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UPGRADING THE EXISTING OR DESIGNED WATER TREATMENT PLANTS

- Innovative and Alternative Technologies
- The Role of Governments

by

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May, 1994

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ACKNOWLEDGEMENTS

I would like to thank Dr. Michael Bell, Principal Research Scientist and Dr. Robert Seidel, Coordinator of the International Urban Fellows Program, for their bibliographic support, comments and advice all along the last three and a half months, necessary for me to prepare this final report.

I want to express my gratitude to Dr. Lester M. Salamon, Director of the Institute for Policy Studies, Prof. Virgil Ioanid and Prof. Anton Anton for the great opportunity they offer by recommending and including me in this Urban Fellowship Program.

It has been very useful for me to attend the classes and seminars at Johns Hopkins University - both at Institute for Policy Studies and Department of Geography and Environmental Engineering - and I thank Dr. John Boland and my friend Ph.D student William Becker for their support and advice.

I am grateful for the understanding and permanent help the following people gave me: Wilbur E. Cunningham, Thomas Bailey, Susan Mitchell, Sylvia Eastman and Ereni Gleason, Linda Davis and Amar Sokhey - Baltimore Water/Waste Water Division, Nick Frankos and Jack P. McClinton - Back River Waste Water Treatment Plant, George Waclawiw - Ashburton Filtration Plant, Howard Bittner - Montebello Filtration Plant and all the nice people I have met during my stay in Baltimore.

Finally I want to thank my colleagues and friends for everything: Milena Horcicova, Katalin Zsamboki, Aynalem Demeke-Bandargew, Stefan Toeplar, Wojciech Sokolowski and David Kantor.

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CHAPTER 1

1. INTRODUCTION

1.1. The Environmental Status in Romania

Romania is suffering from severe environmental degradation as a result of past industrial policies which emphasized heavy energy-intensive industries.

The concentration of these industrial activities into oversized industrial complexes, use of outdated and obsolate technologies, lack of maintenance and inefficient use of raw materials and energy, combined with the almost total neglect of the environmental issues have contributed to create a situation with outspoken detrimental impact on human health, natural productivity and balance of the ecosystems.

These industries are located all over Romania, following a basic (harmful) principle of the past planned economy, which considered (sometimes only) the harmonious distribution of industries. In some of these areas the state of environment is seriously damaged and in other areas the damaging process is in progress due to the pollution of water, soil, atmosphere and vegetation with various polluants.

Water degradation is due mainly to the discharge of insufficiently treated or untreated effluents, oil and petroleum residues and eutrophication from agricultural fertilizers.

Furthermore, much agricultural land has been lost as a result of mining, dumping and soil erosion.

Although the general condition of trees and woodlands in Romania is considered to be good, in some areas it does appear to be deteriorating. Acid rains and the first signs of damage to forest appeared with the development of industry and the increase in the release of toxic substances into the air.

1.2. Hot spots' industries

In early 1992, 14 industrial areas (see Table 1.1) were identified that are under constant pollution to such a degree that they are believed to have significant effect on public health. The first six are considered as the worst.

Table 1.1 List of priority areas

1. Copsa Mica	8. Pitesti
2. Baia Mare	9. Tirgu Mures
3. Zlatna	10. Turnu Magurele
4. Ploiesti - Brazi	11. Tulcea
5. Borzesti - Onesti	12. Isalnita
6. Bacau	13. Brasov
7. Suceava	14. Govora

No priorities had been established.
First six are considered of highest health hazard.

A brief description of these areas is given in Appendix I.

1.3. Environmental Pollution: Causes and Trends

a) Causes

The main causes having determined the environmental pollution are large in diversity. Among them: the concentration of industry and zootechnics into extremly large units; the use of physically and morally worn-out technologies; the lack of repairs; the lack of purification equipment in the technology updating; the need for modernizing the development processes in the domain of electric and thermal power production, of the metallurgical, chemical and machine building industries.

Within this context, it is extremly important to become acquainted with the evolution of the polluant emissions as well as with the state of the environmental quality factors, knowledge substantiating the strategies and decisions for the protection of the environment.

b) Evolution and Trends

1) The amount of the main polluant substances evacuated into the environment.

As a result of the industrial production decrease, during the interval 1989 - 1991, the global amounts of polluant substances evacuated into the environment decreased, but with a reduced percentage, high values being still maintained, as Table 1.2. shows.

2) Air Pollution

During the analyzed interval, the contribution to the air pollution is represented by the economic agents of the power industry (electrical and thermal power production) with a 56.2% contribution to the carbon dioxide emissions; 74.2% for sulphur dioxide; 40.5% for nitrogen oxides; 48.0% for soot and 40.9% for settling suspended particles.

The chemical industry has a contribution of 60.5% to benzine emissions and 27.4% to the nitrogen oxides.

Such industrial platforms are: Copsa Mica, Baia Mare, Zlatna, Ploiesti-Brazi, Valea Calugareasca, Borzesti-Onesti, Bacau, Suceava, Pitesti and others.

A significant impact occurs over the entire territory of the country, especially upon the surface and ground waters, as well as upon the soil, by the use of phytosanitary substances and chemical fertilizers in agriculture.

Table 1.2. Total Amount of Polluants.*

Environmental Factor	1989	1991
- AIR	138,400	110,900
- WATER	6,100	5,100
- SOIL	273,600	243,500
TOTAL :	418,100	359,500

*- thounds of tons.
Source: Ministry of Water, Forestry and Environment, 1991 Annual Report.

1.4. Country's Environmental Strategy and Institutional Framework

Romania is today in a phase of transition resulting in reforms and restructuring in many sectors of the society. The solutions of environmental problems have in this connection been given high political priority. Romania's present environmental policy matches with the worldwide concerns in this field and among others the following areas have been identified as urging for immediate action:

- renewal of existing productive units according to the energy, raw material and environmental constraints;
- adoption of non polluant production processing and technologies;
- support of the existing industries with equipment and technologies for emission reduction;
- organize proper waste management;
- establishment of a national integrated monitoring system for environmental quality;
- environmental training and education at all levels.

The priorities in the domain of environmental protection are also based on a series of considerations derived from theoretical basis of the systemic ecology and from world experience in the field, among which the following are to be strssed:

- environmental protection is the fundamental condition of a sustainable development;
- the structural and functional units of environment are the ecological systems (life suport systems), hence the object of protection activity is maintaining their integrity;
- the support system of environment protection activity should have the structure and the size able to sustain concomi-

tantly actions of both ecological reconstruction and prevention of perturbation effects;

- environment protection activity at a national level should be integrated in the activity of protection at a regional and world level.

In Romania the priorities in environmental protection equally aim at a large restoring process, leading to the removal of the causes of ecologic system spoilage and at their recovery, and also at the development of knowledge on productive and support potential of the environment, as well as at the differentiation of complex structure ensuring a sustainable development.

The central state environment authority in Romania is The Ministry of Water, Forestry and Environmental Protection. It was created in late 1989 and it has forty one subordinate Environment Survey and Protection Agencies (see Appendix II).

The total environmental staff is around 2,800 persons, including The Ministry and The Agencies, but without forestry inspectorate and specialists in research institutes.

1.5. General unsolved problems

Although some steps have been made in environmental protection activity - get acquainted with the antropic pollution sources, carry out annual syntheses concerning the state of environment; introduce the procedure of approving the documentation and of issuing the permits for the polluant activities; a.s.o.- there are still general unsolved problems like:

- the delay in the promotion of the Environmental Law;

- the incomplete project concerning a strategy to protect the environment;

- the uncertainty concerning the perspective of the industrial activities;

- the lack of equipment for the verification of the emissions into environment by the industry, as well as poor provision with systems and devices for monitoring of emissions by the environmental protection agencies;

- the delay in the achievement of the technical documentation, especially for the intensely polluted areas.

1.6. General remarks

In Romania, like in many other countries,groundwater is very limited in quantity and it is no longer ready to drink as it is. Since the surface waters constitute the main source for drinking and industrial water supply systems it is very important to know which are the best solutions in order to build, operate, maintain and manage the drinking water facilities. This is more important for Romania, who, as presented above, has to face dramatic industrial pollution with important negative effects on surface and ground water quality.

Also, like everywhere else in the world, the centralized water supply systems must achieve, generally speaking, four major requirements: quantity, quality, service pressure and continuity.

In order to improve water supply service delivery, to meet the environmental needs, but also for a better understanding and a helpful material for policy options, I present in the report one category of Public Works, important both for social and economic activity: Water Supply Management.

The Report contains two major sections - innovative and alternative technologies, and the role of governments in water supply in U.S.- and, therefore, it is addressed at least to two categories of specialists: 1) technical staff in the field of research and design or operate and maintenance; and 2) administrative staff with decisionmaking role in water supply domain. Making an overview on the U.S. stage of development, management and strategy,in the areas mentioned above,I hope that my findings and conclusions will bring light in understanding the follow:

- Water Supply Management as Public Work facility and part of the Nation's Infrastructure;
- Governamental roles in Public Works;
- Innovative and alternative technologies for high efficiency and cost-effective treatment.

Chapter 2 is an overview on United States water supply systems and contains a section about federal drinking water regulations. These standards - the most exigent in the world and which reflect maybe in the best manner the main environmental concern, i.e., the human health care - are very important for both technical and administrative specialists, because they simply present the goals that a water supply system should achieve in order to respond to the quality requirements. Another important section in this chapter refers to categorial analysis and performance evaluation, also with some data about wastewater and water resources. This is a useful instrument, very good to be addopted by the Romanian governments, in planning, strategy and decisionmaking.

Chapter 3 presents, separately for small and large water systems, the innovative and alternative technologies already available for more efficiency and cost-effective treatment solutions in any particular water supply system, no matter that it is in U.S. or in Romania. There are also included cost comparisions, technological transfer and technical assistance aspects and a large description of Baltimore's water supply system.

Chapter 4 - The Role of Governments - presents the current organization of both national and local governments in U.S. There is also a section about Baltimore's administrative organization in Public Works and a few data refering to the main concerns and future projects for fiscal year 1994. Lessons from this chapter, as well as from Chapter 2, could lead to a realy institutional reform in Romania, of course in the field of water treatment.

Chapter 5 contains the major findings and general conclusions find out in this research of American Water Supply. Also, there are stressed the important lessons to be considered by the Romanian specialists.

Therefore, the report includes not only technical aspects for specialists in the field in order to improve the performance of water treatment, but policy conclusions also in order to be helpful for Romanian Goverments and Local Administration through better management and decision making. The content as well as the conclusions and recommendations, considering the American mode of management which defines clearly the place of water supply industry in one's nation infrastructure, answer the following questions:

- which is the best available technology ?
- what is the role of Government and Local Institutions ?

CHAPTER 2

2. OVERVIEW ON UNITED STATES WATER SUPPLY SYSTEMS

2.1. Introduction

One of the missions of the National Council on Public Works Improvement (NCPWI) is to achieve an improved understanding of the condition, safety, and capacity of the nation's public works facilities. In initiating activities to carry out its mission, it was necessary for NCPWI to define both "infrastructure" and "public works infrastructure". The Council defined infrastructure as "the physical framework that supports and sustains virtually all economic activity". It defined public works infrastructure as "facilities with the following general characteristics: high fixed costs, strong links to economic development, long service life, interaction with other parts of a system, and public ownership".[1]

For purposes of this report, water supply is defined as those central systems or networks of facilities that supply water to the public. This definition embodies municipally owned systems, investor owned water utilities, systems owned by homeowners associations, wholesalers of water to municipal bodies, systems owned and operated by Federal government, and non-community water

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[1] The Nation's Public Works: Defining the Issues, National Council on Public Works Improvement, September, 1986

systems (i.e., those serving non-fixed populations). Many industries supply their own water both for manufacturing and consumptive use. Thus, self-supplied industrial water is included in this definition of water supply.

The nation's infrastructure comprises far more than the two categories studied in this report. Others include highways, streets, road and bridges; airports and airways; railroads; public transit; intermodal transportation; communications; power production facilities; water resources; solid waste; hazardous waste services; schools; public housing; sidewalks; lighting; hospitals; public buildings; parks and prisons. Taken as a whole, the services they provide form the underpinnings of the nation's defense, a strong economy and health and safety.

One measure of a nation's well-being is the quality and extent of services provided by its public works. Water supply and sanitation facilities help determine the quality of public health. Highway and transportation facilities influence social, political and economic integration. Although not always visible or measurable, the effects of these facilities combine to shape the society in which we live.

Of all public services, infrastructure may be the easiest to take for granted. When it functions best, it is noticed least. By the time the public and the press focus their attention on the infrastructure (usually in response to system failure or severe and continued congestion), real damage has already been done.

The present report chose to study one category of public works infrastructure: water supply treatment. It is analyzed only under two aspects: innovative and alternative technologies and the role of governments. A complete analyse will require other consideration like water supply infrastructure needs, pricing and financial practices, water supply and economic growth and international perspective on water supply. Also a global report dealing with water supply could arguably contain discussions on each of the following related subject areas: groundwater protection and aquifer management; water reuse; source development; private wells; dams and reservoirs. It is appropiate to include some of these topics, but only to the extent that they contribute to, or impact on water supply as a service delivery function.

Evolution of Water as a Commodity

The value of water has never been fully recognized by the public, in large part because it has always been plentiful and readily available. In most parts, due to a plentiful supply coupled with inefficient pricing practices, water has typically been underpriced. Its nominal cost does not adequately reflect the importance of water to society and to life itself.

When one turns on the tap, whether in one's home or industry, the expectation is that water possessing a number of important attributes will gush forth. The first expectation is that the water will be of adequate **quantity** to accomplish a variety of purposes. The second expectation is that the water flow will be of **sufficient pressure** to accomplish the same purposes. These are the **quantity attributes** of water supply.

On the **quality** side, the user implicitly assumes that the water is free of chemical or microbiological contaminants. In other words, the consumer assumes that the water is safe to drink. The user also expects the water to be free of taste, odors and color. Finally, the consumer does not want to see sediment or colloidal or suspended particles in the water.

All of these expectations are true for Romania too, but, unfortunately, mainly due to the old age of many system there often are different failures in water supply delivery.

Water generally has not been viewed as a **commodity**. Rather, water supply typically has been viewed as a **service delivery** function provided by a municipality, investor owned water utility, developer or homeowner association. The clear consensus in the water resource economics literature is that the water must be treated as a commodity to assure efficient allocation. Water is both a resource and a product. It has aspects of value in productive and consumptive use, value in exchange through transferrable property rights and all these value aspects are affected by scarcity of the commodity. Without more of a commodity orientation, water supplies will become enormously expensive due largely to effects of inefficient resource allocation. In the long-term, efficient allocation will provide the greatest net benefits to the consumer.

