The Potential for Demand Side Management in Water and Wastewater Infrastructure Planning: A Case Study from Argentina

by

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ABSTRACT

This document contains an evaluation of the potential for including water demand side management (DSM) techniques in water and wastewater master planning. Analytical, structural/operational and social/economic DSM techniques are overviewed and considered for analysis relative to the case study area--the La Plata System of the Buenos Aires Water and Sewer Master Plan. A review of information about the case study area including geography, socio-economic factors, and existing water and wastewater facilities provides the context in which DSM measures are selected for further analysis. Measures were selected according to: contribution to understanding and control of water demand; contribution to good operation and maintenance of public utilities; cost; ease of implementation; long-term effectiveness; availability; and public acceptability. The most promising DSM methods are subjected to quantitative and qualitative analyses to develop a recommended program for the case study area.

The analysis concludes that the case study area is in a good position to engage DSM measures as part of master plan implementation. The case study area's abundant water supply, current lack of emphasis on prudent water use, and plans for widespread expansion of water and sewer service areas permit concentration on cost-effective measures that contribute to good management practice and produce significant demand reductions. The following DSM measures are recommended for the case study area: water and wastewater system audits and surveys; installation of water saving devices, and building/plumbing/manufacturing code changes. The analysis also concludes that infiltration/inflow detection and repair, leak detection and repair, use restrictions and comprehensive metering are likely to be beneficial practices in the case study area. Implementation of the recommended DSM measures will require special attention to developing support for the program both within the infrastructure provider's organization and among its customers.

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Title: Adjunct Professor of Urban Studies and Planning

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1. Introduction

1.1 OPENING REMARKS

Please allow me to introduce you to some of my new friends. Photo 1-1 shows me with several young residents of La Plata, Argentina. When I met them, they were playing and riding bikes through the narrow alleyway separating their houses.

Photo 1-1. "Uno, dos, tres...queso!" The author with friends in the neighborhood between 19th and 527th streets, La Plata. Photo by Lic. Adriana Pascual.

Through conversations with the children and their parents, my colleagues from the National University of La Plata and I learned that their densely populated neighborhood had running water service, but that the tiny solids-clogged ditch running through the alleyway was its only means of disposal for liquid wastes. As if to emphasize the immediacy of the area's level of sanitary risk, a neighbor emerged from her house shortly thereafter to dump her washbasin into the ditch with a splash.

The situation in this neighborhood is not unique among the world's developing areas. According to the World Bank, about 1.7 billion people worldwide do not have adequate sanitation service.[1] While my new friends are served by La Plata's public water distribution system, about one Billion other people worldwide have no access to clean water.[2] Providing adequate potable water and sanitation services to the billions of people in need of them poses an enormous task for planners, engineers, and managers in the years to come.

The Convention on the Rights of the Child, adopted by the General Assembly of the United Nations on November 20, 1989 states,

> Bearing in mind that the peoples of the United Nations have, in the Charter, reaffirmed their faith in fundamental human rights and in the dignity and worth of the human person, and have determined to promote social progress and better standards of life in larger freedom...
>
> States Parties recognize the right of the child to the enjoyment of the highest attainable standard of health... and, in particular, shall take appropriate measures:...To combat disease and malnutrition including within the framework of primary health care, through inter alia the application of readily available technology and through the provision of adequate nutritious foods and *clean drinking water, taking into consideration the dangers and risks of environmental pollution.*

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[1] World Bank (1994, p.82)
[2] World Bank (1994, p.82), emphasis added.

The provision of water and wastewater infrastructure is of prime importance in the effort to foster a healthy environment for the offspring of Earth, young and old. Clean water and adequate wastewater disposal help to protect health by reducing the most widespread contaminant of water: disease-bearing human wastes, and by allowing for water use permitting good hygiene.[3]

The priority position of water and wastewater infrastructure in the context of assuring human health is evident in the institutional structure commonly employed for providing it. Planning, construction and management of water and wastewater infrastructure is typically viewed as one of the duties of public entities such as town, regional or national government. The size of these entities varies greatly, from the small village collective that digs and maintains a local well to the regional water authority that develops water supply sources serving the needs of millions.

This thesis focuses on the activities of water and wastewater provision entities at the largest end of the scale, regional water and sewer authorities, and in particular, on the process of planning for infrastructure provision. During the formulation of infrastructure master plans, planners make decisions which affect the long-term effectiveness of water distribution and wastewater collection system projects. This document discusses the research I conducted regarding demand side management--one way in which the process of master planning for water and sewer infrastructure might be improved--using the La Plata System (a portion of the area covered by the Buenos Aires Water and Sewer Master Plan) as a case study.

The following sections of this introduction describe the master planning context in which my research takes place, discuss the way that I propose to modify that context, and provide an overview of the remainder of this document.

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[3] World Bank (1994, p.82)

1.2 MASTER PLANNING FOR WATER AND WASTEWATER INFRASTRUCTURE

Master plans provide a framework to guide the implementation of water and wastewater provision activities in an area over time. The temporal and geographic boundaries associated with master plans are typically large. Master planning time frames range from 5-30 years, with long-term plans commonly covering a 25 year planning period. Long-range plans, once made, are then supplemented over the course of their implementation with additional short-term and strategic planning.[4] Geographic boundaries for master plans typically encompass a municipality at a minimum and may cover areas including several counties.

Master planning for water and wastewater infrastructure uses a generalized process similar to that used for master planning in other sectors. The process, initiated because of a perceived need for planning, begins with a determination of goals and objectives. The planners then develop base studies to describe the current conditions in the planning area and to provide an assessment of the conditions in the future. Engineers develop a number of alternatives to meet the objectives. Involved parties select the most effective alternatives for more detailed development. The appropriate legislative body adopts the plan and finalized designs are implemented through public and private involvement.[5]

Figure 1-1 illustrate the master planning process used by the planners at the Faculdad de Ingeniaría, Universidad Nacíonal de La Plata (Engineering Faculty, National University of La Plata--hereafter referred to as UNLP) in developing a water and sewer master plan for the greater

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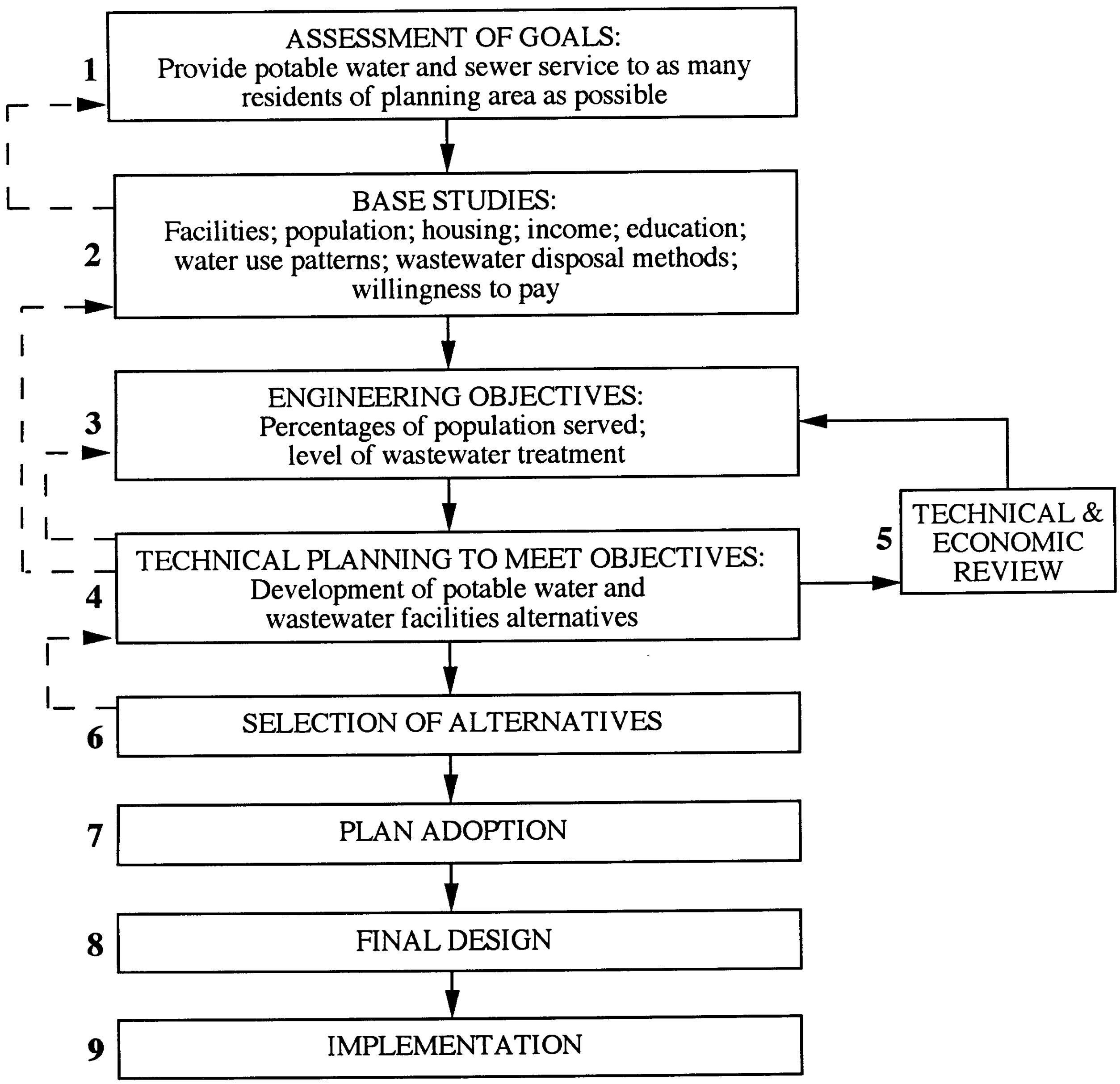
[4] Lexington-Fayette County, (1980)
[5] Lexington-Fayette County, (1980)

Figure 1-1
Water and Wastewater Master Planning Process



Source: Adapted from Lexington-Fayette County (1980) and Kuiper (1971, p. 19)

Buenos Aires metropolitan area. (See Chapter 2 for a description of the case study.) The process may be somewhat iterative, as the dashed lines in the figure illustrate. For example, technical planning (Box 4 on Figure 1-1) may indicate that additional base studies are required. The process of selecting alternatives may similarly bring issues to light that require further technical refinement.

My analysis concerns the steps undertaken in Box 2, base studies, and how they affect the ensuing development of engineering objectives and the formulation of technical plans. Specifically, this analysis examines the potential for reevaluating the demand projections made by the planners at UNLP and how such a reevaluation might affect the technical alternatives proposed by the engineers.

1.3 THE POTENTIAL FOR REFINEMENT OF THE MASTER PLANNING METHODOLOGY

My initial exposure to the Plan Director de Agua y Saneamiento (Buenos Aires Water and Sewer Master Plan, hereafter referred to as The Plan) came when I participated in the technical and economic review of The Plan conducted in May, 1995. The review concluded that the technical development was consistent with The Plan's goals and objectives, but that additional attention to financial and institutional structures was needed. During the review, the base studies and their ensuing use caught my interest, and I suggested the potential for the inclusion of conservation as a long-term demand side management (DSM) measures.

DSM is a set of water system practices such as water auditing, leak detection and repair, installation of water saving devices, pricing schemes and education. The basic objective of using DSM is to control and/or reduce the amount of drinking water consumed in a water distribution system. DSM measures are usually employed in situations of water scarcity, such as a during drought or during period of urban growth, in which demand may exceed developed water supply.[6] The broader objectives of using DSM may be to reduce the need to develop water supply, decrease the need for new infrastructure (both water and sanitation), reduce treatment and discharge flows and increase public awareness of water and sanitation issues. The possibility of accomplishing these broader objectives points to the potential for applying DSM in a non-scarcity context. The Buenos Aires master planning area, with its abundant water supply, provides the context for this analysis.

The consideration of DSM in the planning methodology may have the affect of making demand projections less absolute, providing for technical flexibility in meeting the demands. That is, DSM measures may reduce demands over the planning period, which could have technical planning ramifications. Reduced demands may allow engineers to plan for smaller water and wastewater facilities --treatment plants, pumping stations and piping--by reducing required delivery and collection flow volumes. Reductions in delivered potable water volumes produce corresponding reductions in operation, maintenance, and administration requirements of both water and wastewater utilities over the planning period as well. The inclusion of DSM measures may also have economic benefits. The potential for cost saving due to reduced facility and operation requirements may ease the burden of financing the projects proposed by the master plan, or may allow for the savings to be applied to extending service areas beyond those proposed currently.

1.4 OVERVIEW OF THE REMAINING CHAPTERS

The remaining chapters of this document provide a description of my analysis and conclusions regarding the potential for including DSM in the Buenos Aires master planning methodology. Chapter 2 is an overview of the DSM measures that I considered for inclusion in my analysis. The

[6] Frederick (1993, p. 22)

measures fall into three categories: analytical; structural/operational; and social/economic. Chapter 3 contains a general description of the Plan area and a more specific description of the case study--The La Plata System--including descriptions of geography, socio-economic factors, and water and wastewater facilities. Chapter 4 describes the analysis I performed to evaluate the potential for including various DSM measures in La Plata System planning and provides recommendations for DSM projects in La Plata. Implementation is the subject of Chapter 5, which presents factors that utility planners and managers should consider when employing the recommended measures. Finally, Chapter 6 includes a summary of my findings and provides my conclusions regarding the inclusion of DSM in The Plan.

2. DEMAND SIDE MANAGEMENT METHODS AND PROGRAMS

The first section of this chapter, which is an overview of DSM techniques, includes a brief description of several DSM techniques for water and wastewater systems. This chapter also includes a summary of several existing and proposed DSM programs. Potential reductions achievable with these methods, as well as the costs of implementing these techniques, are discussed in Chapter 4.

2.1 DEMAND SIDE MANAGEMENT METHODS - WATER SYSTEMS

There are numerous methods available for managing the demand for water services. Most of the methods are used with the objective of understanding and controlling , i.e. managing, the demand for water. Water system authorities use these methods in order to: obtain and keep accurate records on facilities, operations and programs, both to provide good service and to plan for future service; to cut down on waste; and to save money. DSM allows systems to save money by permitting the substitution of reduced consumption for supply development and increased services for both water and wastewater. The inclusion of DSM may allow managers to cut down or defer capital expenditures, and may reduce operation and maintenance (O & M) costs for water as well as for wastewater collection and treatment.

Operators of water systems use various DSM approaches, which I will classify for discussion as analytical, structural/operational and social/economic.[1] In the descriptions that follow, analytical methods include those techniques used to provide information about water and wastewater facilities and operations, such as system surveys, auditing and metering. Structural/operational techniques provide actual reductions in the consumption of water by either physical means or by methods of

[1] Literature in the field often categorizes DSM techniques as structural and non-stuctural. I have chosen to use the analytical, structural/operational and social/economic categorization because it provides more information about the *goals* of using the various techniques.

operation, such as leak repair or the use of water-saving devices. Social/economic methods are used with the objective of changing behavior by providing incentives, such as education or pricing schemes.

It is also possible to manage the demand (flows) on wastewater collection and treatment systems with these methods, in addition to methods aimed specifically at wastewater systems. In section 2.2, I include a few methods targeted directly at managing flows in wastewater systems.

2.1.1 Analytical Methods

Analytical methods provide planners, operators and managers detailed information about the water system facilities and flows. Just as it is important for a business manager to understand the various components of the business and how they interrelate, it is important for water system managers to have accurate information about their facilities and the cycle of water through them. With detailed information managers can discern: where to make improvements in facilities; where to eliminate waste; and how to deal with both everyday and emergency situations. Accurate information is vital when planning for new facilities and for future service.

Water Audit. Water audits develop an accounting of water supply, pumping, distribution and consumption. Performing a water audit consists of reviewing and organizing system records. Auditors may supplement records with field inspections and measurements before analyzing information. Typically, auditors use historic and current data to estimate a system balance of water flows: acquired from raw water sources; treated; pumped; delivered to industrial, commercial and residential customers; consumed by authorized public activities (e.g. fire-fighting, street sweeping, etc.); and unaccounted for. Unaccounted for water (UFW) quantities are an especially important result of water audits, in that that UFW often represents water which is wasted, or which is not represented in the billing process. UFW, or system losses, is mainly due to: inaccurate meters;

public authorized uses, unauthorized uses; and all kinds of leaks.[2] Water audit results can help water system managers plan for new facilities, operation and maintenance activities, system rehabilitation, and various other programs. The accuracy of a water audit is dependent on the quality of historical data, the extensiveness and accuracy of meters in the system, and the depth of understanding that the auditors have of the system.

System Survey. System surveys consist of researching and compiling data about system facilities: age; material; location and condition. System survey data is invaluable for planning and management. Activities involved in performing a system survey range from reviewing exiting plans and records to locating and mapping facilities in the field. Surveyors also obtain current information about system facilities by interviewing managers, operators and repair crews.[3] Increasingly, system managers use the process of system surveying as an opportunity to update information in the process of developing automated mapping and facilities management databases.

Metering. Metering consists of measuring fluid flows at various locations in the system. Flow-measuring devices are used to meter public works such as treatment plants and pumping stations as well as points of delivery (customers). Metering allows for a good understanding of the water cycle in the system. Some form of metering is essential for conducting a water audit, and the accuracy of meters is critical in attempts to quantify system losses.[4] The information provided by metering of consumers allows for the implementation of pricing schemes based on actual consumption, which provides an incentive for customers to reduce use.[5] Section 2.1.2 includes a brief discussion of pricing schemes.

[2] Varenhorst, (1982, p.15, note 13)
[3] Frequently, information regarding the exact location and condition of system facilities is *only* available from field crew workers. It is very important, when performing a system survey, not to neglect this first-hand knowledge.
[4] Levy, (1993. p.5).
[5] Flack, (1982, p.22)

2.1.2 Structural/Operational Methods

Structural/Operational DSM methods concentrate on controlling demands and flows through the reduction of waste. Reduction of waste is achievable through maintenance and rehabilitation programs and through the use of devices designed to restrict flow.

