both water and sewage services.*

By implementing the above recommendations related to pricing, Thai government agencies involved in water management would address the distortions in water pricing policies which have undermined efforts to control groundwater use. Expanded enforcement capacity and an aggressive public education campaign would -- albeit gradually -- help to change the dominant attitude of indifference to legal restrictions. Together, these strategies would help to significantly reduce the damage of flooding, water contamination, and land subsidence currently being caused by excessive groundwater use in the Bangkok region.

In this thesis, I have discussed two specific issues of water and wastewater pricing as they affect both the use and quality of water in metropolitan Bangkok. These examples demonstrate the complexity of public service financing in Thailand, and point to larger issues of water resource management looming in Thailand's future. As the country begins to focus more on the problems of managing and protecting its raw water supplies -- and the watersheds which produce them -- strategies which combine effective pricing policies with improved enforcement and institutional capacity-building will become increasingly important.

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