Water Uses and Availability

Water is used for a variety of purposes by residential, commercial and industrial consumers. Water consumption in the U.S. ranges from a low of 40 gallons per day per capita (gpcd) on some Indian reservations and rural communities to more than 200 gallons per day per capita in some western communities. The average usage is belived to be between 120 and 150 gpcd currently

At the household level, only about one-half gallon per day is used for actual consumption or cooking purposes. The remainder is used primarily for laundering, showering, lawn watering, flushing toilets, or washing cars, creating in this way another category of water - wastewater.

Municipalities use water to keep municipally owned golf courses green, wash streets, fill public fountains, and to provide services in municipally owned buildings. The most important municipal use of water is in the fire safety area. This is one of the most important "pressure" or "quantity" attributes of water.

Commercial/industrial uses vary greatly. Restaurants use water for cooking and serving to customers, car washes and laundromats use relatively large quantities in the course of business and various categories of industries use water for process purposes or for cooling.

Industry is an extremely heavy water user. According to Census data, total estimated water use for manufactures totalled about 11 trillion gallons. More than 80 percent of usage was accounted for by four major SIC categories - chemical and allied products, primary metal industries, paper and allied products, and petoleum and coal products.

Institutional Mechanism Through Which Water is Supplied

"From the earliest days of the Nation, cities and industries have provided their own water supplies. In general, there is no reason why they should not continue to do so. For many years this was recognized by the Congress and several laws contain statements to the effect that the Federal Government will confine itself to an ancillary role in this field." These statements, taken from *Water Policy for the Future*,the Report of the National Water Commission, are as true today as they were in 1973.

Provision of water supply in the U.S. has historically been a **local government service delivery function** and, for the most part, this arrangement has served well.

The organization and ownership of local utilities that actually supply water vary greatly. Organization and ownership range from investor owned utilities which are in business to generate profits for their shareholders to developers, homeowner associations, and mobile home parks on the other end of the spectrum, who must provide water to their clientele. In between are several classifications of state chartered public corporations, quasi-governamental units, and municipally owned systems including the following:

1. *State Chartered Corporations* - an example is the Fairfax (VA) Water Authority. This type of entity is virtually independent of local governing bodies and has the authority to set rates, condemn and purchase land, and essentially set its own management course.
2. *Special Districts* - an example is the East Bay Municipal Utilities District (EBMUD). EBMUD was created by a vote of the people of Alameda and Contra Costa (CA) counties in 1921 and is governed by an elected seven-member board of directors. Special districts also typically have substantial operating autonomy.
3. *Independent Non-Political Boards* - an example is the Denver Water Board. Although the Denver Water Department is governed by a five-member board appointed by the mayor, it has broad powers and authority under its original charter and is virtually free from political influence.
4. *Municipal Systems with an Enterprise Fund Accounting System* - an example is the city of Dallas. In this type of system, no water department revenues are comingled with those of other city departments; the water department is fully supported by rates and its primary means of financing capital improvements is through revenue bonds.
5. *Municipal System without an Enterprise Fund Accounting System* - an example is Tallahassee, Florida. In this type of system, revenues from water department are consciously

used to fund other municipal services. Fortunately, there is a trend away from this type of arrangement.

A study conducted for the Subcommittee on Urban Water Supply identified the key attributes of a successful water system and determined that "autonomy" is not a significant factor. One of the most important characteristics of a successful water system is having an enterprise fund accounting system. That is a closely controlled municipal system in which water revenues and expenditures are not "co-mingled" with those of other service delivery functions. Water is an extremely valuable commodity and is essential to life. Entities that supply water have no competition; thus, there is no rational reason why the local water system should not be able to pay its own way whether it is a special district or a department in the local government.

<u>Characteristics of Water Systems</u>

Public Water Supply in U.S.

There are approximately 203,330 public water systems in United States. These systems are divided into two categories: community water systems (CWS); and non-community water systems (NCWS). CWS constitute 28.8 percent of the systems and serve primarily residential areas, while NCWS make up the other 71.2 percent of the total and serve mainly transient or non-residential populations. The 144,800 non-community water systems serve approximately 36 million persons.*

Community water systems are defined as those serving 25 or more persons and having at least 15 service connections. Community water systems serve fixed or residential populations more than 60 days per year. There are approximately 58,530 community water systems in the U.S. serving some 219 million people.

Most community water systems are small. The Environmental Protection Agency classifies systems into the categories of very small, small, medium, large, and very large. According to EPA's statistics[1], approximately 37,425 (63.9%) can be categorized as "very small" - serving 25-500 people; 13,995 (23.9%) can be categorized as "small" - serving 500-3,300 people; 4,029 (6.9%) are medium - serving 3,300-10,000 people; 2,802 (4.8%) are "large" - serving 10,000-100,000 people; and only 279 (0.5%) are classified as "very large" - serving more than 100,000 persons.

Surprisingly, 63.9 percent of the systems serve less than 2.7 percent of the population, whereas 0.5 percent of the systems serve more than 43 percent of the population. Figure 2.1, taken

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[1] FY 1985 Status Report, "The National Public Water System Program for Small Systems", U.S. Environmental Protection Agency, Office of Drinking Water, November, 1986.

* Note: According to USEPA's FY 1988 Compliance Report, "The National Public Water System Program", published in March 1990, there are only approximately 189,600 water systems in the U.S. classified as public water systems in 1988, about 31 percent are community water systems which serve primarily residential areas and 91 percent of the population. Of the 58,099 community water systems that serve about 219 million people, 50,825 were classified as "small" or "very small". These systems served populations of less than 3,300 with a total population served of about 25 million.

from the data furnished by EPA's Office of Drinking Water, shows the breakdown of systems by source and population served. Figure 2.2 shows the size distribution of community water systems and the populations served by each category.

Surface water is the primary source of supply for about 19.6 percent of all community water systems; these systems serve 70 percent of the total population served by CWS. Groundwater is the source for 80.4 percent of all CWS; approximately 30 percent of the population served by community systems take their water from groundwater supplies. In general, the CWS falling into the very small, small, and medium population categories use groundwater as their primary source, while the larger size categories use surface water to a greater extent. Conversely, 96 percent of the non-community water systems are served by groundwater sources. EPA statistics show an increase in the use of groundwater sources between 1975 and 1980 in the smaller size categories, and a decrease in the larger population categories.

Ownership

Public systems are predominantly owned by local municipal governments, although a sizeable number of systems also are owned by the federal government. Wholesalers are one of the major owners of very large systems. Figure 2.3 shows a distribution of community water systems by size category and ownership. Publicly owned systems serve approximately 85 percent of the total popula-

Figure 2.1. Public Water Supply in Nation

FY 1984

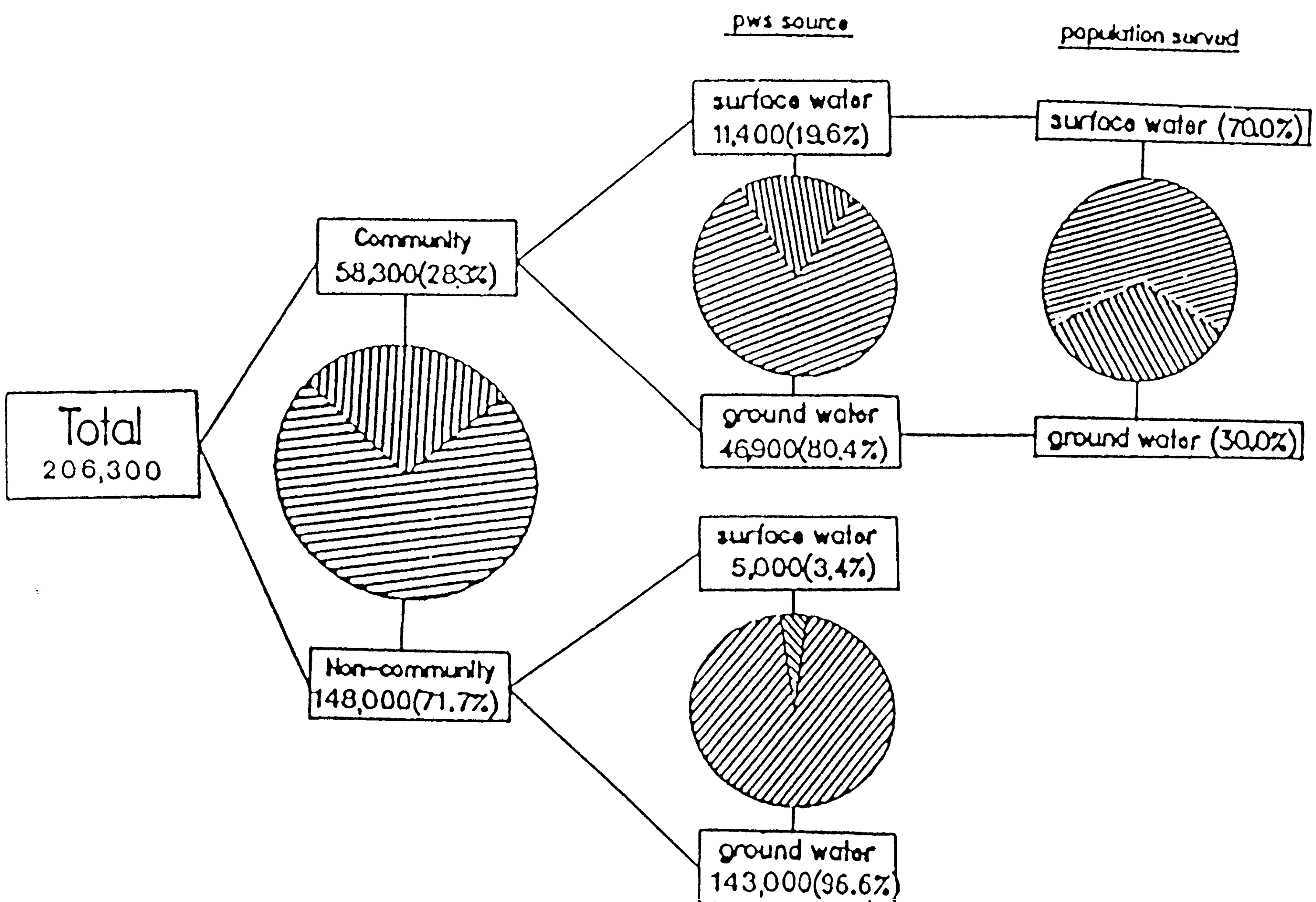
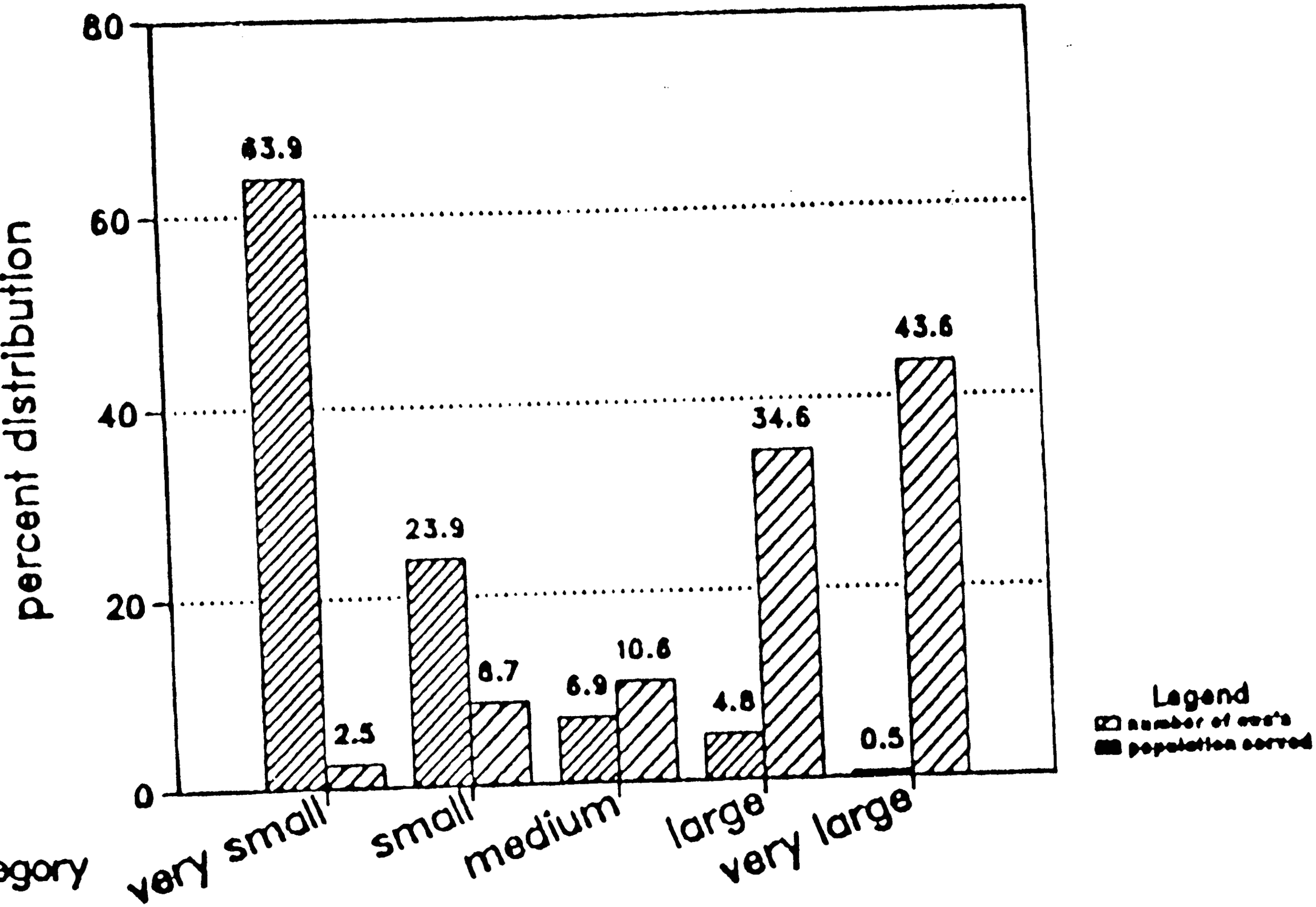


Figure 2.2. Size Distribution of CWS's FY 1985



Size Category	very small	small	medium	large	very large	
Number of CWS's	37,425	13,995	4,029	2,802	279	58,530(total)
Population Served	6M	19M	23M	76M	95M	219M(total)

tion which use community water supplies. Approximately 82 percent of urban water systems, those systems serving 50,000 or more persons, are publicly owned.

There are about 15,740 privately owned public water systems which serve some 37.5 million people. Private systems are usually investor owned in the larger population size categories. In the small and medium size categories, however, they tend to be owned by homeowners associations or developers.

There are another 17,000 community water systems that are sometimes referred to as "ancillary" systems. These systems serve another 1.7 million people who live in mobile home parks and other small developments. As evidenced by the comparatively small population served, these are typically very small systems and are generally not thought of as private water systems in the conventional sense of a regulated utility.