Leak Detection and Repair. Leakage in water pipes and at piping connections wastes potable water. Leakage can occur both in the distribution system and in domestic connections and equipment. Rates of leakage are related to the age of the system, the quality of materials used in construction, chemical properties and pressure of water and the degree of system maintenance.[6] In the distribution system, leakage occur where piping and connections have been damaged or were improperly installed. In households, leakage occurs most commonly in toilets[7] and faucets.[8] A federal survey (USA) indicated that one out of every five toilets leaks.[9]

Leak detection and repair programs are usually prompted by the results a water audit in which balances indicate a high percentage of UFW. These programs consist of a systematic survey of the system for leaks, followed by repair. Because not all leaks are evident on the ground surface, field crews find non-obvious leaks with the use of sonic detection equipment, which amplifies the sound of nearby leaks at contact points in the system (valves, meters, hydrants, etc.). Once they have detected a nearby leak, the crews use more sensitive equipment to pinpoint the leak's exact location.[10] A work crew may then repair the leak, eliminating the waste of potable water at that site. Effective leak detection programs include a complete survey of all piping at regular intervals, using: standard survey techniques; qualified personnel; standardized reporting techniques; and prompt repair of detected leaks.[11]

[6] Flack, (1982, p.23), Reference to Howe, et al, 1971.
[7] Following the example of Murray Milne in his extensive survey of residential water conservation techniques (Milne, 1976), this paper will use the more common terminology "toilet" and "sink" in place of "water closet" and "lavatory."
[8] Flack, (1982, p.24)
[9] Building Sustainable Communities, (1991, p.85)
[10] Building Sustainable Communities, (1991, p.36)
[11] Levy, (1993, p.4)

Mangers of water systems may also choose to incorporate programs designed to detect leaks in domestic connections and equipment. Such programs typically involve house-to-house inspections using water department personnel. Inspectors visually inspect equipment and use techniques such as dyed water testing to locate leaks in service connections and appliances. The intense time and personnel requirements of house-to-house inspections usually means that such programs are only effective in zones of unusually high water consumption.[12]

Water-saving Devices. Water-saving devices are primarily meant for use in the homes of individual consumers[13] to limit flow through household appliances and appurtenances. Many household appliances and appurtenances use more water than is necessary.[14] Water-saving devices typically target those portions of domestic use which account for the highest percentages of domestic consumption, which breaks down, on average, as follows (Table 2.1).

Table 2.1

Domestic Uses of Water

Use Type	Percent of Use	Use (l/day)
Toilet	38	95
Bath/Shower	31	76
Lavatory Sink	5	11
Laundry and Dishwashing	20	49
Drinking/Cooking	6	15
Total	**100**	**246**

Source: Postel (1984, p.45) as adapted from US Environmental Protection Agency, Office of Water Program Operations, Flow Reduction: Methods Analysis, Procedures, Examples, Washington D.C., 1981.

As Table 2-1 shows, the largest potential for reducing domestic water waste through water-saving devices is in toilets, showers/baths and in laundry and dishwashing equipment. Water-saving devices are also available for sinks. These devices can result in money savings to the consumer through reduced bills for water, as well as for the energy used to heat water. (Money savings to

[12] Building Sustainable Communities, (1991, p.85)
[13] Varenhorst, (1982, p.13)
[14] Postel, (1984, p.44)

the consumer is especially relevant in systems which use billing schemes based on actual use. See section 2.1.3.) Water authorities may encourage or require the installation of water-saving devices through retrofit programs which include distribution centers, house-to-house visits, or mail delivery, or by simply requiring their installation through legal means (See Social/economic Methods, section 2.1.3.) The following paragraphs describe water-saving devices used for flow reduction in toilets, showers, laundry and dishwashing appliances, and faucets.

Toilet Devices. Water-saving devices for toilets reduce or eliminate the water used for the transport of liquid and solid wastes. Conventional toilets use 18-22 liters per flush.[15] A wide variety of fixtures and devices is available to reduce that amount. I will concentrate on commonly-used devices, and some which have unique potential for La Plata, in four categories: low flow toilets; volume displacement devices, variable flush modifications; and special systems.[16]

Low flow toilets (LFTs), which are widely manufactured and accepted in the United States, are toilets which use less water per flush than conventional models. A common construction principle for LFTs is the shallow trap--a variation on the conventional toilet. The shallow trap LFT has a reduced tank size and uses a smaller diameter trap. The small trap means that less water is retained in the bowl and the flushing action has less inertia to overcome, allowing for reduced water use per flush.[17] Shallow trap toilets look like conventional toilets, are easy to install (no plumbing modifications necessary), and are widely available.

Volume displacement devices occupy space in the toilet tank, reducing its capacity, and thus, the water available for each flush. Typical devices include toilet dams, bottles or bags, and bricks. These devices, when installed, do not change the water level in the tank, so the same pressure is

[15] Postel, (1984, p.44)
[16] Categorization scheme borrowed from Flack, (1982, p.10)
[17] Milne, (1976, p.179)

provided for each flush[18], with reduced water use. These devices are inexpensive and easy to distribute and install.

Variable flush modifications allow the user to "customize" the water used per flush based on the degree of flushing action required. Two main categories are variable flush attachments and batch-type flush valves. Two types of variable flush attachments are:

- Flush regulating devices, which allow the user to regulate the amount of water used by applying variable pressure to the flush button or lever; and
- Dual flush systems, which allow the user to select between a low volume flush for the transport of liquid wastes, and a higher volume flush for solids.

While not extensively used in the USA, the above methods are more widely accepted in Great Britain.[19] Batch-type flush valves, another flush modification, use oversized feed lines with quick release valves.[20] Batch-type modifications are most appropriate for multiple installations, such as in an institutional setting, because of the special plumbing required.

Special Systems include those which use alternative flushing media such as oil or air and those which use little or no water, such as composting, chemical or incinerating toilets. Designed originally for use in mobile applications and for remote areas, some of these systems may also have applicability for urban areas unserved by sewer services, as either an alternative to septic disposal or an interim measure. Of particular interest is the composting toilet, because of its relatively low cost and simple technology. In a composting toilet, wastes are transported without water to a holding area under the building. The user/maintainer periodically mixes in organic wastes (such as household food waste and yard waste) and agitates the compost. A small electric

[18] Milne (1976, p. 231)
[19] Flack, (1982, p. 13) reference to Bailey, 1969.
[20] Flack, (1982, p.13), reference to North Marin County, 1976.

fan (may be solar powered) provides ventilation for the holding area and the toilet chamber. With proper maintenance, the mixed wastes will form a compost, which may be used as a fertilizer.

Shower Devices. The idea behind using water-saving devices for showers is to reduce the flow per unit time through the showerhead. Reducing flows in the shower not only saves water, but also the energy used to heat the water. There are three basic types of water-saving devices for the shower:

- Low flow shower heads, which allow lower flow rates than conventional shower heads;
- External flow restrictors, which are installed on the outside of conventional shower heads and reduce the flow through them; and
- Washer inserts, which, when installed, reduce the flow-through orifice size of conventional shower heads.

The above devices are inexpensive, easy to distribute and install, and are widely accepted in the United States.

Water-saving Appliances. The primary appliances for which relatively large reductions in water use are possible are clothes and dish washing machines.[21] In the United States, consumers have a wide variety of models from which to choose, some of which are specifically designed to use less water (and energy) than conventional models. A common feature in water-saving clothes washers is a water level chooser, with which the user may select the amount of water appropriate for the amount of clothing to be washed.

[21] Flack, (1982, pp. 15-16)

Faucet Devices. As with water-saving devices for showers, faucet devices save water by reducing the flow per unit time. Types of water-saving faucet devices include:

- Fixed orifices, which are simple inserts installed within the faucet head to restrict flow by decreasing flow-through diameter;
- Aerators, which are attachments for faucets which restrict flow and introduce bubbles of air to the water stream. (As aerators have the desirable effect of reducing splashing, most new equipment includes them.); and
- Spray taps, which are faucet head types that disperse the flowing water into a fine spray.[22]

These devices are inexpensive and easy to distribute and install, however, they provide lower amounts of water savings than other water-saving devices.

2.1.3 Social/Economic Methods

Social/economic methods seek to control flows and reduce waste by providing social, economic and/or legal incentives for customers to reduce use. The four types of DSM methods I will describe in this section include education, pricing, use restrictions, and modifications to the building/plumbing/manufacturing laws.

Education. Education can be a very powerful tool in reducing water waste. Many consumers give little thought to their habits of water use,[23] perhaps because they are unaware of the cost and effort involved in supplying, treating and delivering water and collecting, treating and disposing of wastewater. For this reason, education programs often focus on providing information about water and wastewater systems to their consumers, with the goal of convincing them to adopt more prudent water use habits. Education programs often comprise mailings, workshops and special events, as well as public service announcements in the audio/visual and printed media. Another

[22] Milne, (1976, p.242)
[23] Flack, (1982, p.33)

common method for disseminating information about water use is to include water conservation topics in school curricula. Education programs can increase public awareness, make it less socially acceptable to waste water, and develop a better relationship between consumers and their utility providers.

Pricing Schemes. Pricing schemes geared towards reductions in water use are typically cost-based or full-cost pricing regimes. The goals of using these methods as DSM measures include: generation of revenue to finance water and wastewater management and service; discouragement of wasteful use; and adoption of an equitable form of payment for services.[24] Pricing schemes are usually in the form of cost-based or full-cost pricing, in which the price of delivered water corresponds directly to the actual cost of providing the service. Common additional modifications to traditional pricing schemes include inclining block rate pricing (in which water use - beyond a level designate as basic necessity - is charged at increasing rates) and peak demand pricing (in which units of water used during periods of highest demand is priced at a premium). The adoption of full-cost pricing schemes necessitates the use of domestic metering and requires an accompanying public information program to encourage acceptance and effectiveness.[25]

Use Restrictions. The goal of use restriction is to reduce water waste and to reduce demands during peak periods. These measures are usually first applied to water uses beyond basic necessity and are commonly use to restrict outside home uses (such as lawn watering and car washing), either during peak periods or altogether. Generally, use restrictions are short-term methods used during emergency situations such as an exceedence of system capacity or a raw water shortage.[26]

[24] Levy, (1993, pp.36-7)
[25] Varenhorst, (1982, p.19)
[26] Flack, (1982, p.25)

Building/Plumbing/Manufacturing Law Modifications. Government authorities may elect to codify the use of water-saving devices by making alterations to various laws, with the goal of achieving long term, permanent reductions in per capita water demand. Authorities may use modifications of the building or plumbing codes to require the installation of water-saving devices in new construction or as part of rehabilitation/replacement projects. Such modifications exist in most areas of the United States. Governments may also issue efficiency standards for manufacturing which require certain water use levels in newly manufactured appliances and appurtenances.

2.2 DEMAND SIDE MANAGEMENT METHODS - WASTEWATER SYSTEMS

Various methods exist for reducing the demands (flows) on a wastewater collection and treatment system. The DSM methods described above are all relevant to managing wastewater system flows, as they either contribute to understanding of the water cycle in the system or reduce water consumption (and correspondingly, wastewater flows) in the system. The following paragraphs describe additional analytical, structural, and economic DSM methods that are directly applicable to the wastewater system.

2.2.1 Analytical DSM Methods - Wastewater

System Survey. Like a water system survey, the wastewater system survey provides the system managers and operators with up-to-date information about system facilities: age; material; location and condition. Activities involved in performing a wastewater system survey range from reviewing existing plans and records to locating and mapping facilities in the field. In addition to mapping and data recording, complete system surveys typically include manhole inspection and pipe lamping, as well as continuous flow monitoring. Managers use flow monitoring data to determine which areas of the system may be subject to high rates of infiltration and inflow (see below) -- areas they may then target with flow isolation and comprehensive pipe inspection programs to identify specific problems.

2.2.2 Structural/Operational DSM Methods - Wastewater

Infiltration/Inflow (I/I) Reduction. Infiltration (groundwater which enters the wastewater collection system through damaged pipes and manholes) and inflow (rainwater which enters the system through manhole covers and stormwater drainage connections) can increase flows in sewer pipes dramatically. I/I reduction programs seek to reduce or eliminate infiltration and inflow through facility replacement and rehabilitation, in order to mitigate the need for increasing wastewater collection and treatment capacities. Rehabilitation methods used for reducing I/I typically include manhole and pipe replacement and lining.

2.2.3 Social/Economic DSM Methods - Wastewater

Pricing Schemes. Pricing schemes as DSM measures for wastewater are typically cost-based or full-cost pricing regimes, just as they are for water systems. Similar to water systems, the adoption of full-cost pricing schemes necessitates the use of domestic water metering and requires an accompanying public information program to encourage acceptance and effectiveness.[27]

2.3 EXISTING AND PROPOSED DEMAND SIDE MANAGEMENT PROGRAMS

In cities and regions throughout the United States and in other countries, water and wastewater authorities have adopted programs geared toward reducing water use. In some systems, the impetus for using DSM is a shortage of supply, either seasonally or year-round. In other systems, managers have implemented DSM in order to eliminate or defer the need to expand existing facilities, in both water and wastewater systems. Table 2-2 presents an overview of several DSM programs and includes estimates of water use reductions for each, where available.

[27] Varenhorst, (1982, p.19)

Table 2-2
Existing and Proposed Demand Side Management Programs

System	Analytical			Structural/ Operational		Social/Economic				Reduction	Comments	Source
	Audit	Survey	Metering*	Leak Detection and Repair	Water-saving Devices	Education	Use Restrictions	Bldg/Plumb/Man Code**	Pricing Modifications			
Massachusetts Water Resources Authority, Massachusetts	✔	✔	✔	✔	✔	✔		✔	✔	16%	Door-to-door device distribution	1
Denver Water Department, Colorado	✔		✔	✔		✔		✔	✔	10-15% projected	Irrigation targeted	1
Bogar, Indonesia	✔			✔		✔			✔	29%	Domestic Leak Detection	1
Mexico City, Mexico	✔				✔	✔		✔		17% projected	Efficiency Standards	1
Seattle Water Department, Washington	✔				✔	✔	✔	✔	✔	32 mgd	Included residential	1
Water Department of the Public Utilities Board, Singapore	✔	✔	✔	✔	✔	✔		✔	✔	UFW to 6.7%	Included residential	1
Waterloo, Ontario, Canada	✔			✔	✔	✔		✔	✔	8%	Industrial Standards	2
Tuscon, Arizona	✔				✔	✔		✔	✔	24%	Horticultural Changes	2
El Paso, Texas	✔					✔		✔	✔	15-17% projected		2
Weymouth Water Department, Massachusetts	✔		✔		✔	✔	✔	✔	✔			3
Palo Alto, California	✔					✔		✔	✔	27%	Door-to-door visits to high-use customers	4
Boca Raton, Florida	✔				✔	✔	✔	✔	✔		Horticultural, irrigation restrictions	4
Tampa, Florida	✔							✔	✔	10% projected		4
Marin Municipal Water District, California	✔				✔	✔		✔	✔		Horticultural Changes	5
Santa Monica, California	✔				✔	✔		✔		835,000 gpd projected		5
Endinboro University, Pennsylvania	✔				✔	✔		✔		20%		5
San Simeon, California	✔				✔	✔		✔		28%		6
New York, New York	✔			✔				✔		10% projected		6
Austin, Texas	✔				✔	✔		✔		33% domestic		6
Washington Suburban Sanitary Commission, Washington	✔				✔	✔		✔				7

Notes:
* Most of the cities listed here have comprehensive metering. Checkmarks in this column indicate new metering efforts.
** While not all of these cases involved building/plumbing/manufacturing code changes when DSM programs were initiated, they are all under such requirements now.

Sources:
1) Levy, 1993
2) Postel, 1984
3) CDM, 1991
4) Pujals & Chansler, 1993
5) National Regulatory Research Institute, 1991
6) Rocky Mountain Institute, 1991
7) Flack, 1982

3. CASE STUDY DESCRIPTION AND RESEARCH METHODOLOGY

3.1 RESEARCH METHODOLOGY

In order to gather information necessary to perform my analysis, I performed literature review and visited La Plata, Argentina from May 20 to 25, 1995 and January 29 to February 8, 1996. The Facultad de Ingeniería of the Universidad Nacional de La Plata (UNLP) were my hosts during my research trips, as it was in the Facultad de Ingeniería that The Buenos Aires Water and Sewer Master Plan (The Plan) was constructed. During my visits, I acquired written material, conducted interviews with master planning staff, visited facilities and neighborhoods within the case study area and documented case study information with photographs. My program of research in La Plata included information gathering in 6 basic categories:

1) Background Information
2) Detailed information about demand estimates
3) Appropriate demand side management methods
4) Capital and O & M costs for facilities
5) Photos and figures for documentation
6) Potential implementation challenges

1) I gathered background information in order to gain an understanding of the structure of--and motivations behind--the master planning effort. By reading and discussing plan reports with the staff at UNLP, I acquired an overview of the master plan methodology and the present and projected situation in the case study area. In this category of research, I gathered information on geography, land use, socio-economic characteristics, the water system and the sewer system. I obtained data on existing and proposed water and sewer flows, facilities and costs, and accessed the planners' newspaper archives for information on environmental topics of concern in the case study area.

2) I obtained detailed information about water demand estimates. My meetings with the planners at UNLP provided me with information on the methods used for estimating current and projected water and sewer flows. I obtained information about the staff's market surveys, which determined levels of service, income, education, and willingness to pay for new services. The planners at UNLP provided me with water demand estimates for various categories of use: domestic, commercial, industrial, and unaccounted for. I was unable to obtain estimates for use in public (government) buildings.

3) In meetings with UNLP staff, and according to discussions with my advisor, I identified appropriate demand side management methods for the La Plata System. I researched current programs of demand side management, and the possibility (and appropriateness) of using additional methods including:water auditing; metering improvements; leak detection and repair; flow restricting devices; water pressure adjustments; education; pricing adjustments; and infiltration/inflow detection and rehabilitation in the sewer system

4) Through a perusal of available documents, and through discussions with UNLP staff, I acquired information about capital, operation and maintenance costs for the proposed water and sewer system improvements as a function of flow rates.

5) Throughout my visit in La Plata in January and February, 1996, and, in particular, during tours of facilities and neighborhoods, I visited and photographed public water and sewer facilities, homes, land uses, and domestic water and sanitary equipment. These site visits supplemented the general information I obtained during a helicopter tour of the Plan area during my 1995 visit. I toured the water intake canal area, the drinking water treatment plant, a sewer pumping station, and

the sewer outfall at the La Plata River coastline.[1] Also, I toured many areas of the La Plata System, with particular attention to neighborhoods with high sanitary risk (areas without running water and sewer service). During my research trip I also obtained documentation of socio-economic and geographic factors for La Plata in the forms of maps and tables and I acquired maps depicting the existing and proposed water and sewer facilities for the case study area.

6) Finally, I looked into potential implementation challenges. I met with economists on the planning staff to discuss the political, financial and institutional climates anticipated during implementation of The Plan.

3.2 DESCRIPTION OF MASTER PLANNING AREA

3.2.1 Buenos Aires Master Planning Area

The Plan Director de Aqua Potable y Saneamiento planning area (master planning area) comprises a large proportion of the greater Buenos Aires metropolitan area. The master planning area includes the entire urban and suburban ring surrounding central Buenos Aires. The area is divided into the following partitions: General Sarmiento, Moreno, Merlo, Esteban Echeverría, San Vicente, Quilmes, Berazatequi, Florencio Varela, La Plata, Ensenada and Berisso. The plan excludes the federal capital area - central Buenos Aires - as other planning efforts cover this area. For analysis purposes, the planners divided the area into four sub-areas, or "systems:" North, West, South and La Plata. The master planning area includes about 5,000 square kilometers of land area, and is inhabited by some 3,600,000 people. The projected population for the end of the planning period - the year 2020 - is about 4,700,000 people (Table 3.1).

[1] This latter stop was in the immediate area where the first local case of cholera was detected a few days before my arrival. (See discussion in box in section 3.2.2.)

Table 3.1

Population Estimates for Master Planning Area

System	1995 Total Pop.	2005 Total Pop.	2020 Total Pop.
NORTH			
G. Sarmiento	700,129	797,370	907,575
Merlo	421,410	487,743	569,683
Moreno	318,483	387,345	470,552
Subtotal:	1,440,022	1,672,458	1,947,810
WEST			
E. Echeverría	303,851	366,812	443,459
San Vicente	87,004	103,766	125,317
Subtotal:	390,855	470,578	568,776
SOUTH			
Quilmes	528,439	569,088	619,899
Berazatequi	261,513	298,174	339,723
Fcio. Varela	279,965	338,504	404,677
Subtotal:	1,069,917	1,205,766	1,364,299
LA PLATA			
La Plata	548,696	601,455	664,766
Berisso	77,349	85,530	96,686
Ensenada	49,102	53,823	59,016
Subtotal:	675,147	740,808	820,468
TOTALS:	**3,575,941**	**4,089,610**	**4,701,353**

Reproduced with permission from the Plan Director de Agua Potable y Saneamiento, Executive Summary volume, p.5.

I selected the La Plata System as my case study area. The La Plata System is representative of the larger planning area in that it contains a wide range of land uses, population densities, and household characteristics. Residents in this System use a variety of methods for obtaining potable water and for disposing of wastewater. The La Plata System includes highly developed areas, as well as areas planned for growth. Plans for this area include a new wastewater treatment plant. This area comprises greater La Plata, including the cities of La Plata, Berisso and Ensenada, as well as many outlying villages and other non-urban areas. 19% of the current master planning area population lives in the La Plata System.

3.3 DESCRIPTION OF CASE STUDY SUB-AREA

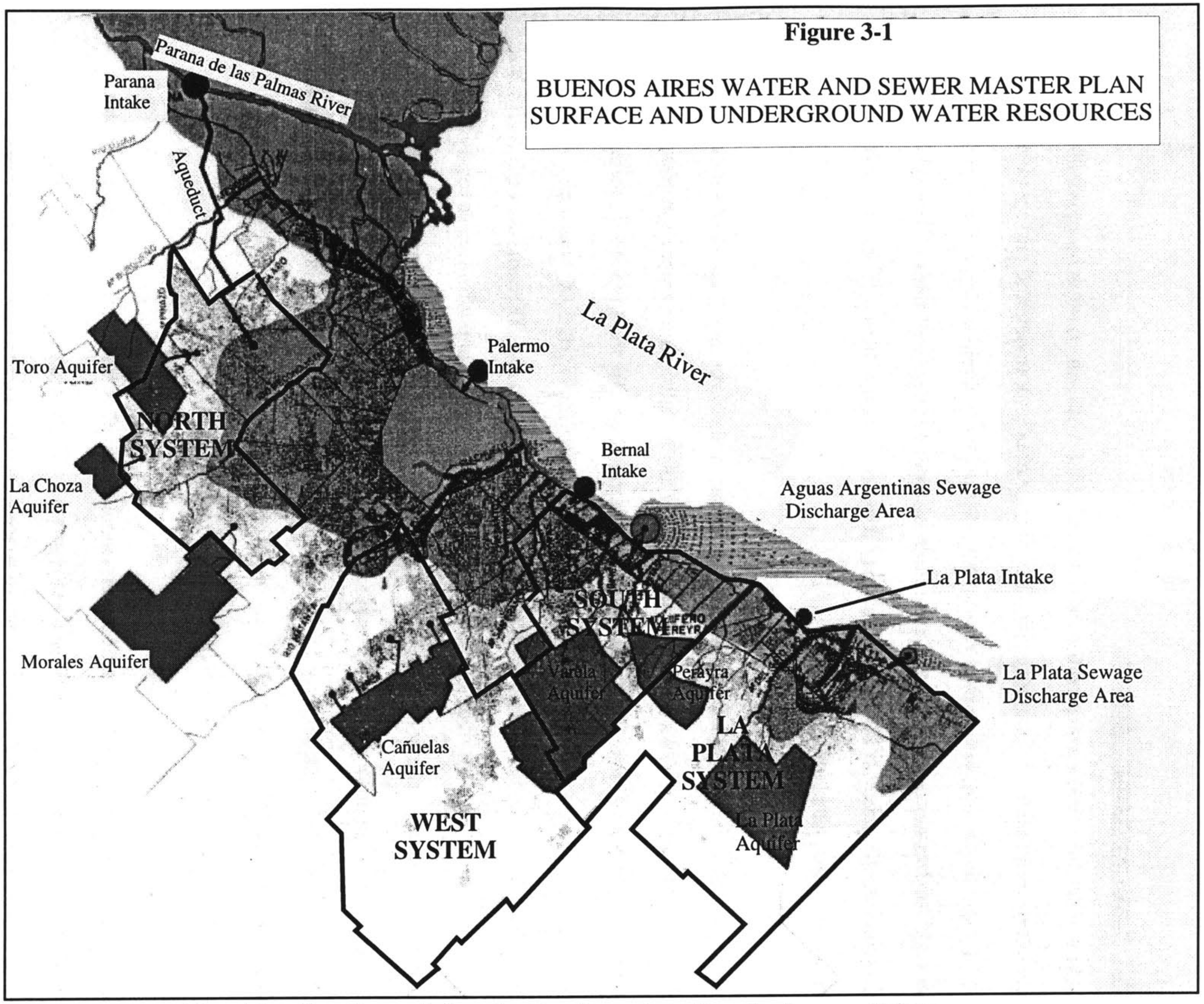
This section presents a description of the La Plata System including its geography, socio-economic aspects, and water and wastewater facilities. The following section includes photographs that I took during my trip to La Plata.

3.3.1 Geography

The La Plata System, is the easternmost of the sub-areas defined by The Plan, and is in the north eastern section of Buenos Aires Province. The La Plata System's boundaries represent the extent of the master planning area to the east. To the west of the La Plata System lie the South and West systems, and to the east are areas not included in The Plan. The La Plata river represents the northern boundary of the La Plata System.

The La Plata river, which is the widest river in the world at its point of discharge to the Atlantic Ocean, is a significant physical and cultural resource for the inhabitants of the La Plata System. This shallow estuary serves many purposes for the greater Buenos Aires area. It functions as an important shipping and transportation conduit, and as a repository/conveyance for liquid wastes. Somewhat in conflict with these uses, but no less important, are the river's roles as a fishing resource, a source of drinking water and a popular recreational destination for sailing and swimming. The master planning area also boasts significant groundwater resources. Figure 3.1 shows the master planning area and highlights the location of drinking water intakes, groundwater aquifers, and wastewater discharge zones.

The La Plata area, like most of the Buenos Aires province, is humid pampas--flat plains. The area is one of little topological relief, and its geological make up is wind- borne loess and river-deposited sediments. Before agricultural development and urbanization, the land was covered by



Adapted from Plan Director de Agua Potable y Saneamiento, Executive Summary Volume lush native grasses.[2] The non-urban areas of the La Plata System are today used extensively for grazing lands, table crop agriculture, and hothouse horticulture and agriculture.

3.3.2 Socio-economic Aspects

A national census (1991) provided the planners at UNLP with information on population and other socio-economic data in the planning area. In order to: obtain more detailed current information on socio-economic factors; understand the current levels of service and patterns of use of domestic water and wastewater equipment; and meet International Development Bank (IDB) information requirements, the planners at UNLP conducted a house-to house survey of the residents of the Buenos Aires master planning area.

First, using the same census tracts selected for the national census, the planners conducted a survey of 1200 census blocks (10,000 households in all) to determine income and education levels for the entire planning area. They followed up with more specific market surveys relating to the provisions of water and wastewater services. The planners surveyed 1,000 randomly selected households (500 households with no water and sewer services, and 500 families with both sewer and metered water service) to determine existing levels of service and willingness to pay for additional/improved water services. They conducted a similar survey, polling only people with no sewer services, to acquire data about sewer services. Their third market survey focused on zones of high environmental risk (See section on Health, below) and polled 600 households about their willingness to pay for improvements in the environment with respect to the construction of wastewater collection and treatment facilities.

The results of these surveys were used to determine the level of service that Plan alternatives should obtain. These levels of service were based on willingness to pay, technical feasibility, financial efficiency, and the goal of eliminating as many of the local environmental risks as

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[2] Bernhardson and Massolo, (1992, p.28),

possible. As an example, the surveys, combined with costs estimates from the technical groups, indicated that it is financially and technically efficient to provide wastewater collection facilities in those areas where population density of 30 persons per hectare or higher. The IDB is also using the results of these surveys for planning projects in other parts of Argentina.

Income. According to reviews of census and survey data for the last several years, income distribution in the Buenos Aires master planning area has not changed a great deal over the last several years. Of the four systems in the master planning area, the La Plata System generally has the highest levels of income and education.[3] Percentages of persons living below the poverty line are estimated at: 17.1% in Berisso; 17.8% in Ensenada; and 12.4% in La Plata; as compared with 18.9% for the entire planning area.[4] Unemployment among heads of households are estimated at: Berisso 7%; Ensenada 7.5%; La Plata 5.3%; and the total plan area 7.1%.[5]

Education. Educational attainment levels in Berisso and Ensenada are on par, or slightly lower, than the rest of the master planning area. La Plata, home of the Universidad Nacional de La Plata, enjoys relatively high levels of education compared with the rest of the master planning area (Table 3.2).

Table 3.2

Educational Attainment in the La Plata System

Section	Primary School (%)	Secondary School (%)	Some College (%)
Berisso	96.5	50.4	8.3
Ensenada	96.2	52.3	8.6
La Plata	97.0	69.0	29.7
Total Master Planning Area	96.4	53.5	14.9

Reproduced with permission from the Plan Director de Agua Potable y Saneamiento, Volume 1, Table 1.7, p.27.

[3] Plan Director de Agua Potable y Saneamiento, Volume 1, (1995, pp.13-14)
[4] Plan Director de Agua Potable y Saneamiento, Volume 1, (1995, p.26, Table 1.6)
[5] Plan Director de Agua Potable y Saneamiento. Volume 1, (1995, p. 25, Table 1.5).

Health. A central concern of the planners at UNLP is public health in the master planning area. Using information from the 1991 national census, supplemented by data obtained through the surveys described above, the planners determined the relative levels of "sanitary risk" for various parts of the planning area. Data on type of domestic water and sewer facilities, level of education and housing occupancy (numbers of people per room) were compiled to establish indices of risk. According to this analysis, Berisso, Ensenada and La Plata have "low" levels of sanitary risk, whereas the remaining areas of the master plan generally have levels of risk in the "medium" to "extreme" range. The Plan's authors point out, however, that the categorization scheme of this method allows for areas with limited sanitary facilities to fall into the "low" risk category, which they feel that this does not represent an adequate assessment of the risks to the La Plata area. The planners note that all areas of the Plan are at risk from health hazards such as water-borne diseases and thus each system requires planning attention.

RECENT CHOLERA CASES

Of particular interest in current discussions of health risks in the La Plata System is the recent local outbreak of cholera. During my visit to Argentina, the news media was concentrating on the reports of cholera cases in Berisso, the first reported instances of cholera contracted locally. Just five days prior to my arrival in Argentina, the cholera bacteria was isolated in the fecal material of a young girl at the Children's Hospital[6]--the first locally-contracted case of this infirmity, which has been working its way through South America since the Peruvian cholera epidemic in 1991.[7]

Cholera is contracted by ingesting the bacterium vibrium cholerae, most commonly through drinking water contaminated with fecal matter. The first reported cases, the young girl and her sister, were from a family in Berisso that lived near the bank of the La Plata river, in the vicinity of the sewage outfall. Several more cases were reported in the ensuing days. Health authorities declared a "yellow alert" while monitoring the possible spread of the cases.

Health authorities in greater Buenos Aires are especially concerned about the possible spread of cholera because of: the low percentages of homes in the area that have wastewater collection service; the poor performance of existing wastewater collection and transport facilities; the potential for contamination of the drinking water supply; and the lack of adequate facilities for neutralizing the bacteria in the wastewater prior to discharge. Of particular concern is the lack of treatment facilities in locations where hospital wastes enter the wastewater collection system.[8]

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6 "Cólera en Berisso: en busca un vibrión perdido en el río." El Dia 4 Feb. 1996: 11.

7 "La epidemia colérica, una vieja enemiga del hombre." El Dia 4 Feb. 1996: 11.

8 Schamun, Ing. Jorge Interview. February 2 and 7 1996, and "Necesidad de que se apliquen recaudos para eliminar los residuos hospitalarios." El Dia 16 Sept. 1993.

Industry. The master planning area in general, and the La Plata System in particular, is home to numerous industries. Some 6,000 industries in the Conurbano area generate 500 tons of residuals every year. [9] Industries in greater Buenos Aires discharge their liquid wastes to the river and to local streams. Some streams in the area actually originate at industrial discharge outfalls. There is currently no comprehensive monitoring program for industrial discharges. The streams also serve as receiving waters for domestic wastes in some areas, a combination which can result in very poor water quality. A recent newspaper article described the water in certain local streams as "cloudy, dark brown and foul-smelling, with a confluence of aromas and colors that is an outrage against all forms of wildlife."[10] Many concerned citizens have expressed a desire to see the streams and canals cleaned up. One local resident commented, "50 years ago our parents and grandparents could fish and swim in the waters of Canal Oeste. Nowadays the only survivors are fungus and bacteria."[11]

Residents in the La Plata area have a history of concern about the soil, water and air pollution caused by local industries. It is not surprising, when inhabitants of the greater La Plata area occasionally receive news such as was published recently--that residents of greater La Plata have the highest rates of asthma in the country.[12] The recent cholera outbreak (See text box), and other events such as deaths caused by a release of toxic gases from the sewer - hydrogen cyanide of suspected industrial origin - have increased the residents' sensitivity to the risks associated with environmental hazards such as inadequate wastewater facilities and the unregulated discharge of industrial wastes.[13]

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[9] Orlando Barone. "La civilazación de las latas." Hoy 26 Apr. 1994.
[10] "La contaminación ambiental avanza en Melchor Romero." Hoy 12 Dec. 1993.
[11] "Piden limpieza de canales en Ensenada." Hoy 20 Jan. 1994.
[12] "La Plata, la ciudad más asmógena del país." El Dia 25 July 1993.
[13] "Preocupación por los desbordes cloacales en distintos barrios." El Dia Jan. 1996.

Housing. Housing in the La Plata System varies greatly, according to income level and location. In certain neighborhoods, spacious ranch-style homes are the norm, whereas in others housing consists of one-room shanties with no water, sewer or electricity. High rise, multi-family buildings and row houses dominate parcels in Central La Plata and in outlying areas, simple farm houses are more common.

3.3.3 Water system[14]

Overview. As of 1995, the La Plata System's public water network serves 520,446 people, or 77% of the inhabitants of the area. This is a great deal higher than the total master planning area, of which 54% of the inhabitants are served by public water networks (Tables 3.3 and 3.4). Small pumps, operated either manually or with motors, serve about 23% of La Plata System residents. Less than 1% of the La Plata System gets its drinking water from either surface water or unknown sources.

Table 3.3

Water Service Methods in 1995, Population Served

Section	Public Water Net	Motorized Pump	Manual Pump	Public Pump	River/Canal/ Stream	Other	Total
Berisso	65,446	5,328	5,956	0	619	0	77,349
Ensenada	43,801	5,006	0	295	0	0	49,102
La Plata	411,199	125,426	7,133	2,743	549	1,646	548,696
System Total	**520,446**	**135,760**	**13,089**	**3,038**	**1,168**	**1,646**	**675,147**
Total Master Planning Area	**1,926,836**	**1,282,317**	**311,438**	**15,520**	**22,816**	**17,014**	**3,575,941**

Reproduced with permission from the Plan Director de Agua Potable y Saneamiento, executive summary volume. p.7.

[14] Much of the material contained in the following two sections was obtained from personal interviews with the following Engineers: Eduardo Perri, Nocolas Ratto, Abel Polonsky and Eduardo Mario Gelati.

Table 3.4

Water Service Methods in 1995, Percentages

Section	Public Water Net	Motorized Pump	Manual Pump	Public Pump	River/Canal/ Stream	Other	Total
Berisso	84.7	6.9	7.7	0	0.8	0	100
Ensenada	89.2	10.2	0	0.6	0	0	100
La Plata	74.9	22.9	1.3	0.5	0.1	0.3	100
System Total	**77.1**	**20.1**	**1.9**	**4.5**	**1.7**	**2.4**	**100**
Total Master Planning Area	**53.9**	**35.9**	**8.7**	**0.4**	**0.6**	**0.5**	**100**

Source: Plan Director de Agua Potable y Saneamiento, executive summary volume, p.7.

The La Plata System obtains its drinking water from both surface and groundwater sources. Before 1950, groundwater was the sole source of drinking water supply for this area. Due to excessive exploitation of the groundwater resources, a zone of saltwater intrusion formed and required the inclusion of a new source. (See Figure 3.1 for an illustration of the saltwater zone, the location of the drinking water intake, and the groundwater aquifer area.) An intake canal at Punta Lara, on the La Plata river, began operation in 1950. As of 1995, the System obtains about 50% of its drinking water from the La Plata River and 50% from groundwater wells. About 1,500 km of pipeline make up the water distribution system.

Water from the La Plata River is conveyed to the O.S.B.A. (Obras Sanitarias Buenos Aires) treatment plant. There, the water undergoes flocculation and sedimentation, filtration, disinfection and pH adjustment. An expansion in 1995 increased the plant capacity to 12,000m^3/hour. The plant has a 45,000m^3 underground tank for treated water. Treated water is pumped to Ensenada and Berisso and conveyed by gravity to the city of La Plata via aqueduct. Because of the poor condition of the aqueduct, the treated water is subject to possible contamination from both industrial and domestic sources. To combat contamination, the treated water is highly chlorinated before discharge to the La Plata aqueduct, and rechlorinated before discharge to the public supply network. A new aqueduct is under construction currently.

Four pumping stations serve the city of La Plata: two for treated surface water (Dique and Bosque, a small service area station) , one a mix of both surface and groundwater (Saavedra, with 10,000m^3 cistern storage) and one groundwater station (Bosque, with 16,000m^3 cistern storage). Eighty-eight groundwater wells serve greater La Plata, 50% of which pump directly into the water distribution network. Another 40% of the wells pump directly into storage, while the remaining 10% pump into both storage and the net.[15]

Villa Elisa, City Bell and Manuel B. Gonnet, which are other municipalities in the La Plata System, are served by public water works (groundwater wells, pumps and distribution networks) but are unconnected to the facilities described above. Three small towns in the southern area of the system, Melchor Romero, Abasto, and Lisandro Olmos, have water service provided by a local cooperative organization.

Problems with Public Water Service. Residents in the La Plata System experience a number of problems with drinking water service. First, due to the compromised integrity of piping in parts of the system, there is a risk of contamination and losses through leakage in certain areas. Second, much of the existing distribution network was constructed to meet the demands of a much smaller population base. The small diameter pipelines that served the system well many years ago do not have adequate capacity to serve today's higher demands. So, while source water and treatment capacity are plentiful, the La Plata System's distribution network is inadequate for delivering the treated water to the end users. Thirdly, many pipes in the system are tuberculated, further reducing their effective diameters. Fourth, numerous valves throughout the System are broken, reducing flexibility in the network and sometimes, eliminating loops which facilitate flows. Finally, while pumping capacity is adequate to meet demand, the pumps are poorly regulated and cannot deliver the treated water at pressures appropriate to the fluctuating daily demand cycles. Water delivered at

[15] Plan Director de Agua Potable y Saneamiento. 2.1. La Plata: Universidad Naconal de La Plata, 1996.p. 59.

pressures higher than necessary during certain periods increases the possibility of losses through leakage.