The total number of investor owned systems is increasing. This is primarily the result of growth in rural areas of so-called sunbelt states such as Florida, Texas, Arizona, and California. In some states, for a developer to proceed with a new housing development, the company must first construct water and wastewater facilities. If the municipality is not willing to acquire the water system after the development is completely sold, the developer has little choice but to "go into the water business".

Figure 2.3. OWNERSHIP STRUCTURE—NATIONAL TOTALS

(number of systems in U.S.)

IN ADDITION TO THE EXPECTED OWNERSHIP PATTERNS BETWEEN PUBLIC AND PRIVATELY OWNED SYSTEMS, THERE ARE OVER 12,000 MOBILE HOME PARKS AND NEARLY 5,000 HOMEOWNERS ASSOCIATION/SUBDIVISIONS.

	POPULATION CATEGORY												
	25-100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-25,000	25,001-50,000	50,001-75,000	75,001-100,000	100 001-500,000	500,001-1,000,000	OVER 1,000,000	Total
							PUBLIC						
Ownership Structure													
Local municipal government	1,512	6,696	4,915	6,529	3,316	994	944	178	80	187	18	10	25,379
Federal government	142	582	100	0	138	42	0	0	0	0	0	0	1,004
Wholesalers	0	0	0	0	0	21	0	4	2	8	2	4	41
Total	1,654	7,270	5,015	6,529	3,454	1,057	944	182	82	195	20	14	26,424
							PRIVATE						
Ownership Structure													
Investor-owned	2,716	2,351	658	638	190	74	99	25	11	26	7	1	6,796
Homeowners association or subdivision	3,170	1,371	188	170	56	19	0	0	0	0	0	0	4,974
Parent company	677	882	71	85	95	86	115	13	6	12	1	0	2,043
Wholesalers	0	0	0	0	0	0	5	0	0	0	0	0	5
Other	1,130	294	259	170	56	7	0	4	2	0	0	0	1,922
Total	7,693	4,898	1,176	1,063	397	186	219	42	19	38	8	1	15,740
							ANCILLARY						
Ownership Structure													
Mobile home park	8,386	4,125	-	-	-	-	-	-	-	-	-	-	12,511
Hospital	227	0	-	-	-	-	-	-	-	-	-	-	227
School	0	223	-	-	-	-	-	-	-	-	-	-	223
Institution	907	111	-	-	-	-	-	-	-	-	-	-	1,018
Other	1,813	1,115	-	-	-	-	-	-	-	-	-	-	2,928
Total	11,333	5,574	-	-	-	-	-	-	-	-	-	-	16,907
GRAND TOTAL	20,680	17,750	6,191	7,592	3,851	1,243	1,163	224	101	233	28	15	59,071

NOTE: National totals calculated by applying survey results for ownership structure to most recent Federal Reporting Data Systems (FRDS) estimates for each population category.

Source: "Summary of Operating and Financial Characteristics of Community Water Systems" EPA Office of Drinking Water, 1982

The trend in larger private systems is in the other direction. Suburban systems are being taken over by cities either through condemnation suits, or because the water system owner cannot obtain large enough rate increases (from the state public utility commission) to yield desired profit margins.

Characteristics of the Municipal Water Supply Industry

A Mature, Conservative Industry

The water supply industry is both mature and conservative. Because it is mature the rate of innovation is low. Consequently, the conventional process by which drinking water is treated has not appreciably changed in the past few decades. Surface waters typically are treated by a combination of unit processes that include chemical mixing, coagulation and flocculation, sedimentation (or clarification), filtration (usually through sand or dual media-sand and anthracite), and disinfection (usually chlorination). Special treatment processes often are needed to remove iron and manganese,color,hardness,or organic contaminants such as total trihalomethanes(TTHMs) or volatile organic chemicals(VOCs).

Innovative treatment techniques are periodically introduced by U.S. equipment manufactures, but acceptance of either new technologies or those proven to be effective in Europe (e.g., ozone, chlorine dioxide, or granular activated carbon) has been slow. The American Water Works Association Research Foundation (AWWARF) conducted an analysis of the barriers to introduction of new technologies into drinking water supplies in 1984-1985. Study findings showed that the procurement process through which water systems are designed and constructed is cumbersome and inefficient.

State regulators, whose primary objective is to protect the public health, often will approve only conservative design plans submitted for review by the consulting engineering community. Consultants, who have little to gain and a lot to lose by submitting designs featuring innovative, but aften unproven technologies, tend to design conservative water plants that are virtualment "risk free". Equipment suppliers often can get their equipment installed only if they submit the lowest bid. For these reasons, reputable manufactures who build quality equipment thus have a disincentive to conduct research and development on new, innovative processes.

A Capital Intensive Business

Water supply is a highly capital intensive, yet not highly profitable business. The water industry is one of the nation's most capital intensive in terms of asset requirements per dollar of revenue. Water has the second highest asset/revenue ratio of any utility; large water systems are operated at approximately $10-$12 of assets per dollar of revenues generated. This can be contrasted with other industries whose asset requirements are much lower. For instance, airlines must invest one dollar in assets to receive one dollar in revenues; the asset to revenue ratio for railroads is approximately 2:1, for telephone companies

3:1, and for electric utilities about 3-4:1.

The Current Performance Measurement

As discussed above, the importance of public works for nation's infrastructure is very great. Thus, it is useful to measure the performance of public works services, but none of the individual measures gives a clear or convincing picture of the state of the nation's infrastructure because they measure only certain aspects of either demand or supply. Only by looking at the interaction of those forces, as manifested in daily performance of public works, can we gain insight into the state of the nation's public works.

The Final Report to the President and Congress, "Fragile Foundations: A Report on America's Public Works", presented in 1988 by the National Council on Public Works Improvement analyzed the current performance of Public Works against four measures: physical assets, product delivery, quality of service and cost-effectiveness (see Table 2.1).

Table 2.1, as well as Table 2.2 and 2.3, also contains data about Water Resources and Solid Waste because, in my opinion, they can be connected.

In most cases, all four measures must be considered to understand their implications for a category's performance; then, together with the factors discussed below, the measures can begin to show system performance. The performance of individual public works categories are presented in Table 2.2 and 2.3.

Table 2.1

Illustrative Measures of Performance for the Nation's Public Works, by category

Public Works	Physical Assets	Service Delivery	Quality of Service To Users
Water Supply	Water production capacity Number of water facilities Miles of water main	Compliance with MCLs Reserve capacity Finished water production Fraction of population served	Water shortage Rate of water main breaks Incidence of water-borne disease Finished water purity Loss ratios
WasteWater Treatment	Capacity (mgd or mc/d) Number of plants Miles of sewer	Compliance rate Reserve capacity Infiltration/ inflow Volume treated Fraction of population served	Compliance with designated stream uses (local) Sewage treatment plant downtime Sewer moratoria
Water Resources	Number of ports, waterways Reservoir storage capacity Number of dams Miles of levees, dikes	Cargo ton-miles Recreation days Flood protected surface Irrigated surface KWh hydropower produced	Shipping delays Dam failure rate Power loss rate Value of irrigated agricultural product Value of flood damages averted
Solid Waste	Landfill capacity Incinerator capacity Number of trucks	Tons of trash collected Tons landfilled Tons incinerated	Collection service interruptions Facility downtimes Rate of groundwater contamination

Source: Fragile Foundations: A Report on America's Public Works NCPWI, 1988

Table 2.2

Categorical Analysis:
Physical Assets and Product Delivery

Mode	Physical Assets			Product Delivery		
	Measure	Time Frame (Yrs)	Annual Change (%)	Measure	Time Frame (Yrs)	Annual Change (%)
Waste Water	Net Capital Assets	1960-85	5.7	Volume of Waste Water Treated	1976-86	0.8
Water Supply	Net Capital Assets	1960-85	2.5	Water Delivered	1984	(a)
Water Resources						
Flood Control,	Dams	1960-85	3.3	Flood Storage	1960-85	2.3
Navigation(b)	Locks & Dams	1960-85	1.8	Ton-miles	1960-85	2.8
Solid Waste	Net Capital Assets	1973-84	1.5	Tons of trash Per Capita	1986	(c)

Notes: (a) No time series available.Based on 1984 survey, 39.7 billion finished gallons were delivered, an equivalent of 175 gallons per person per day.
(b) Inland water navigation only.
(c) No tme series available.Estimated to be 1 ton per capita per year.

Source: Fragile Foundations: A Report on America's Public Works NCPWI, 1988

Table 2.3

Categorical Analysis:
Quality of Service and Cost-Effectiveness

Mode	Quality of Service			Cost-Effectiveness		
	Measure	Time Frame (Yrs)	Annual Change (%)	Measure	Time Frame (Yrs)	Annual Change (%)
Waste Water	Ambient Water Quality	1974-81	(a)	Unit Water Treated Per Dollar O&M	1976-84	-4.5
Water Supply	Water Losses	1982	(b)	Internal Rate of Return	1976-84	(c)
Water Resources						
Flood Control,	Damages Prvntd	1960-85	(d)	Benefits/$ Assets	1960-85	(d)
Navigation	Avg Tow Delay	1986	(e)	O&M Costs per Ton-mile	1977-85	-0.8
Solid Waste	Collection & Disposal Rtg	1984	(f)	Tons per Dollar O&M	1974-80	-0.7

Notes:
(a) Although no detailed data exist,trends suggest little, if any,change.
(b) No time series data exist to asses the annual rate of change in water losses.In 1982,water losses as a percent of total production stood at 10-20 percent.
(c) Data for 30 California water systems suggest internal rate of return ranging from 2-14 percent on capital invested between 1970 and 1982.
(d) Erratic based on flood control structure and rainfall. Over the 1960-85 period,78 percent of total possible damages were prevented.
(e) No time series available.Median delay was 23 minutes in 1986.
(f) Based on a 100 point scale (1=best),the 1984 collection and disposal rating was 36.25.

Source: Fragile Foundations: A Report on America's Public Works NCPWI, 1988

Water Supply. Relatively little data and few analyses are available to evaluate the performance of community water facilities on a nationwide basis. The few statistically significant samples of the nearly 60,000 systems reveal a largely self-sufficient cross-section of publicly and privately owned utilities, the majority of which produce a high-quality product at resonable cost. Nationwide, annual 2.5 percent growth in net capital assets suggests a continuing dedication to investment.

National statistics mask regional and facility variations. One such regional concern is the deterioration of storage and distribution systems in older cities, mostly in the Northeast. Some water systems in Western states are beginning to have allocation problems; users compete as regional supplies are consumed.

Public water systems in all regions of the country face potential performance difficulties that could arise from: 1) artificially low, subsidized pricing conventions that exacerbate revenue shortfalls and encourage over-consumption; 2) compliance with increasingly strict water purity standards, particularly among small systems with limited funds; and 3) acute or chronic source contamination, especially among groundwater users.

Wastewater. Wastewater treatment has made significant gains in the United States in the past decades. From 1978 to 1986, the total value of wastewater facilities rose 25 percent from $ 110 billion to $ 138 billion. This is the fastest growth rate of any of the infrastructure categories. This growth reflects the nation's commitment to preserving water quality. However, the volume of effluent treated increased by only 6 percent, from 26.205 billions of gallons per day (BGD) to 27.692 BGD.

There is some concern that asset values have increased about 4 times as fast as volume of effluent treated. Some suggest that these trends reflect increasingly inefficient use of wastewater treatment resources. However, it must be remembered that there has been an overall improvement in the quality of treatment - 68 percent of all treatment plant capacity was secondary or greater in 1978, 82 percent was secondary or greater in 1986; and 8 percent more of the US population is now served by centralized sewage treatment facilities making a total of three-quarters of all inhabitants served by central facilities.

These improvements have served to hold the quality of the nation's water at nearly a constant level over the past decades in the face of population and industry growth. Such growth and the emerging concern about non-point sources of pollution, groun-water contamination and threats to wetlands are challenges to the nation's commitment to preserving water quality.

Water Supply Performance Evaluation

The previous section presents the illustrative measures of performance and categorial analysis for three public works categories - water supply, wastewater treatment, and water resources. For the purpose of the report, it is very important to go deep in this direction, and a performance evaluation of those mentioned categories of public works will be useful for two reasons at least: 1) to see and analyse a model of evaluation from a country with a strong, modern and developed infra-stucture, and 2) maybe less the dynamic of the parameters measured, but for sure the connection, the interaction between them in order to have a clear sight of the state of one nation's public works.

The following is taken from the Final Report to the President and Congress, "Fragile Foundations: A Report on America's Public Works", February 1988, and again not up-to-date values are very important here, but the significance of the parameters and the correlation between them.

The overall goal of a water supply system, whether public or private, is to deliver sufficient quantities of water at suitable pressures for consumption and fire protection, with a safe chemical and bacteriological quality, at the minimum cost.

Water supply is provided at the local or regional level by a series of disparate entities. These community and regional systems are developed, owned, and operated by various government (public) agencies or investor (private) groups. Other commercial concerns such as trailer parks or hospitals often supply water as an ancillary service (see Fig. 2.4).

Physical Assets

Despite their simplicity, physical assets of water systems are difficult to evaluate at the national level. They vary greatly from one system to another in terms of quantity or size, strength, age, and relative efficiency. To the extent they are available, good records are kept only at the community or utility level. At the national level, readily measurable indicators include number of systems, net depreciated capital assets, treatment plant capacity in million gallons per day (mgd) per 1,000 persons served, and distribution storage capacity, also in mgd per 1,000 persons served.

Numbers of Systems

Based on a 1982 survey of about 1,000 community water systems serving from 25 to over 1 million year-round residents, the EPA Office of Drinking Water estimated that 59,071 water supply systems served the nation. Figure 2.4. presents the distribution of water supply systems by the type of populations they serve.

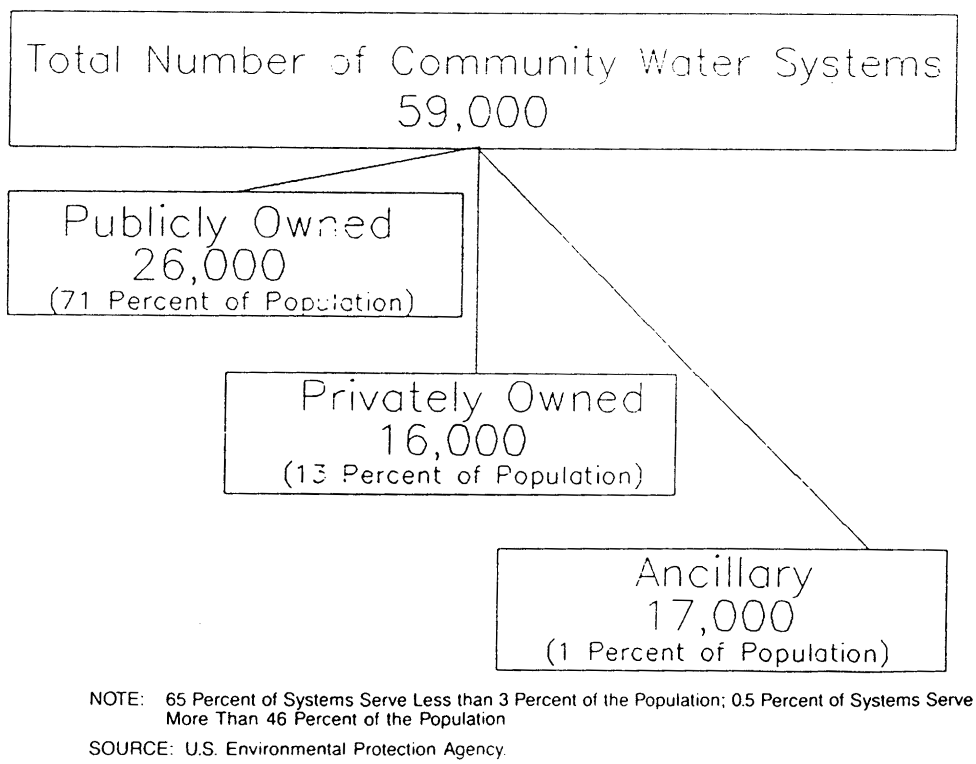


Fig.2.4. 1986 Water Supply Systems.

The vast majority of systems are small in size. Eighty-eight percent of all systems serve less than 3,300 people each and supply only 11 percent of the total population served by all public systems. A very small percentage of systems (0.5 percent) serve more than 46 percent of the centrally served population.

Net Depreciated Capital Assets

The U.S. Commerce Department has estimated the net depreciated capital stock of water supply facilities nationwide. They assumed a fifty-year average life and measured changes in stock levels over time (construction of new sources of supply, treatment facilities, and distribution lines), net of their depreciation[1]. These data indicate a steady build-up of facilities over the entire period of investigation (see Fig.2.5). From just under $60 billion in assets in 1960, water supply capital stock grew by an average of 2.5 percent a year to about $108 billion by 1984. This represent a 37 percent increase in assets per person, from $332 dollars in 1960, to $455 per person in 1984.

Treatment and Distribution Capacity

Treatment plant capacity measures the capability of water systems to meet the overall needs of service area populations. Distribution storage capacity is a measure of readily accessible

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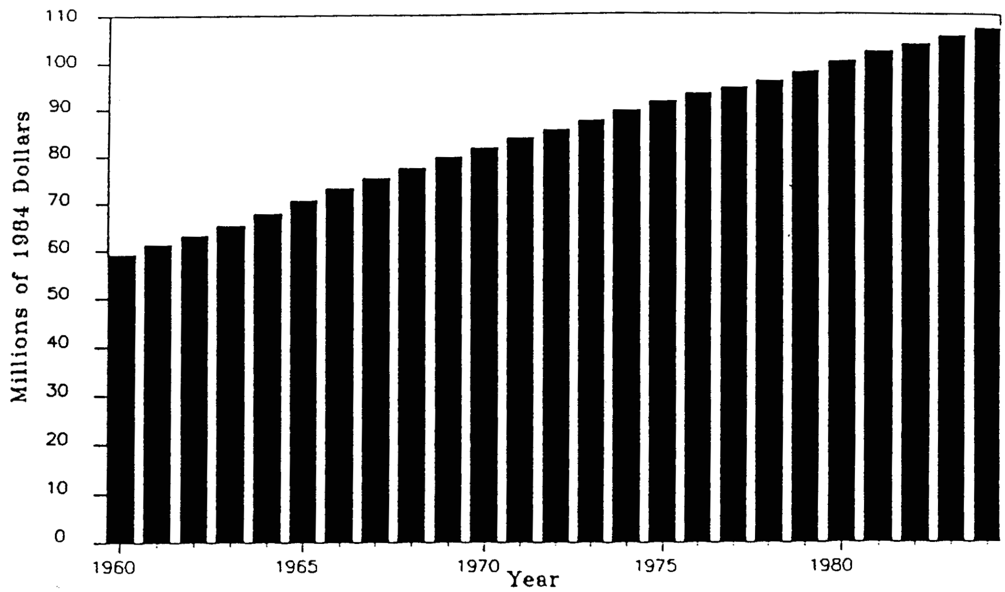
[1] Depreciation is used as an accounting concept only. It does not imply that physical facilities will deteriorate and require replacement after 50 years.



SOURCE: U.S. Department of Commerce, Office of Business Analysis, "Effects of Structural Changes in the U.S. Economy on the Use of Public Works Services," prepared for the National Council on Public Works Improvement, 1987.

Fig.2.5. Net Depreciated Water Supply Assets.

reserves of finished water. Such reserves are important for dealing with unexpected, intensive water requirements such as fire fighting or alleviation of hazardous material spills. Treatment plant and distribution storage capacity estimates were calculated for 1981 and 1984 (see Fig.2.6.). On average, the capacity of the nation's water treatment facilities remains about the same between 1981 and 1984. Storage capacity per person, on the other hand, declined by one half, from 0.39 mgd per 1,000 persons served in 1981 to 0.19 mgd per 1,000 persons in 1984.

	1981[a]	1984[b]
Treatment Plant Capacity		
Average	0.403	0.395
Highest	1.170	0.740
Lowest	0.180	0.100
Storage Distribution Capacity		
Average	0.39	0.19
Highest	2.09	0.55
Lowest	0.01	0.05

[a]Sample size = 1,397
[b]Sample size = 430

Sources: American Water Works Association, *1981 Water Utility Operating Data*, Denver, Colorado, 1981; and American Water Works Association, *1984 Water Utility Operating Data*, Denver, Colorado, 1984.

Fig.2.6. Treatment Plant and Distribution Storage Capacity in 1981 and 1984 (mgd per1,000 person served)

Service Delivery

Service delivery may be defined in terms of water production and delivery. According to the 1984 American Water Works Association (AWWA) survey, 430 utilities in 50 states produced a combined annual total of over 6.5 trillion gallons of water. This corresponds to roughly 120-150 gallons of finished water per capita per day.

Delivery statistics are not readily available due to the difficulty of estimating delivery in unmetered areas. In absolute terms, insufficient service delivery is not a problem at the national or state level. Local delivery failures result from the disruption of individual systems and may affect all or part of the related service area.

Quality of Service

The most important factor underlying the quality of the water supply service in the United States are the continuity of supply and delivery service's compliance with federal drinking water standards.

It is difficult, however, to make general statements about the current quality of the nation's water systems since there is a clear division between the status of small, rural systems and large, urban systems. In the small systems category, many problems exist, and these are pertially reflected in EPA's fiscal year 1985 status report dealing with small systems. EPA data show that of 728 persistant violators of the microbiological maximum contaminant level (MCL), 630 (86.5 percent) occured in very small systems (those serving fewer than 500 persons). By contrast, only five persistant violators were found in systems serving 25,000 or more persons. In the category of turbidity violations (suspended solid matter) small systems also constitute a large percentage.

Large system problems also cover a broad spectrum. It is well known, for instance, that a number of older systems, particularly in the Northeast and Midwest, have deteriorating capital facilities. Distribution systems, which are not visible, tend to represent the largest component of "deferred maintenance" or "rehabilitation needs".

Potable water is essential and the need for continued supplies is paramount. Interruptions in supply, measured by frequency, duration, cause, and number of persons affected, would constitute primary indicators of the quality of service. Unfortunately, such indicators are unavailable.

Compliance with Drinking Water Standards

In 1984, 90 percent of all public systems consistently met EPA's standards for maximum allowable levels of bacteria in finished water and 97 percent met standards for turbidity. These figures represent little change in water purity, on average, since EPA's first analysis in 1981.

They do indicate broad compliance with existing federal standards, but federal health standards have not yet been fully implemented for many synthetic organic compounds and other contaminants found in drinking water. In growing number of cases when drinking water supplies (mostly from groundwater) have been tested, these compounds and other chemical contaminants have been found at high levels. Removing these compounds as is mandated by the 1986 amendaments to the Safe Drinking Water Act (SDWA) will be expensive. Even before accounting for SDWA requirements, local entities currently pay $70 million annually to meet federal regulations. EPA estimates that SDWA amendaments will impose approximately $5.5 billion in capital costs on the drinking water industry.

Incidence of Disease

An examination of the incidence of waterborne disease may indicate the nature and frequency of service quality failures. A 1973 review of the incidence of disease attributable to public water supplies in the United States over the period 1946-1970, indicates 357 outbreaks of waterborne diseases. The single largest cause (53 percent) of disease outbreaks was the contamination of water source in systems delivering untreated water. Other causes were categorized as distribution system deficiency (17 percent), miscellaneous reasons (16 percent), inadequate treatment of supplies (12 percent), treatment process overwhelmed by source contamination (1 percent), and storage facility deficiency (1 percent)[1]. Between 1970 and 1980, an additional 315 outbreaks of waterborne disease occurred. This could indicate an increase in the incidence of disease over time. However, it is not clear whether this is due to increased reporting of outbreaks or an increase in actual outbreaks.

Unaccounted Water

Unaccounted-for water measures the overall efficiency of the delivery process by indicating the difference between the amount of water purchased or produced and the amount sold to utility customers. It is often expressed as the ratio of unaccounted-for water to total production. Unaccounted-for water should not be interpreted as an indicator of physical efficiency alone because it involves several disparate factors such as system leakage,

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[1] Baltimore's water supply practice is to store the finised treated water in open reservoirs like Druid Lake and others. This is a most unusual practice for modern times, and a permanet thret for public health, taking into account only the very possible accidents and not mentioned vandalism or criminal intentions.

inaccurate meters, theft, accounting problems or mistakes, and foregone water sales or revenues. Acceptable rates of unaccounted-for water range from 10 to 20 percent of total production. On the average, unaccounted-for water rates are much higher in severely distressed and declining cities (particularly those in the Northeast of the U.S., or Bucharest as only one example from Romania), while younger cities and cities in the arid West have lower rates.

In a 1981 AWWA survey of 573 water utilities,unaccounted-for water system losses averaged 13 percent of total water produced. This is well within the range acceptable to the water industry.

Water Main Breaks

Although the terms are often used interchangeably, water main breaks differ from leakage. Main breaks involve cracks or tears in the main itself while leaks occur at joints connecting the mains. A main breakage rate expressed as the number of breaks per 1,000 miles of distribution line is frequently used to compare systems of varying sizes.

An average of 229 breaks per 1,000 miles of main occured in 34 U.S. cities from 1978 to 1980. A large number of breaks indicates a problem but does not indicate that the system is uniformly week. The causes of breaks include severe weather, rapid changes in seasonal temperatures,ground movement,corrosive soils, and damages resulting from other utility or construction activities.

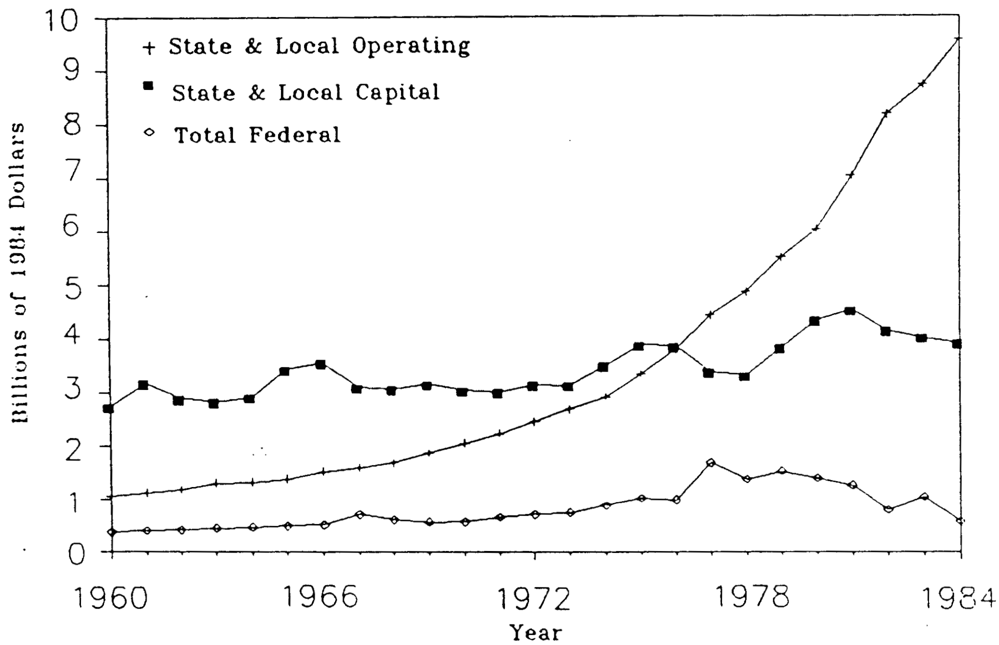
Main failures do not always increase with the age of the system, although the literature is inconclusive on this issue. A study done by the New York District of the U.S. Army Corps of Engineers on the underground water distribution facilities in Manhattan indicated that the age of the mains was not a major factor. The study found that the primary causes of main breaks were location and prior leakage that eroded the bedding. However, a study discussed in the same report found that the age of metallic pipes was an important factor in determining both the time elapsed to the first repair and the number of breaks.

Investment Efficiency

Due to the varied nature of water system ownership and operation, there are few indicators of investment efficiency that may be readily collected and evaluated at the national level. Consequently, water systems were evaluated on the basis of total revenues, total operating costs, total capital costs, and total costs of servicing the system's debt.

In a recent analysis conducted at the individual utility level, the rate of return on invested capital for a sample of 30 California municipal water districts for 1970-1982 varied from less than 2 percent to 14 percent. If 10 percent is taken as the opportunity cost of capital (the rate that competing capital investments would earn), 25 of the 30 districts invested inefficiently. In fact, half the sample earned less than 5 percent. Low average water prices were the primary causes of the lowest rates of return. Only raising water rates could led to earn at least 10 percent on invested capital.

During the period 1960-1984, local governments provided about 90 percent of total expenditures on public water supply, state governments provided 2 percent, and the federal government provided 8 percent (see Fig.2.7).



SOURCE: Apogee Research, Inc., from published and unpublished U.S. Bureau of the Census data.

Fig. 2.7. Government spending for water supply.

In recent years, however, the state role has increased while the federal role has decreased. In 1984, for example, the local contribution covered all operating expenses and 66 percent of capital costs (89 percent of total outlays). The state financed 21 percent of capital expenses (7 percent of the total outlays) and the federal government financed the remaining 13 percent of local capital outlays (4 percent of the total spending).