The most notable water service problems occur due to inadequate pipe capacity. Residents experience insufficient water pressure with frequency, and sometimes receive no water at all. Table 3.5 details relevant results of the planner's market surveys regarding water service. As this table shows, between 21 and 50% of La Plata System residents who are served by the public distribution network experience shortages of water either during certain times of day or during certain times of the year. Residents are becoming more vocal in their complaints about failing service. During my visit to La Plata, a resident group in Manuel B. Gonnet, fed up with insufficient service, was considering an act of protest, such as refusal to remit utility payments.[16]

Table 3.5

Quantity Problems with the Provision of Water Through the Public Network

Section	Sufficient Each Day (%)	Sufficient Over each Year (%)	Sufficient All Day Long, All Year Long (%)	Insufficient (%)	Total (%)
Berisso	59	13.1	6.7	21.2	100
Ensenada	53.8	5.6	0.6	40	100
La Plata	36.7	8.9	4.2	50.2	100
Total Master Planning Area	50	9.6	5	35.4	100

Source: Plan Director de Agua Potable y Saneamiento, executive summary volume.

Operation and maintenance activities associated with the public water distribution network are limited to standard procedures and crisis responses. That is, plants and pumping station operate normally and receive periodic maintenance, and network events which disrupt service, such as obvious leaks and breaks, are serviced immediately. There is no existing program for leak detection and repair, or for water main flushing. A minor cleaning and lining program (using chemical methods) is underway currently.

16 "En distintos puntos de la Ciudad volvió a denunciarse la falta de agua corriente." El Dia 21 Jan. 1996: 1 and 12.

Unserved Areas The La Plata System residents who do not have public distribution network connections use various methods for obtaining water for household use (Tables 3.3 and 3.4, above). A common form of access to water is the motorized or hand-operated individual well pump. Motorized pump installations often pump to small rooftop storage tanks. In some locations, several families share a small well pump, as well as their wastewater facilities.

The use of small well and pump systems represents an enormous potential health hazard for certain neighborhoods due to possible well contamination. In neighborhoods where small hand and motorized pumps are used, limited space and lack of information regarding safe practices prevents residents from locating their pumps a safe distance from waste disposal facilities such as pit latrines and septic chambers. Small well and pumping systems are also subject to possible industrial contamination due to polluted aquifers. Throughout the La Plata System, public works designed to increase pipe capacity are in progress. The Plan's primary recommendations for water system improvements are in this category.

3.3.4 Wastewater System

Overview. Currently, 67% of La Plata System inhabitants have public sewer service (Table 3.6). While this percentage is high relative to the master planning area, the number of unsewered residences in this System poses a sanitary risk. The most poorly served section of the System is Ensenada, with only 32% of the population served.

Table 3.6

Sewer Service Percentages, 1995

Section	Population Served (%)
Berisso	61
Ensenada	32
La Plata	70
System Total	**67**
Total Master Planning Area	**33**

Reproduced with permission from the Plan Director de Agua Potable y Saneamiento, Volume 2.3, Chapter 1.

The La Plata wastewater collection network reaches into all parts of the System. That is, all municipalities have some level of service.

The City of La Plata has a gravity collection system with four main drainage basins, three of which have associated pumping stations. All wastewater from the City of La Plata flows to two large, parallel collector sewers. A small section of Berisso's wastewater is pumped to Ensenada. Ensenada's wastewater flows by gravity to a pumping station, from where it is conveyed to the Berisso system. Berisso's Waste flows by gravity to the La Plata collector sewers. Wastewater from Abasto, Melchor Romero and Lisandro Olmos flows by gravity to the La Plata collection system. All wastewater from the above described networks flows to the La Plata collector sewers, and eventually discharges to the La Plata river without treatment.

Gravity collection networks in Villa Elisa, City Bell and Manuel B. Gonnet drain these municipalities' wastewater to a primary treatment plant on the arroyo del Gato. This plant comprises two lagoons. After undergoing settling in the lagoons, the wastewater discharges to the arroyo. This plant is not known for its effective treatment. A local homeowner said, "It doesn't really work, but it's better than nothing."

Problems With the Wastewater System. Problems with the public wastewater collection system are mainly associated with overflows caused by pipe blockages and breaks. Operation and maintenance activities for the public wastewater collection system are limited to standard procedures and crisis responses. Pumping stations operate normally and receive periodic maintenance, and network events which disrupt service, such as obvious breaks, are serviced immediately. There is no existing program for infiltration and inflow detection, or for pipeline and manhole rehabilitation.

Unsewered Areas. Those people in the La Plata System who do not have sewer service use a variety of methods for wastewater disposal (Tables 3.7 and 3.8). Homes with connections to the water distribution system usually have indoor restrooms, with a backyard absorption pit. Some of the absorption pit units also have a septic chamber, where settling of wastes occurs prior to discharge into the pit, prolonging the useful life of the pit. Homes with detached latrines may use water from a rooftop tank to flush a commode, which discharges to a simple absorption pit. Alternatively, homes may have a simple pit latrine. Detached latrines are sometime shared by several families in a neighborhood. Even when they have the opportunity, some residents elect not to connect to the public wastewater collection system due to cost.

Table 3.7

Wastewater Disposal Facilities in Unsewered Areas, Population

	Indoor Restroom		Detached Restroom			
System	Absorption pit with septic chamber	Absorption Pit without septic chamber	Latrine with flushing water	Latrine without flushing water	Other	Total not served
Berisso	1,621	13,386	8,314	5,793	900	30,013
Ensenada	4,731	12,047	0	16,778	0	33,556
La Plata	29,436	51,879	45,211	32,364	3,741	162,631
Subtotal La Plata System	**35,788**	**77,312**	**53,525**	**54,935**	**4,641**	**226,200**
Entire Plan Area	**491,543**	**699,222**	**561,557**	**604,942**	**23,277**	**2,381,530**

Reproduced with permission from Plan Director de Aqua Potable y Saneamiento: Executive Summary Document p. 8.

Table 3.8

Wastewater Disposal Facilities in Unsewered Areas, Percentages

System	Indoor Restroom		Detached Restroom		Other	Total
	Absorption pit with septic chamber	Absorption Pit without septic chamber	Latrine with flushing water	Latrine without flushing water		
Berisso	5%	45%	28%	19%	3%	100%
Ensenada	14%	36%	0%	50%	0%	100%
La Plata	18%	32%	28%	20%	2%	100%
Subtotal La Plata System	**16%**	**34%**	**24%**	**24%**	**2%**	**100%**
Entire Plan area	**21%**	**29%**	**24%**	**25%**	**1%**	**100%**

Source: Plan Director de Aqua Potable y Saneamiento: Executive Summary Document p. 8.

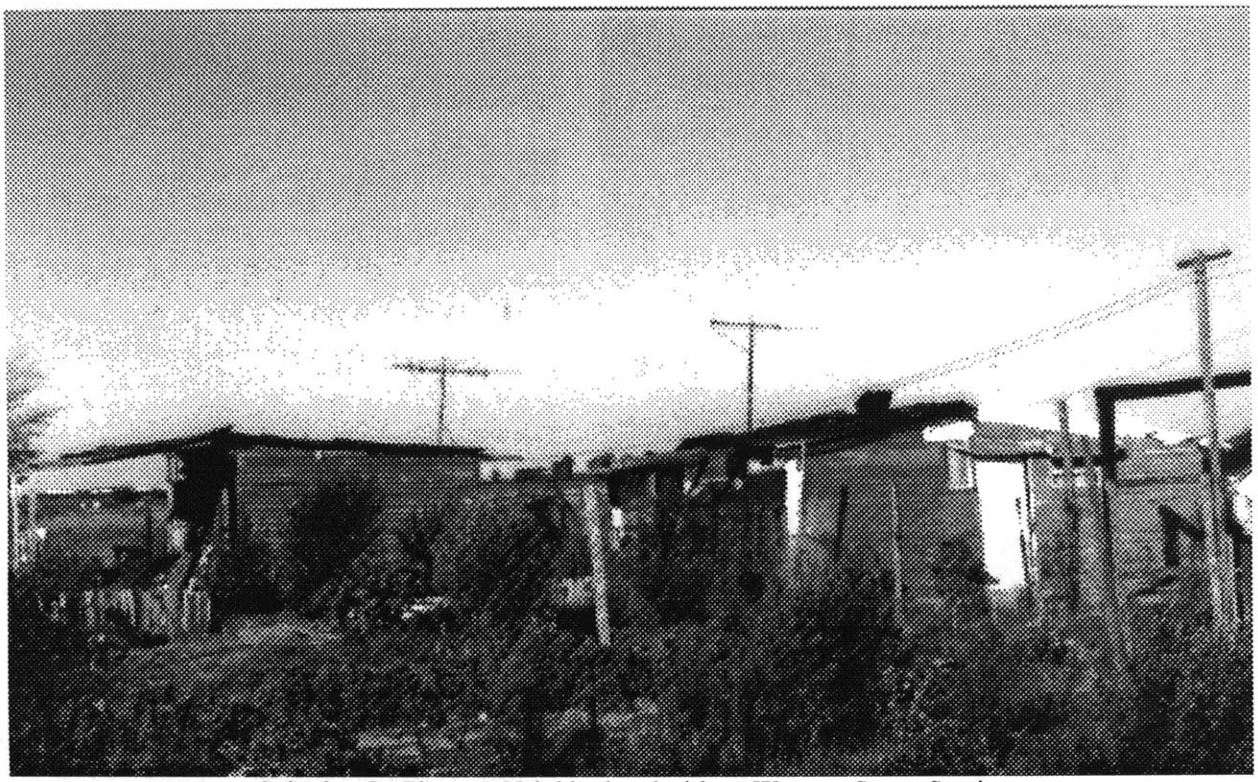
According to the UNLP market surveys, residents in unsewered areas' primary complaints regarding their waste disposal systems are unpleasant odors, problems with obstructed pipes, and overfull absorption pits.[17] Areas with no public sewer service, especially where alternate facilities are not functioning properly, are often zones of high sanitary risk. Due to the congested structure of some unsewered neighborhoods, and because of a lack of information regarding health risks, absorption pits may be very near to drinking water wells, presenting a serious potential health hazard. Some neighborhoods also use surface water ways (rivers, canals, streams and ditches) as waste repositories, creating a significant source of surface water pollution and a further health hazard. The inadequacy of wastewater service in parts of the La Plata System is especially important in light of the current cholera threat.

3.4 PHOTOS (FOLLOWING PAGES)

[17] Plan Director de Agua Potable y Saneamiento. Executive Summary,1995.

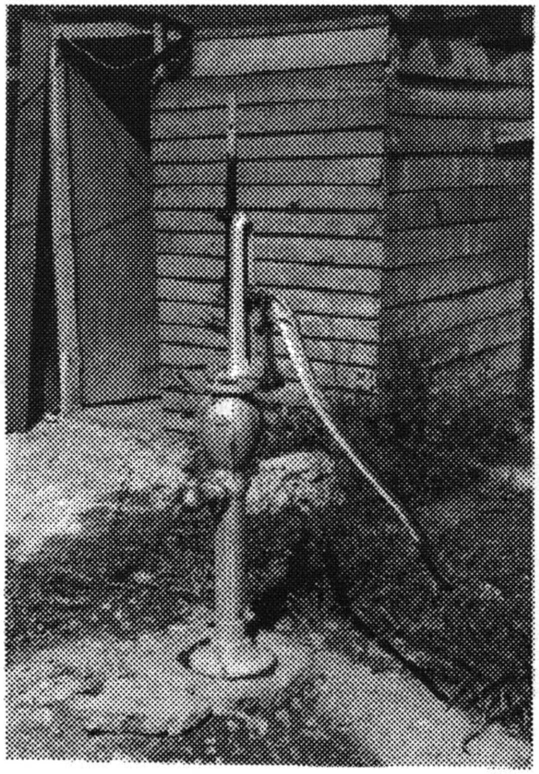
Downtown La Plata: High-rise Office and Apartment Buildings

Downtown La Plata: High-rise Office and Apartment Buildings

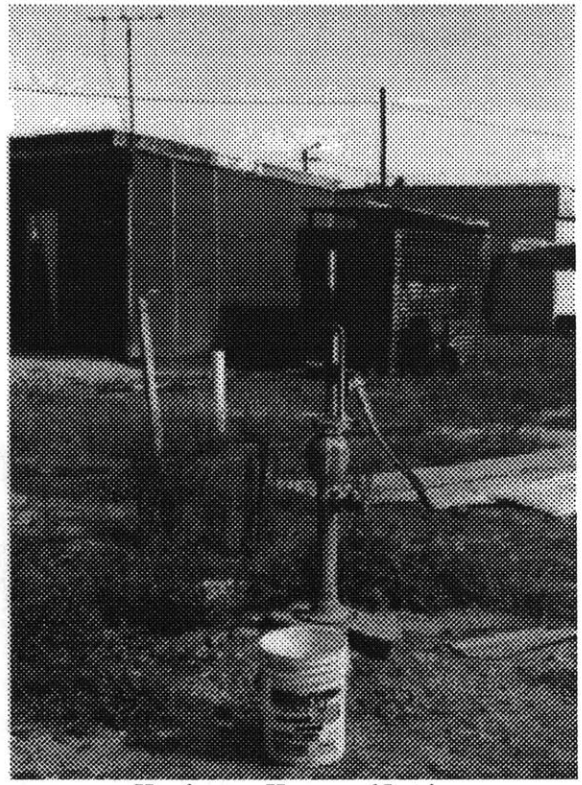


Suburban La Plata: A Neighborhood without Water or Sewer Service

A Neighborhood in La Plata with Water Service but no Sewers

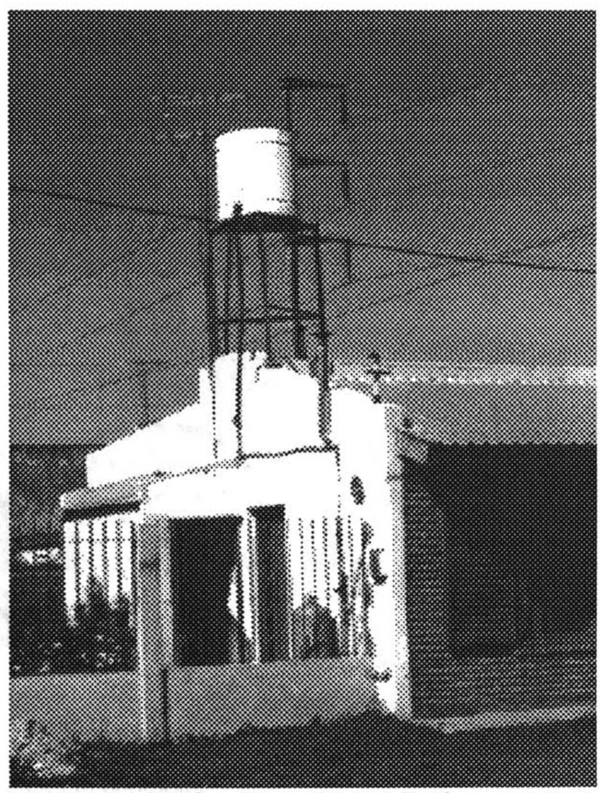


Handpump and Latrine
(Shared by several families)

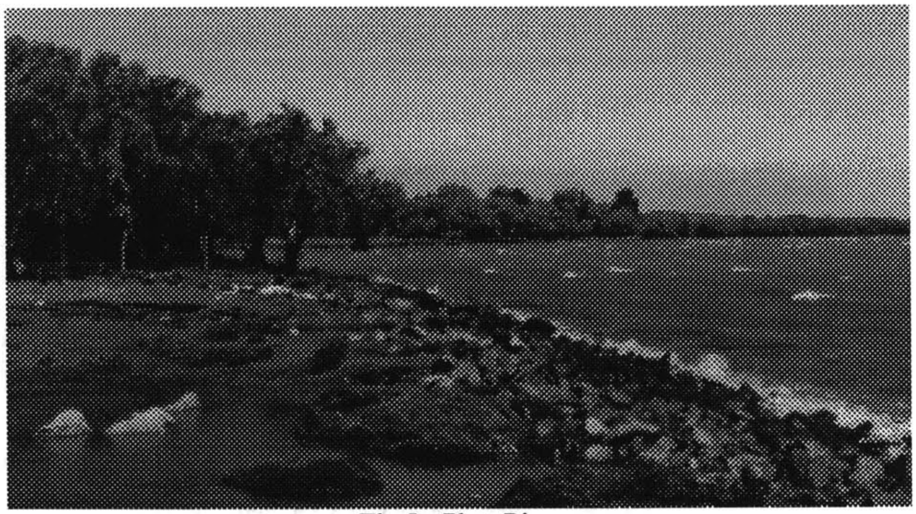


Handpump, House and Latrine

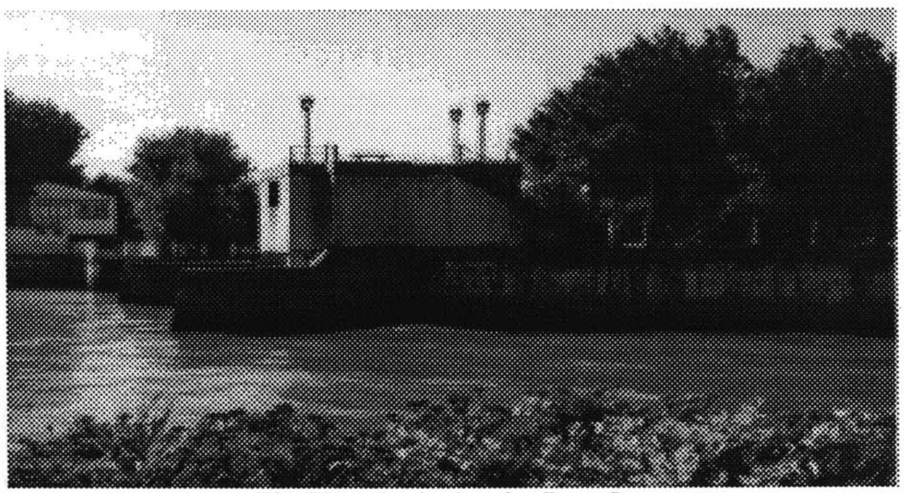
Washing Basin



Rooftop Water Storage Tank

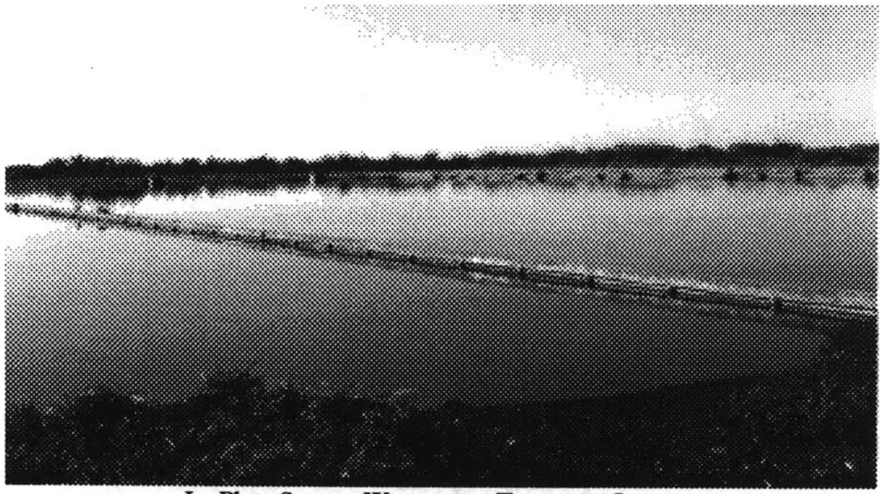


The La Plata River



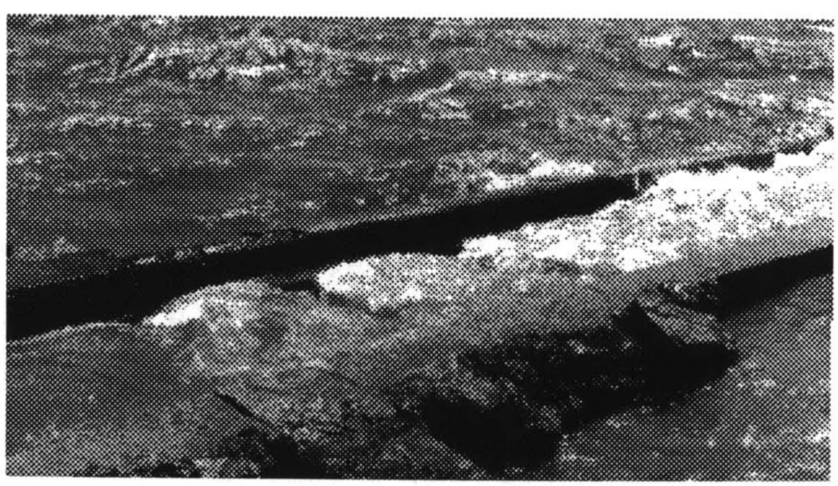
The Water Intake Canal at Punta Lara

The La Plata System's Water Treatment Plant

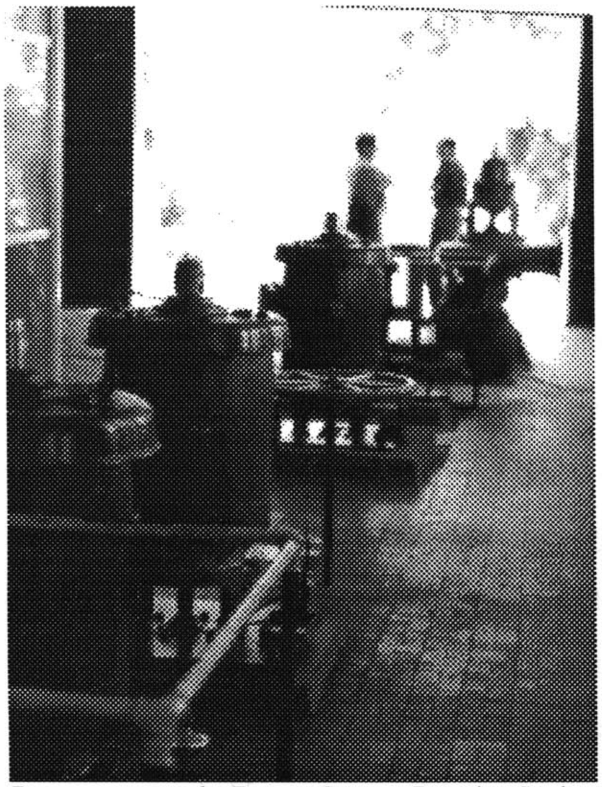


La Plata System Wastewater Treatment Lagoons

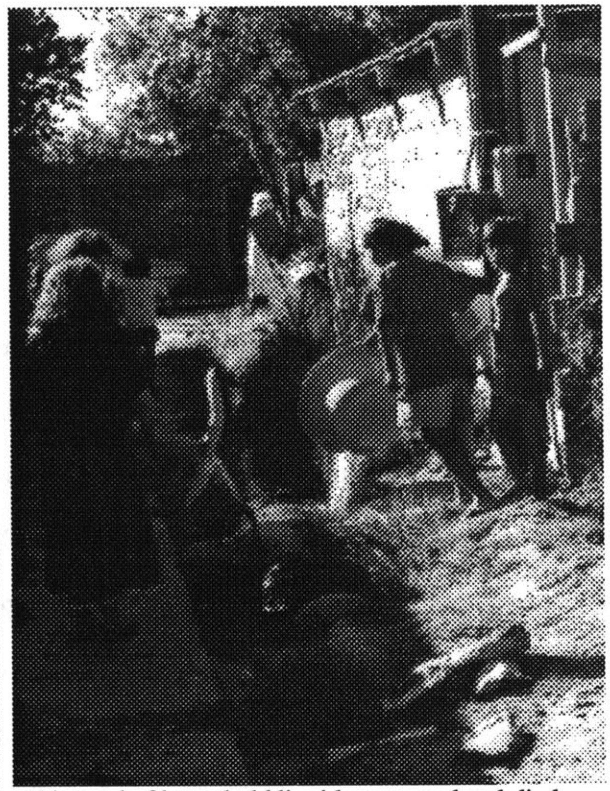
Outfall Pipe near its Discharge Point



Discharge of Untreated Wastewater to the La Plata River



Pump motors at the Bosque Sewage Pumping Station



Disposal of household liquid wastes to local ditch

This clogged ditch is the wastewater collection and conveyance system for one unsewered area in La Plata.

4. ANALYSIS

4.1 INTRODUCTION

Compared with planning areas in the developed world, and in particular, the United States, the La Plata System is in a unique position to implement DSM. First, the La Plata System's plentiful water supply--the La Plata River and abundant groundwater reserves--obviates the need to rely on emergency measures, which may be expensive and difficult to implement, and allows the inclusion of only methods that are cost-effective, easily undertaken and produce significant demand reductions. Second, the current lack of emphasis on prudent water use practices leaves ample room for reducing uneconomic or wasteful consumption among existing customers. Finally, the Plan's focus on providing water and sewer service to those people who are currently unserved and to new residents permits widespread application of measures most suitable for new connections. The anticipated growth of the served population in the planning area means that these measures will contribute a sizable portion of water savings in the long term.

In this chapter, I analyze a number of progammatic DSM options to determine whether they are cost-effective for the La Plata System. In the next chapter, I suggest implementation strategies for those programs I conclude are worthy of undertaking.

The process I used in this analysis is to estimate the potential water use savings from a given program and divide that amount by the program's cost, to derive a cost in dollars per liter saved. I then compare this quantity to the short-run variable cost of operating and maintaining the water and wastewater system. This cost is also expressed in dollars per liter. If the cost of saving a liter of water is less than the cost of delivering and treating that water, I conclude that the program is cost effective.

The short-run variable cost analysis, however, should be supplemented by an analysis of capital cost savings that might accrue from the use of DSM measures. For example, if the La Plata region is able to build a smaller wastewater treatment plant because flows through the system are reduced, the analysis should include the annualized capital cost savings per liter. The factor might be particularly important in La Plata, where much of the capital planning is for system expansions, as opposed to more developed areas, where capital funds might be more associated with rehabilitation of existing facilities.

The difficulty with such an analysis, however, is in determining the "break points" in facilities' design. For example, at what level of flow reduction would planners decide to downsize the design capacity of a new wastewater plant from , say 300,000 m^3/.day to 200,000 m^3/day? In spite of my best attempts, it was not always possible for me to obtain these planning criteria from the Plan's staff, although in some cases I was able to get approximate figures. Accordingly, I present my results in three ways:

1) If a DSM measure was clearly cost-effective, based solely on variable operation and maintenance cost reductions, I have recommended that it be considered for implementation. To the extent that such a program also produces capital savings, there will be an extra benefit to the citizens of the region. Thus, my analysis <u>understates</u> the potential benefit of such programs.
2) If a DSM measure is not clearly cost-effective based solely on variable operation and maintenance cost reductions, but I have reason to believe--based on limited data provided me, supplemented by my judgment as a sanitary engineer--that the measure would be of benefit to La Plata, I recommend it for a more thorough analysis and study before the design plans are finalized for the La Plata water and wastewater system.
3) If, because of data limitations, I cannot demonstrate at this time the efficiency of DSM measures that have nonetheless been shown to be of value in other

jurisdictions, I recommend that they be studied as potential adjuncts to the region's long-term plan.

My analysis concludes:

- Water saving programs comprising door to door household device distribution, requirements for low flow fixtures in all new connections, and a low flow toilet retrofit would be cost effective as DSM measures based on avoided operation and maintenance costs alone;
- The potential for benefit from infiltration /inflow reduction exists in the La Plata System, and should be evaluated before final plans for a new wastewater treatment facility are made; and
- A number of other DSM measures are applicable for the La Plata system and may be beneficial techniques to consider in the current planning effort.

This chapter begins with description of the demand estimates that the planners at UNLP are using for planning purposes and discusses the decision factors I used to select DSM methods for analysis with respect to the La Plata system. The next section of this chapter includes: a simple cost benefit analysis residential water saving device DSM measures as they would be applied in La Plata; a qualitative discussion of the benefits of including I/I, leak detection and metering programs; and an overview of the benefits available through implementing other DSM measures. This chapter concludes with recommendations for components of a DSM plan. Chapter 5 includes a discussion of implementation strategies for the recommended measures.

4.2 LA PLATA SYSTEM DEMAND ESTIMATES

The planners at UNLP used a variety of sources when formulating their demand estimates for the master planning area. Relying on national census data, existing records, and directed surveys, they combined their knowledge of local water use patterns with those of other large metropolitan areas. In describing the process used to generate demand numbers, the Plan's authors note that water usage varies from city to city, even from one neighborhood to the next, and may be dependent on many factors:

- climate;
- persons per household;
- access to public water and sewer networks;
- types of commercial and industrial activity in the area;
- quality of water;
- distribution system pressure; and
- metering practices.[1]

Chapter 3 provides background on these factors for the case study area.

To place water usage levels for the master planning area in context, the planners compared local information with that of several other cities throughout the world. They noted a wide range of consumption patterns, ranging from 662 lpcd in Oslo to 225 lpcd in Hamburg[2], including residential, commercial and industrial. When selecting demand estimates for their study area, the planners identified a usage level that would provide water sufficient for basic needs at a comfortable standard of living, while assuming the existence of a public education program. They estimated consumption of between 150-200 lpcd for combined domestic and commercial use in metered households and 270 lpcd for combined domestic and commercial use in unmetered areas.[3] These estimates are consistent with EPA estimates of 246 lpcd for domestic use (Table 2.1).

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[1] Plan Director Volume 2, Book 2.2, p.69.

[2] Plan Director Volume 2, Book 2.2, p.69. Figures include commercial and industrial use.

[3] Plan Director Volume 2, Book 2.2, p.69-70.

The Plan's industrial use estimates for the La Plata System are based on an examination of available data from large industrial users. For areas outside of La Plata, the planners estimate industrial use demand at 37 lpcd. La Plata, Berisso and Ensenada, with a higher concentration of industrial activity than other Plan areas, are assumed to have a per capita industrial water demand of 70 lpcd.

Including estimated system losses of 60 l/pd, the La Plata System water demand estimates break down as follows (Table 4.1).

Table 4.1
La Plata System Demands

Category	**Usage Level (l/pd)**
Domestic and Commercial	270
Industrial	70
System Losses	60
Total	**400**

Source: Plan Director De Aqua Potable y Saneamiento Volume 2, Book 2.1, p.72.

The planners, citing North American planning practice, also estimate that per capita demand will increase (Table 4.2).

Table 4.2
La Plata System Demand Increase Projections

Section	**1995**	**2005**	**2020**
Berisso	400	404	410
Ensenada	400	404	410
La Plata	400	404	408

Source: Plan Director De Aqua Potable y Saneamiento Volume 2, Book 2.1, pp. 72-3.

This analysis will not alter these baseline demand estimates, with one exception. For demand side management calculations for the entire La Plata System, this analysis will use the City of La Plata demand increase projections (Table 4.2) as representative of the entire case study area.

4.3 SELECTION OF MEASURES FOR FURTHER ANALYSIS

4.3.1 Introduction

A number of factors contributed to the decision regarding which DSM measures to select for analysis here. This section of Chapter 4 revisits the DSM measures introduced in Chapter 2 and discusses, for each, the potential benefits of including them in a DSM program for the La Plata System. Methods that are inappropriate for use in the case study area were eliminated from consideration immediately. Demand reduction techniques already in use - or planned - by the managers of LP's water and sewer utilities were not necessary to analyze, and the remaining possible methods were considered based on several factors:

- Contribution to understanding and control of water demand;
- Contribution to good operation and maintenance of public utilities;
- Cost;
- Ease of Implementation;
- Long-term effectiveness;
- Availability; and
- Public Acceptance.

Because this preliminary analysis concludes that structural/operational methods are especially appealing techniques for the La Plata System, they appear first here. A discussion of the selection of analytical and social/economic methods follows thereafter.

4.3.2 Structural/Operational Methods

Structural/Operational Methods, which reduce water consumption by restricting flow and mitigating waste, have excellent potential for implementation in the La Plata system. They provide immediate and long-term water reductions at low cost, are easy to implement, and are a popular method for combining water reduction strategies with education and information gathering. The practice of distributing water saving devices, in particular, has enjoyed substantial success in the United States, and would be a relatively easy measure to initiate in the La Plata System. The following section begins with a simple cost benefit analysis for the use of water saving devices and continues with a discussion of the benefits of infiltration /inflow detection and removal and leak detection and repair.

Water Saving Devices. Water saving devices, which restrict water flow through common fixtures and appliances, produce the benefit of increased customer awareness in addition to providing immediate water demand reductions. By combining measures applied to new construction with those aimed at existing customers, a significant reduction in demand is achievable. This analysis examines the affects of initiating a water saving device distribution program , a requirement for low flow devices in all new construction and a toilet retrofit program. The benefits of such a combination are many. The distribution and installation of water saving devices such as low flow showerheads, faucet flow restrictors, and toilet tank displacement devices door to door lends itself to excellent personal information dissemination and encourages use and retention of the devices. A change in the plumbing code can assure that low flow fixtures are installed in all new construction. With the initiation of a rebate program for low flow toilets, a utility may encourage people who already have sewer service to replace existing standard toilets with low flow models. This combination of programs will result in a reduction of water demand, increased customer awareness, a reduced need for wastewater treatment capacity, and may improve customer relations.

The educational and public relations benefits of such projects notwithstanding, a utility may require additional justification before undertaking such wide-reaching, visible projects. Typically, the necessary justification consists of a cost benefit analysis. Accordingly, the following pages present the results of a simple cost benefit analysis for water saving device projects targeted at the domestic sector (Tables 4.3 and 4.4). This analysis tracks the water demand reductions possible for each of the three projects over the next 24 years and compares the net present value (NPV) costs of the projects to the NPV of the operation, maintenance and administration costs associated with providing a volume of water equal to that saved through the projects. (Tables 4.3 and 4.4 note in detail my assumptions regarding the timing, costs and water savings for each of the projects.) As Table 4.4 shows, a door-to-door water saving device program would provide a water savings of around 5 million lpd, starting as early as 1999, with a NPV cost of $1.5 million and an associated NPV O & M cost savings of approximately $1.9 million. Low flow showerheads and toilets in all new connections would produce an estimated demand reduction of about 11.4 million lpd by the end of the planning period, providing around $2 million NPV cost savings in operation, maintenance and administration at virtually no expense to the utility. A toilet retrofit program producing around 21 million lpd water savings by 2020 is also cost effective, with estimated NPV costs of $2.5 million and a savings NPV of $2.8 million. The three programs combined would result in an estimated demand reduction of about 37.6 million lpd by 2020 at an NPV cost of $3.8 million, producing O & M expense savings of $6.6 million.

Programs such as those included in this analysis have been implemented with success in many systems in the United States. While the availability of some water saving devices may be somewhat limited in Argentina currently, it is assumed that the implementation of a large scale water efficient device program would attract the involvement of existing Buenos Aires device manufacturers and suppliers to the new product market provided by the program. Similar

Table 4.3
Savings from Domestic Programs

A	B	C	D	E	F	G	H	I	J	K	L	M
Year	Population Served - Water	Population Served - Sewer	Pop. With New Water Service This Year	Pop. With New Sewer Service This Year	**Total Domestic Demand for Pop. Served with Water @ 246l/p*d (l/d)**	Savings from Door-to-Door Water Saving Device Program (l/d)	Savings from Low Flow Shower Heads in New Water Connections (l/d)	Savings from Low Flow Toilets in New Sewer Connections (l/d)	Savings from Low Flow Toilet Retrofit Program (l/d)	Total Savings - All Domestic Programs (l/d)	**Revised Daily Demand including Domestic Programs (l/d)**	Total Savings as a Percentage of Domestic Demand at 246 l/p*d
1995	520,446	448,947	9,040	15,928	**128,029,716**					-	**128,029,716**	0.0%
1996	529,486	464,875	9,040	15,928	**130,253,531**					-	**130,253,531**	0.0%
1997	538,526	480,802	9,040	15,928	**132,477,347**	1,686,836			883,528	2,570,364	**129,906,983**	1.9%
1998	547,566	496,730	9,040	15,928	**134,701,162**	3,374,010	155,667	783,643	1,767,055	6,080,375	**128,620,787**	4.5%
1999	556,606	512,658	9,040	15,928	**136,924,978**	5,061,015	311,334	1,567,286	2,650,583	9,590,218	**127,334,760**	7.0%
2000	565,646	528,586	9,040	15,928	**139,148,793**	5,061,015	467,001	2,350,929	3,534,111	11,413,055	**127,735,738**	8.2%
2001	574,685	544,513	9,040	15,928	**141,372,608**	5,061,015	622,668	3,134,571	4,417,638	13,235,893	**128,136,716**	9.4%
2002	583,725	560,441	9,040	15,928	**143,596,424**	5,061,015	778,335	3,918,214	5,301,166	15,058,730	**128,537,693**	10.5%
2003	592,765	576,369	9,040	15,928	**145,820,239**	5,061,015	934,002	4,701,857	6,184,694	16,881,568	**128,938,671**	11.6%
2004	601,805	592,296	9,040	15,928	**148,044,055**	5,061,015	1,089,670	5,485,500	7,068,222	18,704,406	**129,339,649**	12.6%
2005	610,845	608,224	4,582	4,490	**150,267,870**	5,061,015	1,168,580	5,706,414	7,951,749	19,887,758	**130,380,112**	13.2%
2006	615,427	612,714	4,582	4,490	**151,395,157**	5,061,015	1,247,490	5,927,329	8,835,277	21,071,110	**130,324,046**	13.9%
2007	620,010	617,204	4,582	4,490	**152,522,444**	5,061,015	1,326,400	6,148,244	9,718,805	22,254,463	**130,267,981**	14.6%
2008	624,592	621,694	4,582	4,490	**153,649,730**	5,061,015	1,405,310	6,369,158	10,602,332	23,437,815	**130,211,915**	15.3%
2009	629,175	626,185	4,582	4,490	**154,777,017**	5,061,015	1,484,220	6,590,073	11,485,860	24,621,167	**130,155,850**	15.9%
2010	633,757	630,675	4,582	4,490	**155,904,304**	5,061,015	1,563,130	6,810,987	12,369,388	25,804,520	**130,099,784**	16.6%
2011	638,340	635,165	4,582	4,490	**157,031,591**	5,061,015	1,642,040	7,031,902	13,252,915	26,987,872	**130,043,719**	17.2%
2012	642,922	639,655	4,582	4,490	**158,158,878**	5,061,015	1,720,950	7,252,816	14,136,443	28,171,224	**129,987,653**	17.8%
2013	647,505	644,145	4,582	4,490	**159,286,164**	5,061,015	1,799,860	7,473,731	15,019,971	29,354,577	**129,931,588**	18.4%
2014	652,087	648,635	4,582	4,490	**160,413,451**	5,061,015	1,878,770	7,694,645	15,903,499	30,537,929	**129,875,522**	19.0%
2015	656,670	653,125	4,582	4,490	**161,540,738**	5,061,015	1,957,680	7,915,560	16,787,026	31,721,281	**129,819,457**	19.6%
2016	661,252	657,615	4,582	4,490	**162,668,025**	5,061,015	2,036,590	8,136,475	17,670,554	32,904,634	**129,763,391**	20.2%
2017	665,835	662,106	4,582	4,490	**163,795,312**	5,061,015	2,115,501	8,357,389	18,554,082	34,087,986	**129,707,326**	20.8%
2018	670,417	666,596	4,582	4,490	**164,922,598**	5,061,015	2,194,411	8,578,304	19,437,609	35,271,338	**129,651,260**	21.4%
2019	675,000	671,086	4,582	4,490	**166,049,885**	5,061,015	2,273,321	8,799,218	20,321,137	36,454,691	**129,595,195**	22.0%
2020	679,582	675,576	4,582	4,490	**167,177,172**	5,061,015	2,352,231	9,020,133	21,204,665	37,638,043	**129,539,129**	22.5%

Notes:

B & C. Assumes Population Served increases linearly 1995-2005 and 2005-2020

G. Devices installed and retained in 59% (MWRA) of households over three years. 6.7% water savings per person.

H & I. All new connections will use low flow showerheads and toilets. Showerheads: 7% reduction in domestic per capita demand.
Toilets: 20% reduction in per capita domestic demand.