While federal capital outlays for water supply have declined significantly since peaking at $1.7 billion in 1977, state and local capital spending has remained relatively steady between $3.0 and $4.5 billion a year since 1960. After adjusting for inflation, operating expenses have grown at a rapid rate - about 9.6 percent a year - from about $1 billion in 1960 to over $9 billion in 1984, largely a result of population growth and the increasing real costs of energy and chemicals.

2.2. Overview on Federal Drinking Water Regulations

Since passage of the 1986 amendments to the Safe Drinking Water Act (SDWA), regulations for volatile organic chemicals (VOCs), fluoride, surface water treatment, total coliform bacteria, synthetic organic and inorganic chemicals (Phase II), and lead and copper have been promulgated by the US Environmental Protection Agency (USEPA).

The 1986 SDWA amendments mandated establishment of many new drinking water regulations by USEPA. The new regulations are technically complex, and only highlights are presented here. The schedule of development for all current and anticipated regulations is summarized in Appendix 3 - Table 1, which lists *Federal Register* citations for Advance Notice for Proposed Rulemaking (ANPRM) notices as well as for proposed and final rules. Dates given for anticipated agency actions are based on USEPA's published regulatory agenda and on information released by the agency through December 1991; these dates can change at any time as priorities change within the agency.

Several other tables are presented in Appendix 3 and they will be referenced throughout this review:

- Table 2 lists contaminants regulated in various rules;
- Table 3 provides a summary listing of current USEPA drinking water numerical standards and best available technology (BAT) for regulated contaminants;
- Table 4 lists secondary standards.

Understanding the rules requires some basic information about SDWA. In brief, the Act says that National Drinking Water Regulations will be established and enforced for all public drinking water supplies. The law provides for a regulatory program to protect underground drinking water sources from careless injection of pollution.

In addition, the law includes provisions for an emergency action program; for assurance of adequate supplies of chlorine and other necessary drinking water disinfectants; for a survey of the quality and availability of rural water supplies; for research regarding health, economic and technological problems; for minimum standards for bottled drinking water; for citizen suits against any one in violation of the Act; and finally, for a 15 member National Drinking Water Advisory Council.

The law covers all public water systems with piped water for human consumption with at least 15 service connections or a system that regularly served at least 25 individuals. For example, practically all public water supply systems for municipalities would be covered. Also, a service station with their own water supply that regularly furnishes water to at least 25 motorists; a trailer park with 15 service connections or 25 residents; and a Federal facility such as a military base, would all be covered under the Safe Drinking Water Act.

The following regulations will be promulgated:

1. National Interim and revised Primary Drinking Water Regulations;

2. Special Monitoring for Organic Chemical Regulations (part of the above regulations);

3. Regulations covering radioactivity levels will be promulgated at a later date and shall be part of the Interim Primary Drinking Water Regulations;

4. National Interim Primary Drinking Water Implementation Regulations;

5. Underground Injection Control Program Regulations;

6. State Public Water System Supervision Program Grant Regulations;

7. Grants for Underground Injection Control Program;

8. National Secondary Drinking Water Regulations;

9. Revised Primary Drinking Water Regulations.

Section 1412 of the Safe Drinking Water Act discusses National Drinking Water Regulations. They are: Primary regulations for the protection of the public health, and Secondary regulations for the protection of the public welfare (i.e., taste, odor, and appearance of the water).

Recent developments involving SDWA provisions include the following:

- USEPA may propose national regulations for certifying laboratories that analyze SDWA compliance samples. These regulations would establish the National Quality Assurance Program for Laboratory Certification. These regulations would, in part, simplify interstate certification procedures by codifying minimum national standards.

- USEPA is currently reviewing alternative approaches to the use of practical quantitation levels (PQLs), and a proposed rule is expected in April 1992.

- USEPA in 1990 released draft guidelines for determining the health basis of unreasonable risk to health (URTH) levels, and final guidelines are expected early 1992.

- USEPA is preparing to propose a rule concerning issuance of variances and exemptations; it will not be published for public comment until the agency's overall variance and exemptation and enforcement strategy is determined. The guidlines will include consideration of affordability (i.e., under what circustances a utility should be allowed more time to comply because of its inability to afford the required solution). USEPA has indicated that BAT determinations made as part of future rulemakings will consider costs to small systems.

Phase II: Rule covers 38 contaminants. New drinking water regulations for 38 synthetic organic contaminants (SOCs) and inorganic contaminants (IOCs) were recently finalized by USEPA. These Phase II regulations apply to community water systems and nontransient, and to non-community water systems, too.

MCLGs and MCLs (Maximum Contaminant Level) for the contaminants covered by the rules are summarized in Table 3 (Appendix III). MCLs for all Phase II contaminants take effect July 30, 1992, except those for barium, pentachlorophenol, aldicarb, aldicarb sulphoxide, and aldicard sulfone, which are scheduled to take effect January 1, 1993.

Phase V: Rule to cover 24 contaminants. The Phase V rule will set regulations for 24 contaminants, 23 of which are from the list of 83 mandated for regulation by the SDWA. A proposed rule was published July 25, 1990, and a notice for availability and request for commend was published Nov.29, 1991.

The proposed MCLGs and MCLs for the 18 organic and 6 inorganic contaminants scheduled for inclusion in this rule can be found in Table 2,3 and 4 (Appendix III). Showed are the values included in the initial July 1990 proposal. Modifications to the proposal, which were presented in the November 1991 notice, are as follow:

- use a default value of 20 percent for the relative source contributing (RSC) for antimony was initially proposed, resulting in a proposed MCLGs of 0.003 mg/l. USEPA is considering the use of 40 percent based on available data which would about double the final MCLG and MCL;

- the final rule will likely specify that the MCLG and MCL apply to free cyanide rather than total cyanide, although testing for total cyanide would be allowed;

- the MCLG and MCL for di(2-ethylhexyl)adipate were lowered to 0.4 mg/l based on new health effects studies;

- the BAT for glyphosate was changed to oxidation rather than granular activated carbon;

- the MCL for dioxin was halved based on new performance evaluation studies, with a possible lowering of the PQL and MCL to $3x10^{-8}$mg/l;

- the final MCLG and MCL for beryllium were raised to 0.004 mg/l based on a recent health effects study;

- the health effects evaluation of 1,2,4-trichlorobenzene was reconsidered, which would result in raising the MCLG and MCL to 0.07 mg/l.

D-DBP Rule: Draft pending. The disinfectant-disinfection by product (D-DBP) rule satisfies specific SDWA requirements that USEPA regulate 25 additional contaminants every three years begining 1991. Contaminants to be regulated will be taken from the Drinking Water Priority List (DWPL), which includes disinfectants and a variety of DBPs. Contaminants regulated under the D-DPB rule will satisfy a portion of the regulatory requirement. The balance of the 25 contaminants required to be regulated will be cover in a separate rule, known as Phase VIb.

Phase VIb: To cover 25 contaminants. The balance of the 25 contaminants required to be regulated from the DWPL will be covered in the Phase VIb rule. The specific list of contaminants to be regulated will be drawn from the DWPL and has not yet been finalized. A proposed rule is scheduled for June 1993 and a final rule June 1995.

DWPL: New list due in 1994. A revised DWPL of 77 contaminants and contaminant groups was published Jan.14, 1991; they are listed in Table 5 (Appendix III). As mentioned previously, the D-DPB rule together with the Phase VIb rule will satisfy the requirement to regulate 25 contaminants from the list. The list will be reviewed, updated, and published again in January 1994; 25 contaminants on this list will be regulated.

CHAPTER 3

3. INNOVATIVE AND ALTERNATIVE TECHNOLOGIES

3.1. Small Water Systems

Small systems (<3,300 people served) are the most frequent violators of federal regulations and accounted for almost 89 percent of the 43,000 violations posted in 1988. Microbiological violations accounted for the vast majority of the cases with failure to monitor and report (M/R) exceeding violations of the SDWA Maximum Contaminant Levels (MCLs). The small and very small system violations account for approximately 6 million consumers at risk. In most cases, the violations are short term (less than two months). In addition there are about 19 million individuals on private wells at unknown risk.

Financing is a problem faced by most small systems. Small systems have small production, small revenues, small bugets and only big problems. Small systems are not able to take advantage of economies-of-scale because of the limited number of connections. Certain types of services must be provided such as maintaining a chlorinator, no matter how few the connections. Because of limited revenues, very often only part-time operators can be hired with the funds available for training and certification. Small rural communities normally do not have a large pool of trained engineers and scientists to deal with complex equipment or deal with the constantly changing treatment needs. Treatment technologies with high chemical or energy cost can drain small budgets over time as well. Residual management is another problem that not only small utilities must cope with, but all utilities.

In addition to the numerous problems already mentioned, the cost of meeting the 1986 SDWA amendaments may be out of reach for most small systems. Table 3.2 describes the contaminants to be regulated and the estimated total annual cost nationwide for compliance. Compounding the small systems' current problems with this new set of regulations, requires some new thinking and flexibility in helping small systems and individuals provide safe drinking water. In some cases, the basic technologies used in larger systems can be applied to small systems too. However, for the reasons stated above, treating 50,000 gpd is not simply a matter of designing a treatment scheme at one percent of the size of 5 mgd plant. Options and alternatives for small systems and individuals are necessary and are discussed in the next sections.

Treatment Options

The most significant requirements for small systems are low construction and operating costs, simple operation, adaptability to part-time operations, low maintenance, and no serious residual disposal problems. Two recent EPA reports describe in detail various drinking water treatment technologies for design and upgrade of small systems for compliance with SDWA. The following highlights several technologies from those reports in terms of the above characteristics. The technologies include: filtration systems, disinfection, organics control and inorganic treatment technologies.

Filtration

Filtration through a combination of physical and chemical processes can remove a variety of substances, including particulate matter that causes turbidity, microorganisms, color, disinfection by-product precursors, and some inorganic contaminants. Filtration options include:

* *conventional filtration*
* *direct filtration*
* *slow sand filtration*
* *package plant filtration*
* *diatomaceous earth filtration*
* *reverse osmosis membranes*

Disinfection

The Surface Water Treatment Rule (SWTR) requires systems to inactivate 99.9 percent of Giardia cyst and 99.99 percent of enteric viruses. Currently, the only disinfection by-products regulated are the trihalomethanes (THMs), but new regulations are pending. Typical disinfectants are chlorine, chlorine dioxide, chloramines, and ozone. Only chlorine and chloramines are considered for use to suppress biological regeneration in distribution systems.

Organic Contaminant Removal

The SDWA amendments established the requirement for several MCLs and for the designation of BAT to treat those contaminants. Packed tower aeration and granular activated carbon have been specified BAT for most of the organic contaminants to date. Other treatment technologies to consider for organic contaminant removal include:

* *powder activated carbon*
* *diffused aeration*
* *advanced oxidation processes*
* *reverse osmosis membranes*

Cost and applications vary considerably depending on the contaminant to be removed and the residual produced.

Table 3.1. Small System Treatment Technology Overview

Technology	Advantages	Disadvantages
Filtration		
Slow Sand	Operational simplicity and reliability Low cost Ability to achieve >99.9% Giardia cyst removal	Not suitable for water with high turbidity
Diatomaceous Earth	Compact size Simplicity of operation Excellent cyst and turbidity removal	Most suitable for raw water with low bacterial counts and low turbidity (<10 NTU) Requires coagulant and filter aids for effective virus removal Potential difficulty in maintaining complete and uniform thickness of diatomaceous earth on filter septum
Reverse Osmosis Membranes	Extremely compact Automated	Little information available to establish design criteria or operating parameters Most suitable for raw water with <10 NTU; usually must be preceded by high levels of pretreatment Easily clogged with colloids and algae Short filter runs Concerns about membrane failures High percent of water lost in backflushing
Disinfectant		
Chlorine	Very effective; has a proven history of protection against waterborne diseases. Widely used. Variety of possible applications. Inexpensive. Appropriate as both primary and secondary disinfectant.	Potential for harmful halogenated by-products under certain conditions.
Ozone	Very effective. No THMs formed.	Relatively high cost. More complex operations because it must be generated onsite. Requires a secondary disinfectant. Other by-products.
Ultraviolet radiation	Very effective for viruses and bacteria. Readily available. No known harmful residuals. Simple operation and maintenance for high-quality waters.	Inappropriate for surface water. Requires a secondary disinfectant.
Organic Contaminant Removal		
Granular Activated Carbon	Effective for a broad range of organics	Spent carbon disposal
Packed Tower Aeration	Effective for volatile compounds	Potential for air emissions issues
Diffusal Aeration	Effective for volatile compounds/radionuclides	Clogging, air emissions, variable removal efficiencies
Advanced Oxidation	Very effective	By-products
Reverse Osmosis	Broad spectrum removed	Variable removal efficiencies, wastewater disposal
Inorganic Contaminant Removal		
Reverse Osmosis	Highly effective	Expensive waste removal
Ion exchange	Highly effective	Expensive waste removal
Activated Alumina	Highly effective	Expensive waste removal
GAC	Highly effective	Expensive waste removal

Inorganic Contaminant Removal

Most treatment processes are effective for a specific set of inorganic contaminants including radionuclides. In most cases, the contaminants do not occur simultaneously, thus simplifying treatment technology selection. Inorganic contaminant removal technologies include:

* *conventional filtration*
* *lime softening*
* *ion exchange (cation and anion)*
* *reverse osmosis membranes*
* *activated alumina*

Table 3.1 summarizes the above technologies which are particularly suited for use by small systems. Table 3.2 ilustrates the variation in operating conditions for these treatment technologies. Table 3.3 provides cost estimates for some probable scenarios faced by small systems in the near future.

Table 3.2. Operational Conditions for Treatment Technologies

Technology	Level of Operation Skill Required	Level of Maintenance Required	Energy Requirements
GAC	Medium	Low	Low
Packed column aeration	Low	Low	Varies
Slow sand filtration	Low	Low	Low
Diatomaceous earth	Low	Medium	Medium
Reverse osmosis	Low	Medium	High
Chlorine	Low	Low	Low
Ozone	High	Medium	Varies
UV	Low	Low	Low

Table 3.3. Cost of some Water Treatment Technologies

Population Served by Public Water System	Type of Treatment	Cost per Family per Year, $
501 - 1,000 50,001 - 75,000 > 1,000,000	Conventional coagulation, filtration and disinfection to control microbial contaminants	125 50 25
501 - 1,000 50,001 - 75,000 > 1,000,000	Corrosion control (stabilization with lime) to control lead and other corrosion products	60 15 < 10
501 - 1,000 50,001 - 75,000 > 1,000,000	Packed tower aeration to control organic chemicals	55 28 20
501 - 1,000 50,001 - 75,000 > 1,000,000	Granular activated carbon to control synthetic organic chemicals	190 130 40

Alternatives to Full-Scale Central Treatment

Package Plants

Package plants are treatment units that are assembled in a factory, skid mounted, and transported to the site. The treatment processes utilized in "package plants" are essentially variations of coagulation and filtration treatment trains that treat anywhere from a few thousand gpd to 6 mgd. These units are still "central" in that a distribution system is necessary for water to reach the consumers. The difference between these and custom-design plants is that the package plants arrive on-site virtually ready to operate and built to minimize the day-to-day attention required to operate the equipment. Several hundred filtration package plants have been installed nationwide mostly to remove turbidity and bacteria from water with low to moderate levels of turbidity. Highly variable influent water quality requires more operator attention and tends to negate the package plant advantages of low cost and automation.