J. Toilet retrofit program assumed to affect an additional 4% of people with existing sewer service (1995) each year, 20% reduction in domestic per capita demand.

Table 4.4
Cost Benefit Analysis for Domestic Programs

A	B	C	D	E	F	G	H	I	J	K	L	M
Year	Water Savings from Door-to-Door Water Saving Device Program (l/d)	Annual Costs for Door-to-Door Water Saving Device Program ($)	Annual O & M Cost Savings from Door-to-Door Program, Water and Sewer ($)	Water Savings from Low Flow Shower Heads in New Water Connections (l/d)	Water Savings from Low Flow Toilets in New Sewer Connections (l/d)	Annual Cost to Implement Requirement for Low Flow Devices in All New Connections ($)	Annual O & M Cost Savings from Low Flow Devices in New Connections, Water and Sewer ($)	Water Savings from Low Flow Toilet Retrofit Program (l/d)	Annual Costs for Toilet Retrofit Program ($)	Annual O & M Cost Savings from Toilet Retrofit Program, Water and Sewer ($)	Total Costs - All Domestic Programs ($)	Total Annual O & M Cost Savings from All Domestic Programs, Water and Sewer ($)
1995	-	$ -	$ -	-	-	$ -	$ -	-	$ -	$ -	$ -	$ -
1996	-	$ -	$ -	-	-	$ -	$ -	-	$ -	$ -	$ -	$ -
1997	1,686,836	$ 684,634	$ 100,783	-	-	$ -	$ -	883,528	$ 338,634	$ 52,788	$ 1,023,269	$ 153,571
1998	3,374,010	$ 684,634	$ 201,586	155,667	783,643	$ -	$ 56,121	1,767,055	$ 338,634	$ 105,576	$ 1,023,269	$ 363,283
1999	5,061,015	$ 684,634	$ 302,380	311,334	1,567,286	$ -	$ 112,242	2,650,583	$ 338,634	$ 158,364	$ 1,023,269	$ 572,985
2000	5,061,015	$ -	$ 302,380	467,001	2,350,929	$ -	$ 168,362	3,534,111	$ 338,634	$ 211,152	$ 338,634	$ 681,894
2001	5,061,015	$ -	$ 302,380	622,668	3,134,571	$ -	$ 224,483	4,417,638	$ 338,634	$ 263,940	$ 338,634	$ 790,803
2002	5,061,015	$ -	$ 302,380	778,335	3,918,214	$ -	$ 280,604	5,301,166	$ 338,634	$ 316,728	$ 338,634	$ 899,712
2003	5,061,015	$ -	$ 302,380	934,002	4,701,857	$ -	$ 336,725	6,184,694	$ 338,634	$ 369,516	$ 338,634	$ 1,008,621
2004	5,061,015	$ -	$ 302,380	1,089,670	5,485,500	$ -	$ 392,846	7,068,222	$ 338,634	$ 422,304	$ 338,634	$ 1,117,529
2005	5,061,015	$ -	$ 302,380	1,168,580	5,706,414	$ -	$ 410,759	7,951,749	$ 338,634	$ 475,092	$ 338,634	$ 1,188,231
2006	5,061,015	$ -	$ 302,380	1,247,490	5,927,329	$ -	$ 428,673	8,835,277	$ 338,634	$ 527,880	$ 338,634	$ 1,258,932
2007	5,061,015	$ -	$ 302,380	1,326,400	6,148,244	$ -	$ 446,586	9,718,805	$ 338,634	$ 580,668	$ 338,634	$ 1,329,634
2008	5,061,015	$ -	$ 302,380	1,405,310	6,369,158	$ -	$ 464,500	10,602,332	$ 338,634	$ 633,456	$ 338,634	$ 1,400,336
2009	5,061,015	$ -	$ 302,380	1,484,220	6,590,073	$ -	$ 482,414	11,485,860	$ 338,634	$ 686,244	$ 338,634	$ 1,471,037
2010	5,061,015	$ -	$ 302,380	1,563,130	6,810,987	$ -	$ 500,327	12,369,388	$ 338,634	$ 739,032	$ 338,634	$ 1,541,739
2011	5,061,015	$ -	$ 302,380	1,642,040	7,031,902	$ -	$ 518,241	13,252,915	$ 338,634	$ 791,820	$ 338,634	$ 1,612,440
2012	5,061,015	$ -	$ 302,380	1,720,950	7,252,816	$ -	$ 536,154	14,136,443	$ 338,634	$ 844,608	$ 338,634	$ 1,683,142
2013	5,061,015	$ -	$ 302,380	1,799,860	7,473,731	$ -	$ 554,068	15,019,971	$ 338,634	$ 897,396	$ 338,634	$ 1,753,843
2014	5,061,015	$ -	$ 302,380	1,878,770	7,694,645	$ -	$ 571,981	15,903,499	$ 338,634	$ 950,184	$ 338,634	$ 1,824,545
2015	5,061,015	$ -	$ 302,380	1,957,680	7,915,560	$ -	$ 589,895	16,787,026	$ 338,634	$ 1,002,972	$ 338,634	$ 1,895,247
2016	5,061,015	$ -	$ 302,380	2,036,590	8,136,475	$ -	$ 607,809	17,670,554	$ 338,634	$ 1,055,760	$ 338,634	$ 1,965,948
2017	5,061,015	$ -	$ 302,380	2,115,501	8,357,389	$ -	$ 625,722	18,554,082	$ 338,634	$ 1,108,548	$ 338,634	$ 2,036,650
2018	5,061,015	$ -	$ 302,380	2,194,411	8,578,304	$ -	$ 643,636	19,437,609	$ 338,634	$ 1,161,336	$ 338,634	$ 2,107,351
2019	5,061,015	$ -	$ 302,380	2,273,321	8,799,218	$ -	$ 661,549	20,321,137	$ 338,634	$ 1,214,124	$ 338,634	$ 2,178,053
2020	5,061,015	$ -	$ 302,380	2,352,231	9,020,133	$ -	$ 679,463	21,204,665	$ 338,634	$ 1,266,912	$ 338,634	$ 2,248,755
NPV (1996, 12%)		$ 1,468,193	$ 1,869,170				$ 1,993,072		$ 2,353,604	$ 2,803,287	$ 3,821,797	$ 6,665,529

Notes:

B, E, F, & I. See Table 4.3

C. Assumes a three year program, during which time every household is visited at a cost of $17/household. (Rocky Mountain Institute, 1991)

D, H, K & G. Operation, Maintainace and Administration costs are $0.08879/m3 for water and $0.0749/m3 for sewer, or $0.1637/m3 total (Plan Director Memoranda on Rate Calculations, 1996).

J. Assumes 4% of households with sewer service existig in 1995 will replace a toilet each year. 3.5 persons/household, cost of toilet = $150. Utility pays for 40%, Administrative costs = 10% of rebate cost (Rocky Mountain Institute 1991) requirements have prompted relatively rapid responses from manufacturers (as fast as 1 year for newly designed, inexpensive low flush toilets) in the United States.[4]

The potential for wide-spread use of water saving appliances such as dishwashers and laundry equipment may be more limited. Most efficient appliance designs in the US today are geared for energy efficiency, rather than reduced water use. Colin Laird, in Water-Efficient Technologies: A Catalog for the Residential/Light Commercial Sector (Rocky Mountain Institute, 1991), writes:

> "In many ways the appliance industry is in the same position the toilet industry was in 10 years ago: most of the innovative technologies for using water efficiently are first manufactured and marketed in European countries and Japan. Today, there is a large selection of ultra-low flush toilet in this country and, with the growing interest in water efficiency, the domestic selection of water-efficient appliances is likely to increase."

The managers of the La Plata System water and sewer systems should remain alert for the potential of encouraging water efficient appliance use in the years to come.

Infiltration/Inflow Detection and Removal. I/I detection and removal, which reduces the entrance of stormwater runoff and groundwater into the wastewater collection system, may be a beneficial project for the La Plata System to undertake. As with programs that involve field investigations, I/I detection provides operators increased knowledge of the wastewater collection system. Removal of I/I decreases collection system capacity needs and reduces the potential for structural failures in the collection network. Elimination of "clean water" flow in the collection system diminishes unnecessary hydraulic load on the wastewater treatment plant.

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[4] Personal correspondence with Pete Fetterer of Kohler Company, 444 Highland Dr., Kohler, WI 53044. (404)457-4441. 4/22/96.

Minimizing stress on existing wastewater treatment capacity and reducing planned capacity have been the motivations for extensive I/I projects in several communities in Massachusetts. In Lowell, extensive I/I detection was undertaken as a component of a wastewater facilities planning effort. Lowell's regional water pollution control facility, which treats flow from a combined wastewater/stormwater collection system, experiences exceedences of its capacity that become severe during periods of high runoff (usually snow melt periods and heavy rain events) and during high groundwater season. These severe exceedences of the plant's capacity result in the undesirable discharge of untreated combined sewage flow to the City's receiving waters: the Merrimac river and its tributaries. I/I removal, along with collection system storage augmentations, are planned as methods for reducing the severity of these high flow periods in lieu of increasing wastewater treatment plant capacity.

The reduction of necessary wastewater treatment capacity (as a strategy for increasing pollution control in a cost effective manner) motivated a legal requirement for extensive I/I detection and removal in the South Essex Sewerage District (SESD), a 5-city wastewater authority in northeastern Massachusetts. SESD is currently expanding its water pollution control facility in accordance with strict court-ordered deadlines. The design capacity of the expanded plant has been reduced by successful I/I detection and removal in the communities served by SESD.

Communities in the Massachusetts Water Resources Authority (MWRA) collection system are engaging in a variety of I/I detection and elimination programs. These I/I programs are part of a comprehensive effort to reduce wastewater flows in the system, with the ultimate goal of reducing or eliminating discharges of untreated sewage to the MWRA's receiving waters (in particular, the environmentally strained Boston Harbor.)

The examples above are projects being undertaken in wastewater systems that have I/I flows comprising 20-60% of average daily flow (based on results of continuous flow monitoring). In accordance with standard sanitary engineering practice for determining design flows, the planners at UNLP estimate that 80% of the potable water delivered to customers reaches the wastewater collection system (80% return rate). UNLP staff also estimate that design flows include 26 lpcd of infiltration.[5] This infiltration rate estimate for the La Plata System, with its aging collection network and high groundwater table, is highly optimistic. It is possible that the La Plata System's infiltration - and inflow - rates are higher (perhaps *much* higher) than those estimated in The Plan.

The La Plata System's wastewater facilities plan includes a treatment plant. If La Plata's infiltration rates are significantly higher than those estimated in The Plan, it may be advisable for the La Plata System planners to compare the cost of removing infiltration and inflow to the cost of constructing treatment facilities for it. The simple chart below shows how, for infiltration levels of about 30% and higher, it is more cost-effective to remove I/I than to build treatment capacity for it (Table 4.5).

Table 4.5

I/I Removal Costs vs. Treatment Costs

A	B	C	D	E	F
Potable Water Return Flow (m^3/day)	Assumed Additional I/I % of Flow	Flow to Plant Including I/I (m^3/day)	Achievable I/I Reduction (m^3/day)	Total Cost to Survey and Repair	Cost Avoided - Treatment for Removed Flow
160,000	20%	192,000	19,200	$7,620,000	$5,072,655
160,000	30%	208,000	28,800	$7,620,000	$7,608,983
160,000	40%	224,000	38,400	$7,620,000	$10,145,310

Notes:
A. 400 lpcd water consumption, 80% of delivered water entering sewer system.
D. Assumed 60% reduction of I & I possible.
E. 1,500 km of sewer main @ $5,080/km (MWRA Board of Director Memo, 1995, p.6)
F. Planning estimate of treatment plant cost at $1/gpd.

[5] Plan Director Volume 1, p.65

Given the possible operational, managerial and financial advantages of undertaking I/I detection and removal in areas with high I/I rates, I recommend that the La Plata System evaluate the potential for I/I projects through preliminary investigations. Continuous flow monitoring, as part of a system survey, would provide the data necessary to justify and design an extensive I/I detection program, as described in Chapter 5 - Implementation.

Leak Detection and Repair. Leak detection and repair programs, which reduce the waste of treated water from leaks in the water distribution system, have many benefits. First, comprehensive leak detection and repair programs can provide significant reductions in system-wide water use. For example, leak detection and repair programs throughout the Massachusetts Water Resources Authority service area resulted in a system-wide demand reduction of 10 percent. The process of surveying the system for leaks increases knowledge about the system facilities. Repair of leaks allows for more efficient use of existing supplies. Leak repair increases the integrity of the distribution system and reduces the potential for property damage. This in turn may improve public relations.[6]

It is difficult to quantify the benefits of leak detection and repair, because such programs do not result in drastic changes in facility needs, nor do they affect wastewater flow volumes. Changes in cost based pricing that are possible as a result of leak repair may favor the consumer, but are hard to quantify before the quantity of recovered leakage is known. The value of averted property damage is similarly difficult to estimate.

La Plata System managers can use the results of a detailed water audit (See Analytical Methods, Section 4.3.3) to estimate leakage and decide if leak detection and repair program is warranted.

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[6] Building Sustainable Communities: An Environmental Guide for Local Government, (1991, p.36)

> "Water system losses...do not automatically mean that an expensive leak detection program should be undertaken. An agency should not perform a leak detection survey until it is certain one is needed and it will be cost effective. Some experts estimate that the cost of the program should not exceed five to seven times the expected annual savings. Another authority recommends that any water loss above 10 percent is worth some effort to control, and a 20 percent loss definitely calls for action."[7]

The La Plata System's losses, estimated by UNLP at 60 lpcd or 15% of total consumption, may warrant a leak detection and repair program. Another factor to consider in evaluating the need for leak detection and repair is the value of keeping system piping in good condition. Typical inner city piping, installed at the turn of the century, experiences 31 breaks per 1000 km every year.[8] Because of its potential for waste reduction and good system maintenance, and because of its value as good management practice, I recommend that La Plata evaluate the potential for leak detection and repair carefully.

4.3.3 Analytical Methods

Analytical methods, which provide planners, operators and managers detailed information about a utility system and its facilities, are not usually undertaken with the primary goal of reducing water demand. These methods nevertheless lay the groundwork for planning and implementing other DSM methods.

Audit and System Survey. Performing a water audit and taking a system survey are considered good management practices, in that they contribute to a solid understanding of public works and networks. Detailed audit and survey information may be viewed as tools which equip the system manager to plan for growth, perform periodic maintenance and make timely repairs. Accurate and comprehensive system information fosters the undertaking of structural and

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[7] Building Sustainable Communities: An Environmental Guide for Local Government, (1991, p.36)

operational DSM methods such as leak detection and repair and I/I detection and removal. I recommend that the La Plata System utility managers perform a detailed water audit and system survey for all areas currently not represented by this type of data.

Metering. Water metering, which is often implemented with the goal of recording and billing for water (and sewer) use, has the beneficial effect of reducing consumption in most installations simply by making customers aware of the quantity of water they are using. UNLP estimates that the inclusion of metering throughout the La Plata System would reduce overall per capita demand from 400 lpcd to around 300 lpcd. The engineers' preliminary cost benefit analysis of complete meter installation indicates that the cost to install and read meters would roughly equal the cost savings associated with reducing the size of system-wide (water) improvements based on the lower demand. There are several reasons why the planners may elect to augment the system rather than install the meters: increased network capacity would provide improved service and fire protection system-wide; installing meters on every water service connection would involve disruptive construction activity throughout the system; and there has been poor public acceptance of metering practice in other parts of the country.

There are, however, several important reasons why engaging system-wide metering would be highly beneficial to the La Plata System's operations, relative to both costs and good management practice. First, metering all connections would allow for excellent cost recovery through the initiation of full cost pricing based on actual use. Pricing based on actual use would permit an equitable remuneration for service. In addition, the consumption data provided by meter reading could be used as a planning tool. Finally, state-of-the-art meter reading technologies (including electronic meters readable over phone lines or via radio) have reduced meter reading costs to levels

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[8] Rainer, (1990, p.12)

below those estimated in UNLP's preliminary cost benefit analysis.[9] These new meter-reading technologies permit meter reading personnel to obtain consumption data with a minimum of disruption to customers. Because of the cost and operational benefits of meter installation, in addition to its potential for demand reduction, I recommend that UNLP reevaluate the potential of installing meters throughout the La Plata System.

4.3.4 Social/Economic Methods.

These methods, which reduce water demand by providing various incentives for customers to reduce use, can produce significant reductions, be cost-effective, and are not generally hampered by availability. It is not surprising that the managers of the La Plata System already plan to include an education program and a cost-based pricing scheme in their operations. While water use restrictions are not particularly appropriate for the La Plata system as a whole, because there is no scarcity of supply, system managers may wish to consider use restrictions as an interim measure on peak days in those areas which experience temporary water delivery interruptions. The potential for changes in the building/plumbing code are discussed under water saving devices, above. Changes in the manufacturing code, which would assure the production of only devices meeting certain water use standards, would be a good complement to building/plumbing code changes.

4.4 SUMMARY OF PROGRAM RECOMMENDATIONS

Structural/Operational Methods:

- Water Saving Devices - implement
- I/I Detection and Removal - evaluate potential before constructing treatment plant
- Leak Detection and Repair - evaluate

[9] Personal communication with representatives of Badger Meter, Inc. (800-633-0986) and ABB Kent Meters, Inc. (800-874-0890) 4/8/96.

Analytical Methods:

- Audit - implement
- System Survey - implement
- Metering - reevaluate

Social/Economic Methods

- Education - already planned
- Pricing - already planned
- Use Restrictions - perhaps, in selected cases
- Building/Plumbing/Manufacturing Code Modifications - implement

5. Implementation of Recommended Program

5.1 INTRODUCTION

During the Water and Wastewater Finance and Institutional Structure Seminar, held for delegates of The Buenos Aires Water and Sewer Master Planning Team at MIT in January of 1996, Richard Fox, President of Camp Dresser & McKee International[1], summarized his program management presentation in the following manner, "Plan, plan, plan. Never stop planning." Carrying out the recommendations provided in chapter 4 will require planning, not only for management of each DSM project, but also for program management in order to aid smooth implementation of a system-wide DSM effort. Good program management will incorporate DSM projects into other expansions and improvements envisioned by the planners at UNLP, will minimize costs and will set the stage for positive results.

Comprehensive program management, as well as individual project management, requires careful attention to organizational structure, schedule, budget, staffing and monitoring. Adherence to certain guidelines can increase the effectiveness of the various projects as well. The first section of this chapter will revisit each of the DSM measures suggested in Chapter 4 and present some of the keys to success that practitioners and authors in the DSM field have suggested for typical projects using these methods. The ensuing section will suggest a program path for carrying out the suggested projects in the La Plata System and will discuss general guidelines for DSM program management. Chapter 6 includes a discussion of how the master planning process is affected by the inclusion of DSM and points out where the managers of this program may face implementation challenges.

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[1] Camp Dresser & McKee Inc., a private consulting firm headquartered in Cambridge, Massachusetts, provides environmental planning, engineering and management services for public and private clients worldwide.

5.2 DSM PROJECTS - KEYS FOR SUCCESS

5.2.1 Analytical Methods

There are several management guidelines which are applicable to each of the analytical methods recommended for inclusion in La Plata's DSM program (water audit, system surveys, and metering). Following these general guidelines, which relate primarily to information and staffing, will help to establish the results of these preliminary efforts as valuable bases on which to plan and implement a continuing DSM program, as well as other projects associated with water and sewer infrastructure.

First, because analytical methods focus on obtaining and using information about water and wastewater systems, it is important to identify the data that the system planners, engineers, managers and operators will find most useful in their continuing efforts. The project efforts should then focus on identifying and obtaining access to the best data sources, using the best available methods.

Second, the information obtained during analytical-type projects will be used for years to come, so it is critical to provide for timely updates of the data and for access to the data by everyone who needs it. Following this guideline requires thorough planning for information format, storage and access and attention to anticipated information flows among users of the data. Anticipating the needs of data users will help to make the acquired data as useful as possible.

A final general guideline for implementing analytical measures (as well as to the structural/operational projects discussed in section 5.2.2) relates to the activities involved in system information acquisition. Employing these measures will probably require augmentation of system management staff in the form of new analysts and consultants, both in the office and in the field. Where possible, system managers should make every effort to hire and contract with the most qualified, experienced personnel and use the most up-to-date, efficient methods and equipment. Doing so will help to ensure the quality of the data obtained and will decrease "ramp up" time in the use of the new data.

Water Audit. Because the engineers performing a water audit will be relying on data from master meters, as well as selected meters throughout the distribution and collection systems, it is important to verify the accuracy of any meter data being used. It is not necessary to use data from completely accurate meters, as long as any consistent errors in the meters' readings are known. Any meter used in a water audit should be tested so that data may be adjusted appropriately. (Good management practice dictates that *all* meters are tested periodically.) If the expertise for testing meters is not available within the utility, a qualified consultant should be retained to perform the tests.

Another guideline for successful implementation of a water audit is to use at least one year's worth of data. If insufficient data is available at the start of the project, the final results should be delayed until data for at least one year is acquired. The auditors should, however, begin to analyze data as soon as it begins to be available, to check for inconsistencies and to make preliminary observations about usage trends.

System managers may also wish to treat the occasion of a water audit as an opportunity to update record-keeping techniques, if necessary. The analysis of water audit data may show that additional meters in the distribution or collection system would aid in system management.

The results of a water audit will include system flows, broken down into various components. As described in Chapters 2 and 4, these results will help system managers in determining whether additional studies are warranted. For water systems, the important category of use to examine is

UFW. Water flows that are not attributable to domestic, commercial, industrial or authorized public uses may be leakage and could warrant a leak detection project. Wastewater flows that are not attributable to the same categories may be infiltration or inflow and could indicate the need for I/I detection and repair. (See sections on Leak Detection and Repair and I/I Detection and Removal, below.).

System Surveys - Water and Wastewater Systems. In addition to the general guidelines for analytical methods presented above, there are several ways to contribute to the effectiveness of system surveys. First, define objectives for the surveys based on the ways in which system data is anticipated to be used. Managers of system survey projects must decide what level of detail and what degree of accuracy they need from survey results. This decision affects methodology, and thus, costs. For example, sewer system survey results that will eventually be used as part of individual pipeline design documents must be at a finer scale than results which will be used for planning at the drainage sub-area level. Fine scale results may require extensive use of ground survey crews, whereas larger scale mapping may be possible using aerial photography supplemented by field verification. Managers of survey projects must also decide - early in the process - in what format the data will be most useful and plan for how this affects data acquisition methods. Data which will eventually be stored digitally, for example, might be possible to acquire using electronic methods, rather than paper methods, at many stages in the survey process.

Second, begin with a map. A system map, at some reasonable level of accuracy, will provide surveyors with the information necessary to plan an efficient project. (The La Plata System planners already have system-level mapping, which, with review and updating, may be sufficient for this purpose.) It is also useful to create maps at finer scales for use by surveyors in the field. While recent information may not be available for La Plata System facilities at the individual block level, providing surveyors and cartographers with accurate street maps (showing edge of pavement and right-of-way lines) is one way to start the mapping effort.

Third, timing of final product assembly is important. Where possible, survey projects should be scheduled so that review of data and creation of final products (such as maps and databases or geographic information systems) overlaps with field studies or other survey efforts. This type of scheduling facilitates a flow of information between final product assemblers and the surveyors. Review of any field survey data should begin as soon as the data comes in, so that if changes in survey methods are needed, they may be initiated as early in the project as possible. Or for example, if someone doing GIS data entry has a question about the data, active field crews may verify it.

Finally, establish and maintain smooth communication paths among groups involved in the project. Given the immense amount of data acquired during survey projects and the wealth of categorization schemes possible for the data, it is important that survey project managers define the methods for accessing the data, both during and after the project. As an example, it may be beneficial to designate one person whom surveyors in the field may contact with their questions about existing data or about procedural issues such as access to private property. That person should then have the resources to find the answer and provide a response to the field crews in a timely fashion.

Metering. The recommendation presented in this document is for a reevaluation of the benefits of metering all La Plata water service connections. This reevaluation primarily involves a careful reconsideration of the long-term costs and benefits of metering. In doing so, it is advisable to calculate the costs of a metering program that uses state-of-the-art equipment. While data may not be available for the use of such equipment in the La Plata region, it might be helpful to evaluate the success of previous metering efforts in the region on a qualitative basis to complement any financial data that is available.

5.2.2 Structural/Operational Methods

While the general guidelines provided above for analytical methods also apply to structural/operational methods, the following paragraphs present both general and specific recommendations regarding the implementation of projects intended to produce reductions in water consumption. First, structural/operational methods, which require installation, construction and rehabilitation activities should be phased so that geographic areas with the highest potential for demand reduction are targeted first. The results of analytical methods will provide the information necessary to phase structural/operational projects effectively, as described below.

A second general guideline for structural/operational projects s is that, where possible, these projects should be combined with other DSM efforts and with the implementation of other Plan activities. One example of the incorporation of this guideline is that door-to-door device distribution programs may include an education component. A second example of project combinations it to have sewer survey personnel install, maintain and read continuous flow monitoring devices while they are in the field.

Because structural/operational methods require the inclusion of construction personnel and equipment providers, it is important to establish and maintain good working relationships with manufacturers, vendors and contractors to ensure the most efficient and cost-effective provision of these aspects of the projects. Contractors, vendors and manufacturers are often willing to expend considerable effort--at little or no cost to their prospective clients--to secure markets for their products and services. Managers of these type of projects should not hesitate to take advantage of the information and expertise available from service and equipment providers when making decisions about business relationships during the planning phase of structural/operational projects.

Leak Detection and Repair.[2] The success of a these program is dependent on the accurate detection of leaks in the field. With that in mind, it is critical to retain the services of qualified, experienced personnel using state of the art equipment.

> "Trained personnel will be needed to effectively use the leak-detection equipment. In a complex subsurface environment, ambient noise - such as underground streams, built-up areas, water pumps and traffic noise - may require skilled, experienced technicians to interpret the signals and assess the information."[3]

As described in the general guidelines for structural/operational projects above, it may be helpful for project managers to begin establishing relationships with leak detection survey contractors during the project planning phase.

Because damage or failure may occur at any time during the life of a water pipeline, leak detection must be regarded as an ongoing, periodic project rather than a one-time effort. Successful leak detection and repair programs in the United States typically include comprehensive survey and repair efforts every two to three years.

The inclusion of standard survey techniques and specific reporting requirements will help to ensure the consistency and usefulness of the data that has been gathered. Monitoring the completeness and usability of the data received will allow project managers to contribute to - and benefit from - the information acquired as part of other water and wastewater system projects. Vigilant attention to the validity of the data will also allow project managers to adjust or update field methodology as indicated by the incoming results.

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[2] The recommendations provided in this section are largely based on the successful implementation of a leak detection and repair program in the Massachusetts Water Resources Authority service area. See Levy (1993, p.4)

[3] Building Sustainable Communities (1991, p.36)

To gain the most benefit from a leak detection effort, this type of project should include timely repair of the leaks that have been identified. Not only will timely leak repair provide the most rapid reduction of water waste, it will also minimize the potential for additional damage to other underground facilities or to other public or private property.

Finally, a leak detection and repair project should be well publicized. Announcements regarding the purpose or the project and its activities will serve two main purposes. First, it will explain the presence and actions of field crews to the residents in project areas. Second, and perhaps more importantly, such publicity can contribute to better public relations.[4] Publicity lets people see that their water utility is making a concerted effort to provide good service by minimizing waste and by keeping the system in good repair. Public information efforts might include, for example, a weekly update of the locations and sizes of leaks that have been repaired through the project.

Infiltration/Inflow Detection and Repair. The first and most important guideline that will be presented here is to concentrate detailed I/I detection projects in areas with the highest potential for infiltration and inflow. The results of continuous flow monitoring efforts will help managers focus detailed I/I detection projects on areas with high levels of I/I. According to Massachusetts Department of Environmental protection guidelines, extensive facility I/I inspection is warranted where flow monitoring results indicate that I/I equals or exceeds 370 lpd/mm*km.[5]

When conducting these projects, it is necessary to use appropriate methods for I/I detection. Methods available for identifying sources of I/I include: [6]

- Smoke testing;

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[4] Building Sustainable Communities (1991, p.35)
[5] This unweildly benchmark refers to the flowrate (lpd) per diameter*length (mm*km) as an average figure, calculated for each sewage drainage area according to the Massachusetts Department of Environmental Protection Guidelines for Performing I/I Analyses and Sewer System Evaluation Survey (1993).
[6] Building Sustainable Communities (1991, p.45)

- Rainfall simulation;
- Manhole inspection and lamping;
- Building plumbing inspection;
- Flow isolation; and
- Television inspection.

The selection of appropriate methods for each drainage area depends on the likely sources of I/I in those areas. In areas with very old piping, for example, television inspection may be the most appropriate measure for pinpointing the location of leaks in failed piping or faulty joints. Where manholes are known to be in very poor condition, person-entry manhole inspection may be most appropriate. As a final example, neighborhoods which are known to have high numbers of roof drains connected to the sewer network are areas for which smoke testing and/or rainfall simulation should be used.

Once detailed I/I investigations have commenced, begin analyzing the data as soon as it comes in from the field. By keeping up with the field crews' pace in gathering data, the managers not only maintain the opportunity to field verify questions about the data, but also place themselves in a position to modify data collection and reporting methods early in the project, if necessary. As with leak detection and repair programs, it is also advisable to employ standard survey and reporting techniques. Another way in which I/I projects are similar to leak programs is in the probable necessity of including outside (external to utility management and operations) expertise. I/I projects should be undertaken using experienced, qualified personnel.

Using the information gathered during I/I detection projects, utilities or their consultants must perform a cost effective analysis to determine which facilities exhibit excessive I/I. "Excessive I/I" may be defined as "the quantities of I/I which are less costly to remove by sewer system rehabilitation than to transport and treat at the receiving facility, when both capital costs of increased sewerage facilities capacity and resulting operating costs are included." [7]

During all stages of I/I projects, it is advisable to include a public awareness program. Publicity about the program will inform residents about the purpose of the project and help to answer their questions about the activities of field crews. Project managers should pay special attention to informing residents about upcoming field investigations which may be disruptive or which may appear highly unusual, such as smoke testing and rainfall simulation.[8] Publicity about I/I programs will also send a message about the utility's commitment to maintain system facilities and will help in efforts to gain public support for certain activities. In Des Moines, Iowa, for example, property owners were required to detach their roof drains from sewer connections and discharge the flow onsite. A public awareness program instituted by the utility helped to gain support for this requirement.[9]

Water Saving Devices. There are a great number of projects that utilities may undertake in this category, a couple of which were recommended in Chapter 4. The guideline for electing a starting point is to begin where it is easiest. As Chapter 4 suggested, it is possible to begin with domestic device programs. Colin Laird writes:

> "Why start with residential? The residential sector is rather concentrated, relatively uniform (thanks to plumbing codes), and generally accessible. Efficient technologies are readily available for this sector, and residential water efficiency project have the potential to pay for themselves, or even better, make money."[10]

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[7] Massachusetts Department of Environmental Protection (1993, p.3)
[8] I recall vividly the reaction of some concerned residents when a rainfall simulation I was conducting temporarily created a billiant red plume of rotamine dye in a nearby wetland. While the non-toxic, biodegradable plume soon vanished, the lesson I learned about being an on-the-spot public relations manager stuck with me, just like the rotamine stains on my shoes did.
[9] Building Sustainable Communities (1991, p.41)
[10] Rocky Mountain Institute (1991, p.13)

On the other hand, La Plata System managers may wish to consider beginning a water saving device project in government buildings, where control of a project is assured, boundaries are simply defined, and monitoring and evaluation may be easier to implement. Furthermore, the presence of a large number of government buildings in La Plata, due to its role as Provincial capital, may mean that significant demand reductions are possible through a water saving device project targeted at this sector.

As the previous paragraph hints, the inclusion of pilot programs with early monitoring and evaluation of results is advisable.[11] Results of pilot programs will aid in focusing continuing efforts, choosing appropriate equipment, and establishing device distribution avenues and methods.

For all facets of water saving device projects, use high quality fixtures.[12] The use of high quality water efficient fixtures will help to ensure that users are satisfied with their performance and will retain them in lieu of standard fixtures. User satisfaction in this respect is very important in that it will help to garner public support for water saving device projects.

While there are several possible ways to encourage residential customers to use water saving devices in their homes, including delivery and canvassing, direct installation, device depots and direct mailing, one of the most effective in the long run is to use door-to-door device delivery and installation, coupled with an education program. [13] Door-to-door personnel should have with them explicit instruction for installation and use of the fixtures and be prepared to answer any questions the customers may have during their visit. The appeal and effectiveness of a door-to-door program may also be complimented by including pickup and recycling of old fixtures and an inspection of

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[11] Rocky Mountain Institute (1993) and James E. Robins & Associates (1993, p.20)
[12] Rocky Mountain Institute (1993, p.16)
[13] Rocky Mountain Institute (1993, p.22) and James E. Robins & Associates (1993, p.20)

household fixtures for leaks. Obviously, door-to-door personnel must be sufficiently trained to provide all of these services in a time-efficient, courteous manner.

Where possible, combine water saving device project efforts with similar efforts being undertaken by other utilities. Energy utilities, for example, may wish to employ the door-to-door method as an energy DSM tool. It may be possible to combine the water and energy projects into a single visit "home audit" type project. [14] Such a combination would reduce duplication of effort and minimize disruption to customers.

5.2.3 Social/Economic Methods.

As Chapter 5 explains, La Plata is planning to implement pricing and education programs. These efforts, along with building/plumbing/ manufacturing code changes and use restrictions, could benefit from adherence to the following general guidelines. First, use heavy preliminary advertising so that new policies and procedures are understood and expected. Second, where possible, employ pilot programs and surveys to target projects and monitor success. For example, the planners in La Plata may wish to evaluate the success of the pilot program that was initiated in Berisso to teach ecology and environmental issues to school-age children[15] during its own efforts to develop school curricula. Finally, managers of social/economic type projects should maintain flows of information to and from the public at all phases of implementation for these projects, to garner public support and understanding and to help shape the policies according to public acceptability.

[14] Rocky Mountain Institute (1993)
[15] "Ecología para los más chicos." Hoy, June 1994

5.3 DSM PROGRAM PATH AND GENERAL IMPLEMENTATION GUIDELINES

5.3.1 Introduction

The overall process for designing and implementing a DSM program is to establish a demand reduction goal, incorporate projects into a plan that will help to meet that goal, and then monitor, evaluate and revise the plan to ensure success. The planners at UNLP may review the recommendations made in this document, set a demand reduction goal, and adopt those projects that will help them to meet their goal. In developing an overall DSM program, they will need to construct a program schedule that facilitates smooth interactions among projects and among departments. This section provides a simplified program path diagram for using DSM in La Plata, assuming all recommended projects are adopted, and discusses general guidelines for DSM program management.