Other treatment technologies such as GAC, aeration, reverse osmosis (RO), ion exchange (IEX), etc., are also amenable to this "package plant" type of operation. These units are basically several POE (Point-of-entry) units in parallel or scaled-up versions of POE treatment units that range from 10 gpm to several hundred gpm operation for industries, apartment buildings, restaurants, trailer parks, etc. Data on the cost and performance of these units is not simply to present, since there are more than 400 manufactures, suppliers and regulators of POU and POE treatment technology. The different types of treatment technology available in the 10 gpm and above range are shown in Fig.3.1. Table 3.4 provides a cost breakdown for each available technology. Similarly to the filtration package plants, these pre-assembled units are designed for minimal operator attention and low cost.

Table 3.4. Package Plant Database Technology Cost Breakdown

Technology	Minimum Cost	Maximum Cost	Average Cost
AER	2995.00	2995.00	2995.00
DESCALER	500.00	1200.00	800.00
FIL	40.45	1359.80	564.15
GAC	2500.00	7222.25	4861.12
RO	795.40	6125.00	3320.80
SOF	2400.00	2400.00	2400.00
UV	799.00	21950.00	7521.13
COMBINATION*	559.00	28080.00	6447.45

* Any of the above technologies in series (e.g., FIL/GAC/RO, etc.)

Figure 3.1. Breakdown of Model Types for Package Plants.

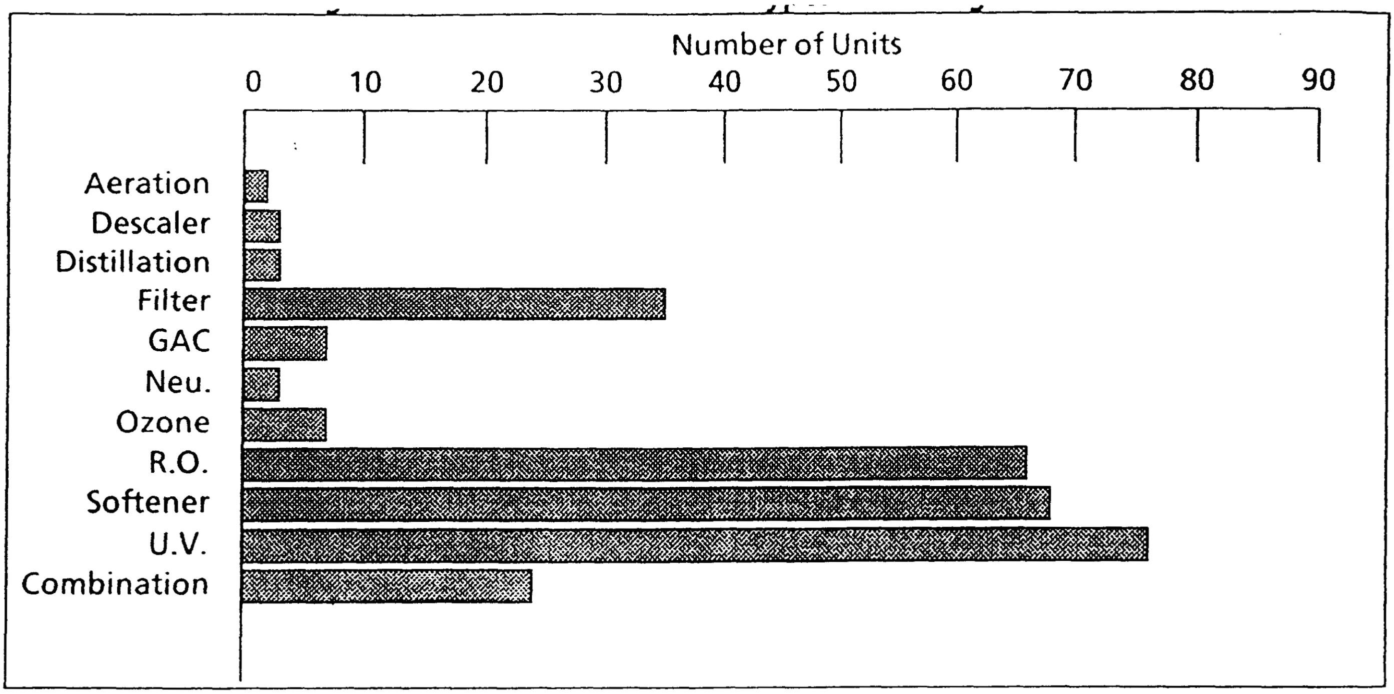
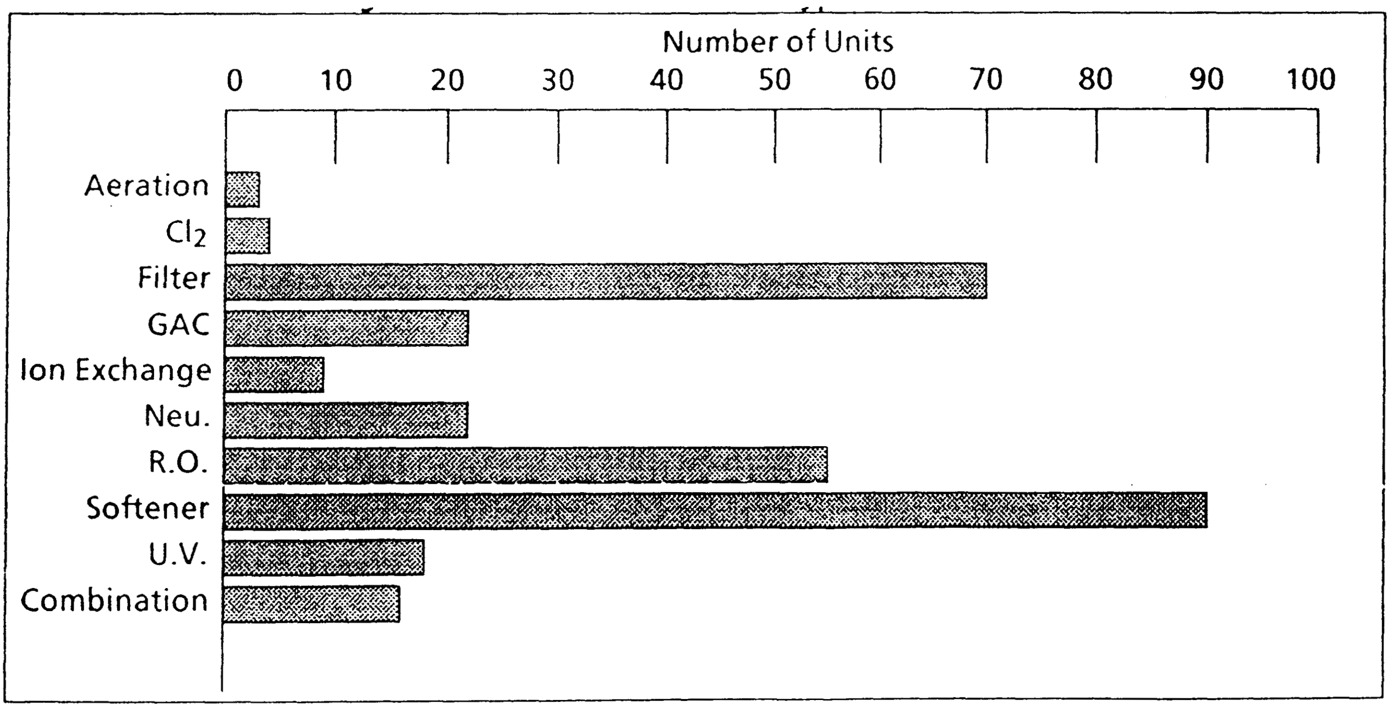


Figure 3.2. Breakdown of Model Types for POE Units.



Point-of-Entry Treatment Units

Whole-house POE treatment units are truly an alternative to centralized treatment technology for individuals and small systems. The technologies mentioned previously with the exception of slow sand and diatomaceous earth filtration have been widely adapted to treating water for the entire house (POE) or single faucet (POU). Their off-the-self availability make POU/POE an attractive alternative for individual homeowners. Figure 3.2 displays the number and type of POE units currently manufactured. Table 3.5 provides a range of cost for POE. Very small systems may find POE devices less costly to buy and easier to install and maintain than a custom-design or package plant, especially when considering technology to meet the new MCLs.

Table 3.5. POE Database Technology Cost Breakdown

Technology	Minimum Cost	Maximum Cost	Average Cost
AER	1650.00	1650.00	1650.00
CL2	235.85	246.95	241.40
FIL	48.75	852.20	359.22
GAC	539.00	1329.85	939.71
IEX	415.00	1250.00	956.67
NEU	335.00	395.00	368.33
RO	79.00	6340.00	2996.02
SOF	425.00	1200.00	731.67
UV	317.00	637.00	486.00
COMBINATION*	379.00	1650.00	750.00

* Any of the above technologies in series (e.g., FIL/GAC/RO, etc.)

Federal Position on POU/POE

EPA views the use of POU and POE differently. EPA is willing to accept POE treatment as an available technology for complying with drinking water regulations but not POU devices. In the November 1985 Federal Register, the USEPA proposed that POU and POE treatment not be considered Best Technology Generally Available but be considered acceptable technology to meet Maximum Contaminant Levels (MCLs), provided certain conditions were meet. This proposal was made because of difficulties associated with monitoring compliance and effective treatment performance comparable to centalized treatment. In the 1987 Final Rule, POU and POE treatment devices are not designated as BAT because:

1) of the difficulty in monitoring the reliability of treatment performance and controlling their performance in a manner comparable to the central treatment,

2) these devices are generally not affordable by large metropolitan water systems, and

3) not all of the water is treated in the case of POU devices which can lead to VOC exposure through indoor air transport by showers or dermal contact.

POU treatment is not considered as an acceptable means for complying with MCLs. These treatment devices are acceptable only for interim measure such as a condition for obtaining a variance or exemption to avoid reasonable risks to health before full compliance can be achieved. Because the Safe Drinking Water Act requires EPA to establish necessary conditions for use of treatment that will assure protection of public health, systems that use POE treatment for compliance must adhere to the following conditions:

a) the public water system must be responsible for operating and maintaining the treatment device,

b) the public water system must develop a plan and obtain State approval for a monitoring plan before it installs the POE devices,

c) the State must require adequate certification of performance, field testing, and review of each type of device,

d) the design and applications of POE devices must consider the tendency for increases in bacterial concentrations in water treated with activated carbon and some other technologies, and

e) every building connected to a public water system must have a POE device installed, maintained and adequately monitored.

State Position

States have dealt with the problem in different ways:

* New York has established a legal entity called Water Quality Treatment Districts, which establish guidelines for POU/POE as a formal regulated taxing entity. The state is also considering a registration program.

* California and Iowa have regulations requiring product testing and certification of treatment devices.

* Wisconsin requires review and approval of product testing.

In addition, some states are looking at advertising regulations.

Others

Local governments - through local regulation - can restrict, license, and control the sales, use, operation, etc., of POU/POE devices. However, they are generally reluctant to do so because of implementation costs. Public and private water purveyors may also enact similar requirements. The Water Quality Association, which represents the dealers and manufacturers of POU/POE equipment, has instituted its own set of advertising guidelines and maintains a council that oversees the guidelines.

Cost Comparisons

Table 3.6 describes cost estimates for central POE treatment alternatives. Assumptions include 275 gallons/day/house with 95 percent contaminant removal. The costs are for those central water supply systems with a distribution system already in place. In each case the cost becomes more favorable toward central treatment. Having to install and maintain a distribution system will shift the least cost alternative towards POE use for a larger number of households. Established water supply systems will already have a distribution system, thus POE is not likely to be a viable alternative, except for the smallest utility or one incapable of financially building or maintaining a new central treatment plant.

Table 3.6. POE vs. Central System Cost

Households	Contaminant	Initial Conc., µg/L	Central System Cost, ¢/1,000 gal	Average POE Cost, ¢/1,000 gal
10	DBCP	50	1385	475
25	DBCP	50	669	475
50	DBCP	50	398	475
10	TCE	100	1395	675
25	TCE	100	679	675
50	TCE	100	408	675
10	1,2-DCP	100	1494	800
25	1,2-DCP	100	750	800
50	1,2-DCP	100	465	800

The scenario of 25, 50 or 100 homes or more requiring treatment of their well water is one that state and local governments will have to face increasingly over time to combat the contamination of individual wells from leaking underground storage tanks, municipal landfields, and agricultural chemicals. Trailer parks and new subdivisions are other entities that may have to consider treatment to meet new MCLs. It is these situations where decisions will have to be made whether it is feasible to connect these homeowners to central treatment, install central treatment and a distribution network, or provide POE units. Connecting to an existing central supply is usually the first alternative considered and begin so unique to each situation will not be included in this evaluation.

What is considered in this analysis is a trailer park and a subdivision needing drinking water treatment technology to remove first, an organic contaminant (nitrate). Each scenario will compare central treatment with distribution system costs versus POE installation. Each residential area has 150 homes (approximately 500 consumers) requiring about 40 gpm total. The trailer park being very densely populated requires 3400 feet of pipe whereas the subdivision requires 15,840 feet (3 miles). Eight inch PVC pipe is used for cost estimating incorporating additional costs for trenching, embedment, backfill, paving and variable connection costs given different population densities.

GAC Analysis

Trichloroethylene (TCE) is one of the most common contaminants in groundwater. GAC can be used to remove TCE. Central system GAC updated cost assumptions include: an empty bed contact time of 10 minutes, a carbon service life of 165 days, 30 percent excess capacity, and 10 percent financing for 20 years. The POE unit consists of two adsorbers in-series, each with 2 cubic feet of F-400 carbon, 4.1 minutes empty bed contact time, loading rate of 4 gpm/square foot, and 8 percent financing for 10 years. The GAC POE capital cost is 2,000 dollars with an annual carbon replacement cost of one tank per year to be 240 dollars with a 15 dollar per month maintanance charge. An influent level of 100ug/l of TCE is being treated to 5 ug/l (the MCL) in each case.