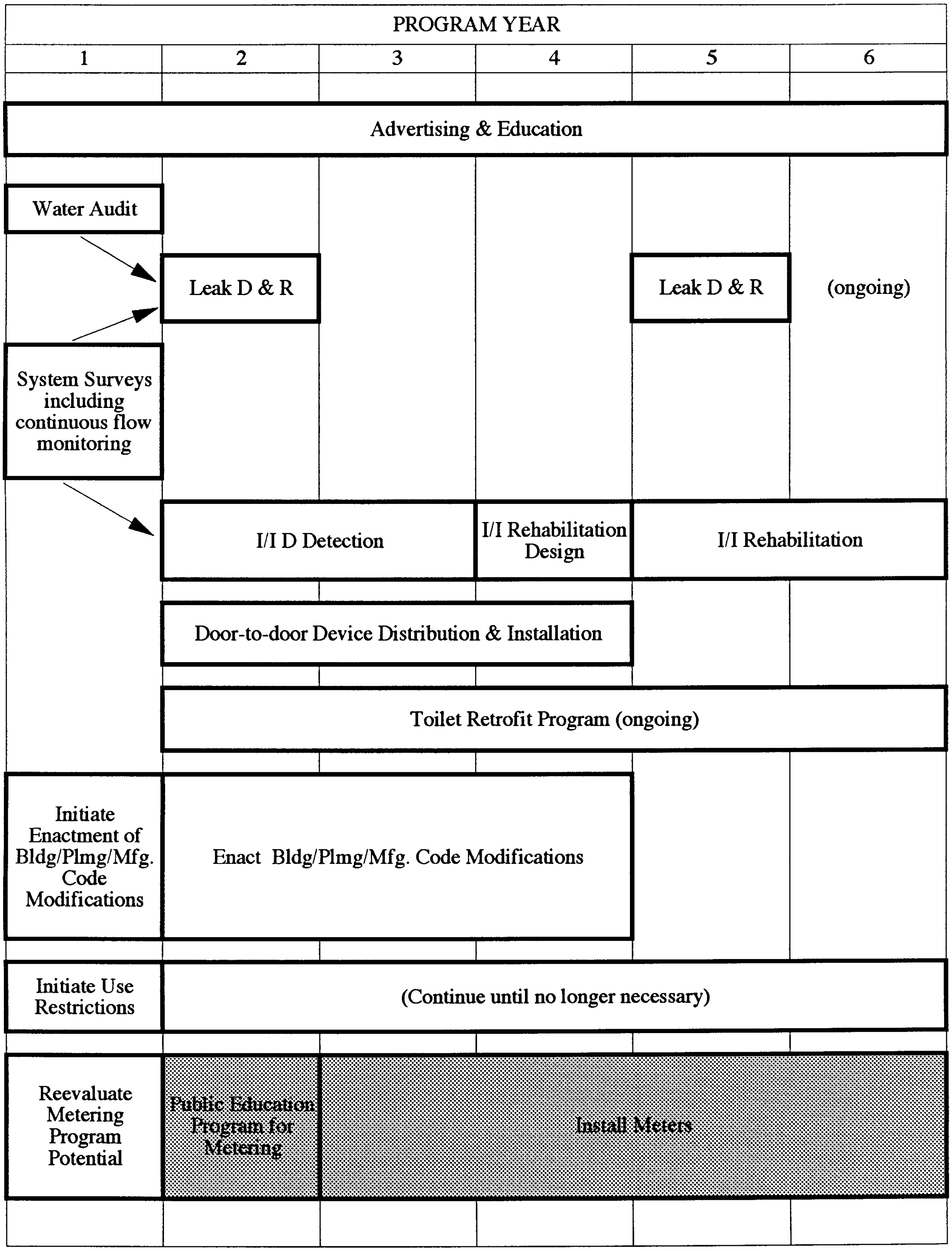
5.3.2 Program Path

Figure 5-1, on the following page, shows a suggested path for implementation of the DSM program recommended in this document. As this figure illustrates, publicity and education efforts with respect to the DSM program should begin as soon as the decision is made to implement DSM and should continue throughout the program, as described in the preceding section. Early publicity ventures may focus on the selection process for DSM projects itself and move on to provide increasingly specific information about the projects as they are initiated and continued.

This figure also illustrates the placement of the water audit and the system surveys at the start of the program, as later projects targeting leak and I/I reductions depend on the results of the analytical efforts. Figure 5-1 further illustrates the timing assumptions regarding domestic device programs that were incorporated into the analysis in Chapter 5. The possible inclusion of comprehensive metering in the La Plata System is shown by the shaded areas at the bottom of the figure.

Figure 5-1

Program Path



5.3.3 General Program Implementation Guidelines

First and foremost, an essential aspect of program management for ensuring the success of incorporating DSM is to have buy-in at the highest management levels. In order for the program to receive the continuing support it requires, the heads of all involved organizations and departments must understand the goals of the program and the role of each of the projects in meeting those goals. Without widespread and specific support, the program may falter because of unnecessary political or institutional barriers. This is not necessarily a recommendation for top-down implementation practices, but rather an admonition to strive for consensus regarding goals and program components among the most influential decision-makers in the involved institutions and departments.

To facilitate rapid decision making and information flows, there should be a designated responsible party at each decision making level. This person should understand the aspect of the program or project for which he or she is responsible, have the ability to make necessary decisions with minimal consultation and have good communication relationships with other persons who are in the same capacity. All participants in each project should know who these people are and how to contact them when necessary. To accomplish this, a clear organizational structure is necessary.

The parties in charge of program implementation should plan and arrange for funding of DSM projects in advance. Funding sources should be identified and secured, subject to change as additional resources become available. It is of interest to the La Plata System situation that World Bank lenders support funding for demand side management projects.

Because many of the suggested projects involve field investigations, construction and public interaction, it is crucial to ensure the health and safety of project workers and the affected public when implementing this program. Procedures designed to protect the health and safety of all involved parties must be considered an essential aspect of program implementation, as well as a continuous concern during day-to-day project management.

"Plan, plan, plan. Never stop planning." The more distinctly the various aspects of the DSM program are envisioned during the program planning phase, the less surprises program managers will encounter as the program proceeds. Mid-stream changes from the planned course of program implementation typically mean increases in cost, and they may often be avoided by careful planning of projects in advance. If changes are necessary, program managers should use the opportunity to plan carefully how the changes will affect the program and adjust previous plans as required. Plan, plan, plan. Never stop planning.

6. CONCLUSION

6.1 PROGRAM RECOMMENDATIONS

This document analyses the potential for including a variety of DSM measures in the water and wastewater infrastructure provision process in the La Plata System of the Buenos Aires Water and Sewer Master Plan. The following sections: summarize my DSM project recommendations and the reasoning behind my suggestions; theorize how the process of reevaluating demand by planning for the inclusion of DSM affects the master planning methodology as outlined in Chapter 1; and point out where the planners in La Plata may face challenges in implementing my recommendations.

6.1.1 Structural/Operational Methods

This analysis indicates that Structural/Operational methods may be particularly beneficial for the La Plata System. These methods provide reductions in water demand, potable water waste and in wastewater flows. Including these methods in a DSM program may allow planners in La Plata to design facility and equipment alternatives for the System which have smaller capacity and thus, lower capital and operational costs. My recommendations are summarized below.

Water Saving Devices. Plan for the implementation of three projects involving water saving devices: a door-to-door domestic water saving device distribution and installation program; enactment of laws requiring low flow devices in all new construction; and a toilet retrofit program in which the utility offers a rebate for homeowners replacing conventional toilets with low flow models. My analysis indicates that these projects would be cost effective based solely on avoided operation, maintenance and administration costs. Possible capital cost savings and heightened consumer awareness increase the attractiveness of this DSM method.

I/I Detection and Removal. Evaluate continuous flow monitoring data, (performed as part of a detailed water audit) to determine whether extensive I/I detection and removal is warranted. The La Plata System probably has sufficiently high levels of infiltration and inflow to make an I/I project worthwhile. If I/I detection and removal is initiated, the reduction in wastewater flows may allow engineers to revise the design capacity of wastewater treatment facilities. I/I detection provides system managers with valuable information about the condition of system facilities, and I/I removal by system rehabilitation improves the condition of the wastewater collection network.

Leak Detection and Repair. Examine the results of detailed water auditing efforts to determine whether the percentage of unaccounted for water in the La Plata System warrants a comprehensive leak detection and repair program. The La Plata System probably has a high enough percentage of unaccounted for water to justify leak detection and repair: as a good management practice; as a method for improving the condition of the distribution network; and for demonstrating to the public the utility's commitment to reduce waste and provide good service.

6.1.2 Analytical Methods

These methods, which provide system managers with detailed information about facilities in the water and wastewater systems, will be of use to La Plata both as good management practices and as tools for system maintenance and facilities planning.

Water Audit. Conduct a detailed audit of flows in both the water and wastewater systems to identify flow volumes and components. Information from the water audit will aid in refining demand estimates and unit costs. The water utilities in the System may also use water audit data to evaluate the potential for leak detection and repair. An audit of wastewater flows will provide planners the data necessary to refine wastewater facility capacity needs and to determine whether I/I detection and removal is necessary.

System Survey. Conduct a comprehensive survey of water and wastewater facilities: location, age, material and condition. Produce detailed maps and databases with the information acquired through the surveys. The data acquired through these surveys will provide a basis for good management of water and wastewater facilities including network design and rehabilitation, planning for implementation of DSM measures and for periodic system maintenance.

Metering. Reevaluate the potential value of metering existing water customers by comparing the benefits of installing water meters to the possible reduction in capital costs for system augmentation. The actual use data provided by comprehensive metering may allow planners to revise plans for new facilities and will facilitate cost based pricing for water and sewer service.

6.1.5 Social/Economic Methods

The benefits of implementing DSM methods in this category has already attracted the attention of UNLP planners. Their plan for the La Plata System includes an extensive education program and the implementation of a cost-based pricing scheme. The potential for demand control and increased consumer awareness afforded by social/economic methods may be increased by including additional measures as summarized below.

Water Use Restrictions. Consider the enactment of water use restrictions during peak usage period in areas that experience service interruptions currently. The employment of restrictions may help to ensure uninterrupted flow until system facilities are augmented sufficiently.

Building/Plumbing/Manufacturing Code Modifications. Enact changes in the building or plumbing code to require low flow toilets, showerheads and faucets in all new construction and in new water service connections. If necessary, modify the manufacturing code to require the inclusion of low flow devices in product lines. These measures will ensure prudent water use in all new connections.

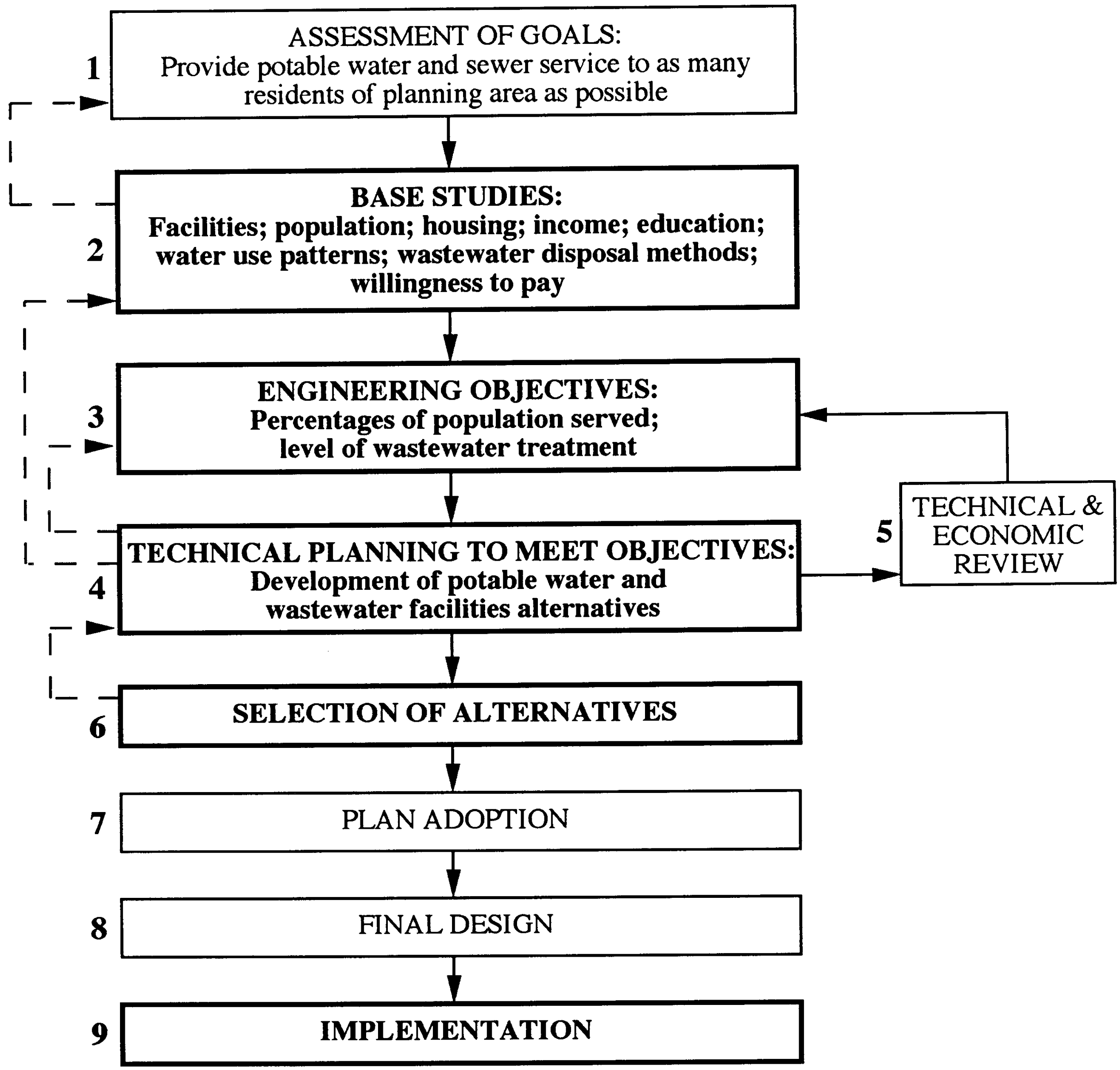
6.2 AFFECT ON THE MASTER PLANNING METHODOLOGY

The generalized methodology for water and wastewater master planning included in Chapter 1 would be altered by planning for the inclusion of the DSM program recommended here. Figure 6-1 highlights in bold those steps in the master planning methodology that would be most affected by the inclusion of DSM. The following sections describe how the steps in the methodology would change.

The primary alteration to the master planning methodology that result from the including DSM would be augmentation of the base studies step (Box 2 on Figure 6-1). Planners would need to expand their assessment of water use patterns with directed surveys to obtain detailed estimates of the demand reductions possible through DSM. Surveys assessing the public's acceptance of measures such as water saving devices, metering and use restrictions would also be required. The results of these surveys may alter the next step of the methodology, the definition of engineering objectives (Box 3). Preliminary demand estimates, supplemented by reevaluated demand estimates including the effects of DSM, may allow for the revision of engineering objectives to include some that are contingent on the inclusion of DSM. For example, the engineers may determine that is it reasonable to strive for serving 80% of the planning area population based on standard demands, but that it may be possible to design for service coverage at higher percentages if it is necessary to meet a lower overall demand. Or, in a case where supply development is required to fulfill master plan goals and objectives, the inclusion of DSM may allow for alternatives that employ DSM *instead of* new supply development.

Figure 6-1
DSM's Effect on theWater and Wastewater Master Planning Process

(altered steps shown in bold)



Source: Adapted from Lexington-Fayette County (1980) and Kuiper (1971, p. 19)

If engineering objectives are adjusted to consider the DSM contingency, or changed altogether as a result of reevaluated demands, technical planning (Box 4) changes will result. For example, reduced demands could result in the design of alternatives including a smaller treatment plant, or fewer treatment plants, if more than one is planned. It may be the technical planning step that actually prompts the inclusion of DSM. Engineers striving to meet their objectives may find that meeting unmanaged demand necessitates technical alternatives of a scale (budgetary or physical) beyond that which is desired. These findings may result in an iteration back to the base studies step to reevaluate demand.

The selection of alternatives step (Box 6) will also be affected by the inclusion of DSM. The selectors of plan alternatives would, with the inclusion of alternatives that account for DSM, have increased flexibility in choosing a satisfactory solution to the planning area's needs. This flexibility may be especially important for both developing areas and areas where water is scarce. In developing areas, the flexibility afforded by having options of varying costs, with a variety of schedules for implementation, may ease the financing burden by providing more opportunities to match borrower needs with lender/donor project preferences and repayment conditions. In water-poor areas, the availability of alternatives that include DSM may offer needed flexibility for meeting the demands of regions where enormous growth is anticipated while remaining attentive to the environmental effects of huge supply development.

Finally, the implementation step (Box 9) would be altered if an alternative including DSM were chosen. Initiating DSM as a component of a master plan alternative requires special attention to certain operational, institutional and public relations aspects of implementation as described in Chapter 5. The following section outlines some of the challengers that the planners in the La Plata region may face if they elect to implement DSM.

6.3 IMPLEMENTATION CHALLENGES

The primary obstacles that planners, engineers and system managers would face in implementing DSM in the La Plata System exist in the form of resistance to alteration of proven technical solutions. Thus, the main challenges to overcome would be acceptance of DSM as a viable component of the master plan both within utility organizations and in the public at large. Secondary challenges would be retaining contractors with the appropriate expertise and acquiring water saving devices for distribution.

As Chapter 5 suggests, a very important aspect of successful DSM implementation is garnering support for the measures within the organizations that plan for and provide water and wastewater services. Overcoming this challenge may require extensive information dissemination within water and wastewater organizations. A series of discussions, structured to meet the information needs of parties at various levels in the organizations, could help to provide the level of understanding necessary to foster support for DSM projects. Such discussions could be particularly important in gaining approval for analytical projects, the benefits of which may not be easily quantifiable in simple cost benefit terms.

An equally--if not more--important challenge in implementing DSM will be educating the public sufficiently to acquire acceptance and participation in DSM efforts. The program recommended here will affect the day-to-day lives of water consumers in many ways. Field crews will perform investigations and construction work in the streets during surveys, leak and I/I detection and pipeline rehabilitation. Personnel will visit customers homes as part of the door-to-door device distribution program. Customers daily water use habits will be altered by the installation of water saving devices and through conservation education. Some users may be affected by water use restrictions. Without adequate information, consumers may not appreciate the goals that are motivating these public activities and may have no desire to participate in their own homes. A highly involved public awareness campaign will be necessary to meet this challenge.

Finally, those who will manage the recommended DSM program will need to obtain the cooperation of contractors, manufacturers and vendors in order to obtain the services and equipment necessary for implementation. This may pose a challenge because the expertise necessary for leak detection and repair and/or I/I detection and removal may need to come from outside Argentina. While there are plenty of consultants and contractors with adequate expertise worldwide, obtaining their participation in the La Plata region may require more research and screening on the part of the system managers than it would if local expertise were available. With regard to manufacturers and vendors of plumbing devices, on the other hand, The Buenos Aires market is well covered. The challenge for those implementing DSM will be in convincing these parties of the potential for profit obtainable through their participation in DSM efforts. Judging by the responses of corresponding parties in the United States, meeting this challenge will require assurances from water providers and associated governmental institutions that DSM will be a long term component of water and wastewater infrastructure provision.

These challenges need not necessarily be viewed as barriers to the implementation of DSM, but rather as opportunities for incorporating additional contributions into the ongoing efforts of water and wastewater service providers. Involving utilities, governmental entities, those involved in related commerce and the public at large helps to render master plans more effective in that it requires planners to direct their efforts toward solutions that respond to the expressed needs of those parties. In this manner, including DSM in the master planning methodology may make the process of providing water and wastewater infrastructure more efficient and stable in the long run.

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