Table 3.7 displays the dollars/household/year and the cents/1000 gallons for each scenario. Another alternative is considered in this table which incorporates four smaller GAC units of 10 gpm each rather than one unit of 40 gpm. In some circumstances, this may save on the amount of pipe needed given population clusters. In this case, it was assumed that 25 percent less pipe was needed. As can be seen, central treatment for the densely populated trailer park is the least expensive scenario. However, the subdivision costs are within 10 percent of the POE cost. Distribution system costs account for about 70 percent of the total costs for the subdivision and only 50 percent of the trailer park's cost. Should ductile iron pipe be used instead of PVC, distribution costs would double, thus making POE cost-effective for even more homes.

Table 3.7. GAC Cost Scenarios for TCE Removal

Residential Area	1 GAC Unit (40 gpm)	4 GAC Units (10 gpm each)	150 GAC POE Units
Trailer Park	$357/house/yr $3.70/1,000 gal	$636 6.60	$690 7.16
Subdivision	$619/house/yr $6.42/1,000 gal	$837 8.68	$690 7.16

The scenario incorporating four 10 gpm units proved to be vary costly. The 25 percent reduction in pipe was not enough to offset the extra treatment device costs.

Ion Exchange Analysis

In order to remove nitrate below the 10 ug/l standard, ion exchange can be used. Nitrate contaminaton of drinking water supplies has been increasing over the years mainly because of normal applications of agricultural fertilizers leaching into groundwater contaminating not only riral wells, but wells on the fringe of some very large cities. Ion exchange central treatment cost include: daily regeneration, 25 cubic feet of resin, 4.7 minute empty bed contact time, with 10 percent financing for 20 years. Ion exchange POE assumptions include: 2,000 dollars purchase price, auto-regeneration, 15 dollars/month service contract, with 8 percent financing for 10 years. Table 3.8 displays the cost comparing ion exchange central treatment versus POE. The four unit scenario is not included since the costs were so prohibitive in the GAC example.

Table 3.8. Ion Exchange Cost Scenarios for Nitrate Removal

Residential Area	1 Ion Exchange Unit (40 gpm)	150 Ion Exchange POE Units
Trailer Park	$312/house/yr $3.24/1,000 gal	$480 4.98
Subdivision	$5747house/yr $5.96/1,000 gal	$480 4.98

Once again, the trailer park is least expensive for the central treatment. However, because of the lower POE cost for ion exchange versus GAC, the difference is not as large. The subdivision scenario shows central treatment to be approximately 20 percent more expensive than installing 150 POE units to remove nitrate.

In conclusion, given the analyses presented, decision-makers will have to consider the intangible but potentially very expensive costs such as:

a) pipe installation, repair, rehabilitation, or replacement

b) long-term central treatment operation and maintenance versus POE maintenance and monitoring when evaluating treatment options and alternatives for small systems and private homeowners

In either case, some type of water quality district, water company, or maintenance contract would have to be created to satisfy the federal regulations.

The POE water treatment industry is growing very rapidly and, as shown in many cases, POE technology can be a cost-effective solution for small systems and individual homeowners, eliminating many of the problems small systems face when attempting to finance and operate central treatment facilities. The assurance of long-term maintenance and monitoring of POE technology remains the main problem to be dealt with.

Applicability to Romania

When talking about small drinking water systems in Romania the first observation is that they are only a few in the sense of the deffinition use in this report. The usual solution for solving the problem in small rural communities is with private individual wells. But this is not possible everywhere - for technical or economic reasons, or both - and more than that, there are many small communities placed near large industrial areas where the groundwater is no longer ready to drink (see Chapter 1).

This section presents both technical options in order to make the raw water safe to drink, and the costs too. When trying to extent these practices to Romania there are at least two aspects to be consider very carefully: 1) each technology, the instalations dimensions and costs are designed to meet the U.S. Safe Drinking Water Regulations (SDWA), and 2) more than in U.S. both operating and maintenance aspects are a great problem.

3.2. Large Water Systems

Speaking about upgrading the existing or designing water supply systems we must consider both managerial and technological areas of potential innovation. However, this paper deals only with the second - areas of potential technological innovation - taking into account the present stage of development and research in U.S. and in other developed countries.

Areas of Potential Technological Innovation

Drinking water treatment technology can be divided into centralized systems and point-of-use categories. Centralized systems feature surface or groundwater sources, one or more water treatment plants, and storage, transmission and distribution components. Point-of-use systems are installed on location at the point of consumption. They may be used to improve the quality of well water sources or by individual consumers who are not satisfied with the quality of the water supplied by the central system "Point-of-entry" systems are a variation of point-of-use systems in which the treatment equipment is located either in the immediate neighborhood (and serves only a few homes) or outside an individual dwelling to allow for ready access by service personnel. The following section discuss potential technological improvements, centralized treatment technologies, storage and distribution technologies, and point-of-use/point-of-entry technologies.

Improvements to Centralized Treatment Technologies

Significant technological changes appear to be taking place. In the case of filtration, an old technology (slow sand filtration) is enjoying renewed interest.Concurrently,another old technology (multimedia filtration) is not being universally accepted. Many consulting engineers are unware of the numerous benefits of ozone and, as a result, its use has been largely restricted to disinfection. Similarly, carbon adsorbtion has been widely accepted in Europe but not in the U.S. Packaged treatment systems are readily available and useful for a large number of systems. The majority of systems, however, still prefer to construct and assemble equipment on-site. Thus, a number of technology are available and newer technologies are emerging, but there are barriers to their widespread usage and acceptance. Among of these barriers, the traditional conservatism of both the consulting engineering community and state health agencies takes a very important place.

Reservoir/Water Supply Enhancement

Minimization of treatment requirements and costs can often be attained through protection of the raw water source. For example, erosion control at development sites reduces the amount of solids washed into streams and lakes (a major source of turbidity), in turn reducing the amount of chemicals and equipment needed to remove the solids. Reservoir aeration can reduce the incidence of algal blooms, in turn reducing treatment requirements for taste and odor control.

Prevention of source degradation requires extensive monitoring and enforcement of waste discharges and surface runoff. The costs of cleanup must be balanced against the costs of prevention. Ideally, discharge standards and water quality programs should consider both environmental and economic concerns. After basic environmental protection is provided, the decision on whether to treat discharges to a higher standard, versus more thorough treatment of the potable supply, could be made on technical and economic grounds.

Pretreatment

Traditional pretreatment practices generally focus on removal of suspended and colloidal solids by chemical coagulation, flocculation, and sedimentation. Chemicals may be added at this stage for pH adjustment, taste/odor control, disinfection, and/or oxidation. Pretreatment facilities usually include flocculation and conventional clarifiers, which tend to be large and costly to construct. More compact and lower cost approaches, such as combined flocculator clarifiers, upflow clarifiers, tube settlers, lamella separators, Pielkenroad separators, and reactor clarifiers, have been available for some time, but their use is still not widespread among water utilities as a result of "barriers" alluded to earlier. They are considered innovative technologies.[1]

Several equipment suppliers have developed pretreatment units for solid removal that use physical entrapment rather than simple sedimentation. One supplier of package water treatment systems has developed an "adsorption clarifier" which uses a suspended bed of plastic beads as the solids capturing medium. The unit is presently being applied in package treatment form, but could be applied in a more conventional manner in plants of sizes up to 15 million gallons per day (mgd) [5678.5 mc/d]. Another major specialist in water treatment technology has developed a "depth clarifier" which operates on the principle of contact flocculation. This concept has been developed for treatment plants up to 2.5 mgd in size.[2]

These units are much more compact for a given treatment capacity and might substantially reduce the cost of pretreatment. However, the technologies would require extensive development and testing before they could be applied to large water treatment systems. At present, the technology is limited primarily to smaller and medium sized water treatment systems which comprise the bulk of U.S. water utilities.

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[1] James M. Montgomery Consulting Engineers,Inc., "Water Treatment Principles & Design", John Wiley & Sons, 1985

[2] American Water Works Association Research Foundation, "A Definitive Study of Barriers to the Introduction of New Products and Technologies Into Water Supply Systems", July 1985

Filtration

Filters are generally used as part of an overall water treatment process scheme which includes chemical addition, coagulation and flocculation, filtration, and disinfection. There are four general classes of filtration technology in widespread use for potable water treatment:

- Slow Sand Filtration;
- Rapid Sand Filtration;
- Multimedia Filtration; and
- Diatomaceous Earth Filtration.

Of these four types, rapid sand and multimedia filters account for the majority of applications. Diatomaceous earth filters enjoy only limited use because of media costs and limited regulatory acceptance. Slow sand filtration, an old technology, is enjoying renewed interest for small water systems due to its simplicity and low maintenance requirements.

Multimedia filtration was first developed in the early 1940's at Hanford, Washington, where higher water quality was required for wartime processing of radioactive materials. Rather than use a uniform filter media of sand, the multimedia filter mixed aggregates of varying size with anthracite coal. In the 1960's, the technology began to gain widespread acceptance. To date, there is more than 25 years experience with the technology, yet acceptance problems continue.

Direct filtration is a turbidity removal process that may eliminate separate flocculation and settling steps. Coagulation either occurs immediately before the water enters the filter or within the filter unit. It is most suitable for source waters with low turbidity caused by silt. Direct filters usually have multimedia filter beds. Because operating requirements are more complex and there is less margin for error than with systems that have seprate coagulation and settling, regulatory agencies tend to discourage the use of direct filters by smaller utilities.

There is a tendency among regulators and engineers to restrict the use of multimedia filters to flow rates similar to, or only slightly higher than those used for conventional rapid sand filters. Multimedia filters have been demonstrated to be effective for filtration rates of 5 - 7 gallons per minute per square foot (gpm/ft^2), or 12.21 - 17.01 m/h. Rapid sand filters are normally rated at 2 - 4 gpm/ft^2, or 4.88 - 9.77 m/h. Thus, multimedia filters can potentially reduce the size and cost of filters by as much as 50 percent. These savings, however, can only be realized if the technology is applied at its full capability.

Reverse Osmosis

Reverse osmosis (RO) is most widely used for rendering brackish or saline waters potable. It is based on the principle of osmosis. If two solutions one dilute and one concentrated are separated by a semipermeable membrane, water will migrate from the dilute solution into the concentrated solution. Applying pressure to the concentrated solution will reverse the process, hence the term "reverse osmosis". RO units force filter water through a semipermeable membrane leaving most of the contaminants behind to be flushed out in the waste stream.

In recnt years, RO technology has improved from the stand point of energy consumption, system longevity, and reliability. These improvements have allowed the use of RO for relatively inexpensive and simple home treatment units.

Deionization

Deionization, or "ion exchange", is most widely known for its use in water softening, wherby calcium and magnesium are removed to reduce water hardness. A regeneration process purges the contaminant from the bed; hence, like RO, ion exchange does not destroy the compounds, but rather concentrates them in the waste stream. This could present problems with final disposal especially in situations where concentrations of the contaminant in waste streams are so high that it is rendered "hazardous".

Ion exchange is most suitable for smaller water systems where the ease of operation and low capital costs offsets chemical costs. Waste disposal is less likely to be a problem on the smaller scale as well. A recent application of ion exchange in Jefferson County, Colorado, to remove low level radioactive contaminants provides a good example of how a small water system can utilize this process for removing potentially toxic contaminants.

Packaged Treatment

Packaged treatment, as the name suggests, is not a process, but an alternate means of assembling all or part of a water treatment system in a package rather than as a collection of individual processes. Packaged treatment systems are usually fabricated of metallic or fiberglass materials and are designed to be pre-manufactured and shipped to a location rather than constructed on site.

Pakaged treatment systems have a number of major advantages for small water utility applications:

- *Economy:* factory rather than site construction techniques are used and tanks are constructed of less expensive materials; the plants tend to be compact and much less expensive than site built systems.
- *Integration:* properly designed and constructed packaged systems have highly integrated processes;compact design often allows for the entire plant to be housed under cover,thus improving the operating environment.
- *Automation:* many pakaged systems incorporate a high degree of instrumentation and automated operation; this frees the operator to focus on maintenance and repair and can result in more efficient overall operation.

Packaged systems tend to be less costly than site constructed plants in sizes up to two mgd (~7571 cm/d). Plants of this size account for about 90 percent of U.S. utilities[1]. Thus, when viewed in terms of numbers, the market that could potentially use existing packaged treatment technology is large.

The best packaged systems available in the U.S. combine innovative technology, quality construction, good documentation and support, and high performance. Unfortunately, there is a wide range in quality of equipment that is bid as "equal" on most public water supply procurements; there have been enough failures to make engineers and state regulatory personnel reluctant to allow extensive use of packaged systems in many states.

Instrumentation and Automation

Instrumentation and automation (I&A) refers to equipment that is used for monitoring and controlling water treatment processes. Historically, the water industry has been slow to use I&A equipment. Instead, there has been a strong reliance on manual sampling,laboratory analysis and process operation,due to the belief that I&A equipment is failure prone and costly to maintain. Statistics gathered by the highly respected SIRA Institute of the United Kingdom, which provides instrument testing services to industries in both the U.S. and Europe, tend to support this point of view. Nevertheless, industry has historically spent considerably more on I&A equipment than public water or wastewater utilities.

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[1] Sigurd P.Hansen, "Package Plants: One Solution to Small Community Water Supply Needs", Journal AWWA, June 1979

Improving the quality and reliability of water treatment plant instrumentation and automation devices has consistently been a high priority item among municipal engineers and managers. Problem identification and prioritization studies by such public interest groups as Public Technology, Inc[1]. (PTI) have consiterently identified the need of improvement in this area. Growing out of the PTI/EPA work, a group spearheaded by large wastewater utilities formally established an Instrument Testing Service (ITS) in 1986, with the assistance of the Association of Municipal Sewerage Agencies (AMSA). The ITS has already conducted rigorous field tests on several instruments and an expanded test program is planned which will include testing on a group of dissolved oxigen analyzers. Funding for the test program is provided by membership fees.

This section suggests that a large number of treatment technologies are currently available and innovations occur from time to time. However, the greatest potential for improvement appers to be in getting these technologies accepted by small water treatment systems.

Removal of Synthetic Organic Chemicals

Drinking water contaminants are sometimes described as being

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[1] Public Technology, Inc., and the U.S.EPA co-sponsored an "Urban Consortium Program" during the early 1970's; this program surveyed U.S. municipalities to determine their priority technology-based needs. Better I&A equipment for water and wastewater treatment was consistently selected as one of the top ten priority needs.

either organic or inorganic. This distinction and terminology came about as a result of earlier concepts in chemistry which designated all carbon containing compounds as being formed in nature, hence organic. Modern chemical manufacturing firms produce a wide range of carbon containing compounds which do not occur naturally, yet are still designated as organic. The term "synthetic organic chemicals" (SOCs) has been coined to describe this new class of organic materials. Man-made organic compounds are increasingly found in surface and ground waters and there are major concerns about their long term human health effects.

As early as 1973, the U.S. EPA reported that most surface waters and a growing number of groundwater supplies are contaminated with low levels of SOCs. Proposed revisions to existing EPA drinking water regulations would add an additional 30 chemicals or chemical classes (see Appendix III). Conventional water treatment processes vary in effectiveness in removing these substances. Many are not removed at all by the sedimentation and filtration processes commonly used. Chlorination of waters containing SOCs may produce potentially carcinogenic chlorinated (halogenated) organic compounds. For example, chlorination of wastewater treatment plant effluent, common in U.S., is a signifiant source of chlorinated hydrocarbons in downstream drinking water supplies.

The EPA and state regulatory agencies are looking closely at additional treatment requirements specifically for SOCs in many areas. Processes that are being applied for SOCs removal include the following:

- o Oxidation
- o Activated Carbon Adsorption
- o Biological Treatment
- o Reverse Osmosis
- o Ion Exchange
- o Coagulation/Sedimentation/Filtration
- o Air Stripping

Coagulation, sedimentation and filtration were discussed previously. Organic removal through these processes is largely limited to high molecular weight compounds such as humic and fulvic acids. Air stripping is effective in removing organic compounds that are highly volatile, such as organic solvents (e.g., carbon tetrachloride).

Oxidation

There are four primary means of oxidizing dissolved organics in water: chlorination, chlorine dioxide addition, potassium permanganate addition, and ozonation. Chlorination tends to form byproduct chlorinated compounds, considered to be potentially harmful contaminants. Chlorine dioxide additions have been limited to 1.0 mg/l by regulation, since the by-product of chlorine dioxide reduction is the toxic chlorite ion. Potasium permanganate is a powerful oxidant, but results in increased manganese concentrations in water. The chemical does not produce the halogenated organic compounds which are of major concern as potential carcinogens.

Ozone (O_3) is a powerful oxidant - as well as a stong and non-selective germicid - that is generated on-site using electrically powered ozone generators. Ozonation of waters containing SOCs can produce many new oxidized products which are generally less toxic than the precursor compounds.[1]

However, certain pesticides may form more toxic intermediate compounds which should be further oxidized to assure a safe water supply. Ozone is the oxidant of choice in European water treatment plants. It is used in conjunction with activated carbon and biological treatment to effect a high degree of SOCs breakdown and removal. Because ozone is relatively short-lived in a water solution, it is not suitable as a final disinfectant and is seldom used as a terminal treatment step in either the U.S. or Europe.

Water utilities in the U.S. have been slow to use ozone for water treatment and there has been a mistaken impression among many engineers and utility operators that ozone is primarily a disinfectant. However, there is a growing recognition of ozone as a superior oxidant among the larger utilities that must upgrade treatment processes for various types of contaminant removal. There are currently 30 major U.S. water utilities with operation-

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[1] U.S. EPA, "An Assessement of Ozone and Chlorine Dioxide Technologies for Treatment of Municipal Water Supplies", Aug.1978

al ozone systems and 10 plants are under design or construction. The largest ozonation plant in the U.S., devoted to potable water treatment, is in Los Angeles, with a total capacity of 600 mgd or 2,271,300 cm/d.

Although ozone is a powerful oxidant, it does not break down all organic compounds found in water supplies to the point where no further treatment is required. European water utilities use ozone as part of a comprehensive approach to organics removal which includes activated carbon adsorption and sometimes biological treatment. Ozonation is a well developed technology whose use is increasing rapidly as the process become better understood by consulting engineers.

Activated Carbon Adsorption

Activated carbon is manufactured from carbon-containing materials such as wood, pulp mill residues, bones, peat, coal, and lignite[1]. Some water utilities use activated carbon as a separate treatment, by adding carbon on the surface of sand filters or as a slurry in the pretreatment process. The European practice is to precede activated carbon with ozonation so that the organic compounds are broken down and more readily adsorbable. This results in a high degree of SOCs removal. The technology for combining ozone with activated carbon treatment is well

[1] U.S. EPA, "Adsorption Techniques in Drinking Water Treatment", NATO/CCMS Drinking Water Pilot Project Series, Oct., 1984

known and widely applied overseas. Currently, only a few U.S. utilities use activated carbon and it has been noted that there is substantial resistence to its use here. Part of the reason for the resistance are the high capital and operation and maintenance costs. The costs of carbon adsorbers, the carbon itself, and the high costs of thermally regenerating the spent carbon are often cited by utilities as the reasons for not using the technology.

Biological Treatment

Biological treatment has been widely used in water treatment, either by accident or by design. Biological activated carbon treatment is widely used in Europe. It combines the organics treatment capabilities of ozone, activated carbon, and biological treatment. It has been found to greatly extend the life of activated carbon columns, aid in the conversion of ammonia to nitrate, and reduce ozone requirements. This concept, however, has not been widely accepted in the U.S. Water utilities here stress the avoidance of any biological growths in the treatment process, and will often prechlorinate if necessary to prevent or kill such growths. Ironically, such prechlorination is often a potential source of chlorinated organic compounds.

Biological treatment is an important part of slow-sand filtration. A layer of biological growth occurs on the surface of the sand and serves to remove and oxidize organic compounds in the water supply. Slow sand filters are cleaned by removing and replacing several inches (5-10 centimeters) of the surface material periodically. It has been observed that some time is required after cleaning (one week or more) to regain optimal water treatment capabilities with this technology since the bacteria must become reestablished on the filter.

Reverse Osmosis

Although reverse osmosis (RO) is best known for its application to treating waters of high salinity or dissolved inorganic solids, there is increasing interest in the use of this technology for removing organic compounds as well. However, large scale application of this process to organic removal is uneconomical in most cases. It may have more use in solving specific organics removal problems for small water sources.

Deionization

Highly soluble, low molecular weight compounds or classes of organic compounds may be removed by ion exchange. This approach is most suitable for smaller water systems where the ease of operation and low capital cost offsets chemical costs.

Improvements to Dsinfection/Storage/Distribution

As suggested in the previous section, the relevant technologies are readily available. The challenge lies more in ensuring their widespread acceptance.

Disinfection

Disinfection is usually the final step in the treatment process before potable water is pumped to storage or distribution. Disinfection in the U.S. has almost always been accomplished by the application of chlorine, usually in gaseous or liquid forms. Chlorine is relatively cheap, is readily available, and the technology of its use is well known. There are, however, a number of effective chemicals that can be used for disinfection, including iodine, bromine, chloramines, and chlorine dioxide. In addition, there have been substantial advances in recent years in the use of ozone, ultraviolet light, or combined process of both ozone and ultraviolet light as a method of disinfection.

In order to kill any microorganisms present and protect against their regrowth in reservoirs or the distribution system, the disinfectant, usually chlorine, is added in sufficient quantities to assure that a residual remains after oxidation is complete. Typically, chlorine may be applied in concentrations ranging from 1 - 20 mg/l. As mentioned earlier, chlorine may produce a number of potentially carcinogenic halogenated compounds in the process. This characteristic is true of chloramines as well, and recent studies showed that also ozne use can lead to harmful by-products - bromide.

Chlorine dioxide is widely used as a final disinfectant in Europe because of a number of important advantages:

1. it can be generated on-site using readily available

chemicals;

2. it does not produce significant quantities of chlorinated compounds as by-product of disinfection;
3. in the concentrations needed for adequate protection of the distribution system, it does not impart a strong "chlorine" taste and odor to the water.

Chlorine is not as widely used in the U.S. for two reasons: a) it is higher in cost that chlorine; and b) there is concern over the toxicity of the chlorite ion which ends up in the treatment stream if the chemical reaction which produces the chlorine dioxide is not complete.

Although ozone is a powerful oxidant and disinfectant, it cannot produce a residual that is long-lived enough to protect most reservoirs and distribution systems. Hence, it is almost always used in conjunction with a disinfectant that does produce a residual, such as chlorine or chlorine dioxide.

Microorganisms are destroyed by ultraviolet light (UV) when the UV energy is adsorbed by the genetic material in the cells. UV disinfection is most effective when the water supply is highly clarified and bacterial loads are moderate. UV disinfection is instantaneous but there is no protective residual created.

Storage and Distribution

After the treated water leaves the plant, the next step is usually storage and distribution to the service area. The water treatment plant represents a sizeable investment, but the bulk of capital expenditures are in the delivery system (due to its lengh and high cost materials used, the distribution systems cost are generally around 70 - 80 percent of the total investment costs for a water supply system). Reservoirs are usually buried,surface-standing, or elevated tanks that are sized to hold enough treated water to supply several days demand. The reservoirs provide added insurance that there will be sufficient water available during short-term shutdowns of the treatment facility or to meet extraordinary emergency demands.

Reservoirs are linked to the residences and businesses of the user population via piping networks that are fed either by gravity, pumping, or a combination of the two. The system as a whole represents a geographically large and dynamic network, one which generally requires substantial management.

Electrical utilities and water utilities have many similarities. Both can make extensive use of computerized control and remote monitoring. SCADA (supervisory control and data acquisition) technology, widely used and highly developed by the electrical utility industry, is being rapidly applied by water utilities to save energy and improve reliability.

SCADA allows the water utility to continuously monitor and control reservoirs levels, pumps, pressure controls, motorized valves, system flows, and pressures. Operation of the treatment facility can be "paced" to demand within the system. With this technology, the utility can operate a far-flung system from a "command post" in the manner practiced by electric and gas utilities. SCADA, coupled with computerized demand/energy management technologies, permits the utility to automatically manage the system 24 hours per day to get the most stable operation at the lowest cost.

SCADA for water utilities has matured rapidly,spurred by the efforts of large and forward-looking utilities such as Denver, Seattle, East Bay Municipal Utility District, and Los Angeles. The technology has been given widespread publicity by the AWWA and other water industry groups. However,most of the applications and publicity center around the activities of larger utilities; little has been done to apply and publicize use of the technology in small systems.

Groundwater Technology

Over 80 percent of U.S. water systems rely on groundwater for potable water supplies. While most groundwater systems are either individual home or small to medium sized utilities, there are a few large utilities which rely totally on groundwater and a larger number that augment surface supplies with groundwater supplies. In 1983, it was estimated that one to four percent of the usable groundwater is already contaminated. In general, the contaminated groundwater underlies areas of major population concentration and is most severe in the Mid-Atlantic and New England states. Sources of groundwater contamination include septic tanks, land-applied pesticides and herbicides, drainage from landfills and mines, and leaching from improperly disposed industrial wastes.

Groundwater contaminants can be oxidized and/or removed using the same technologies that are used for surface waters. Because of the physical filtering effect of the aquifer, most groundwaters are low in suspended solids. Hence, filtration may not be required or, if needed to remove low-level solids, can often be accomplished using direct filters. The most effective processes for oxidizing or removing groundwater contaminants are ozonation, activated carbon, ion exchange, and reverse osmosis. Because many groundwater supplies serve individual homes or very small water systems, point-of-entry or point-of-use technologies, discussed below, may present a cost-effective means of producing safe drinking water.

Point-of-Entry/Point-of-Use Treatment

The point-of-use (POU) industry provides water treatment products for residential, commercial and industrial applications. These products generally involve small volumes and flow rates and are installed in the home or on the premises of a business. A water "purifier" which mounts on faucets or underneath the kitchen sink in the home is an example of a POU device. Point-of-entry (POE) refers to water treatment equipment which may be installed immediately outside of the home or may serve a small group of homes or businesses. An exterior-mounted water softner unit serviced on periodic basis by a supplier is one example of a POE device.

During the last decade, treatment of drinking water through the use of POU or POE has incresed greatly. Most POU equipment is purchased for improving the aesthetic qualities of water, but greater emphasis is being placed on the removal of health-related contaminants, such as SOCs or microorganism.

Some contaminants that are present at the consumer's tap, such as discoloration from water main corrosion, microorganisms from regrowth after treatment and disinfection, and contaminants from cross-sections or main breaks, occur after the water has left the treatment plant. Other contaminants are simply not removed by the conventional coagulation/settling/filtration processes used by most water treatment plants. Groundwaters from local or homeowner's wells may be contaminated by a variety of contaminants which should be removed prior to consumption.

Relative to the cost of centrally treated water supplies, POU or POE treatment can be quite high. An economic analysis of a "complete treatment" POU device using reverse osmosis and carbon adsorption indicates a range of costs per gallon treated of 13 - 25 cents[1]. By comparison, bottled water costs about one dollar per gallon and centrally treated water may be as cheap as one-tenth cent per gallon.

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[1]Economic analysis by Wade Miller Associates (WMA) based on data from Rodale "Water Treatment Handbook". WMA analysis assumes a $35 installation cost for each device, 10 year economic life, and annual operation at rated flow.

Although the cost per gallon treated by POU or POE devices may be high, only a small fraction of the water produced by central water treatment plants is actually consumed for cooking or drinking. If only this small portion is treated at the point-of-use, the resulting cost to the consumer is not unresonable.

There are two primary problem areas with the use of POU and POE devices:

a) if they are used to treat only a portion of the water supply delivered to the consumer, what effective safeguards can be taken to avoid accidental ingestion of the untreated supply? This is of particular concern when the treatment device is being used to remove potentially harmful compounds or microorganisms.

b) what assurance is there that the device or devices will be properly maintained? This is a particular concern with devices installed within the home. Provision of safe drinking water supplies cannot realistically rely on the homeowner for required maintenance.

Theoretically, at least, the use of externally housed POE devices, coupled with a "circuit rider" maintenance system, could handle the second objection. It would appear that the first objection could only be handled by ensuring that all water supplies at the point-of-use meet some minimum standards for safety.

There are also, other potential technological areas where improvements could result both in a more hydrolic secure operation, under quality and quantity aspects, and in a reduce in operating costs.

For example, improvements in pipe materials and construction not only reduce the incidence of failure (along with the average age of system), but also prevent potential contamination of the water distribution system. More widespread implementation of leak location and repair programs might mitigate deterioration of water distribution systems as well as reduce operating costs. Corrosion control, which must consider both externally and internally attack will primarly result in long service life for the metalic components of the distribution system. For both of them - internal and external corrosion control - the know-how for design and application is readily available. Finally, metering, i.e., charging the consumer on the basis of water usage, provides the utility with more opportunity to rise needed funds for system maintenance and improvement and, in addition, to greater control of system and more incentive for conservation.

The general conclusion of this section is that the technologies for improving every drinking water supply component already exist. The challenge is to encourage more widespread acceptance, especially among small systems.

Technology Transfer and Technical Assistance

Technology Transfer

Research and development efforts, whether conducted by government or the private sector, bear no fruit if they are never applied in actual operational situations. Technology transfer is the process through which technology - process equipments, management systems such as SCADA, or process modifications - are translated from the drawing board and prototypes into actual operations. Technology transfer can be affected through presentation of technical papers, workshops and seminars, handbooks or manuals, or, with the greatest impact both on specialist and public, pilot testing and project demonstration.

The Environmental Protection Agency (EPA) had an active program of technology transfer in the early 1970's. That effort has now been reduced considerably in scope and buget and is now called the Center for Environmental Research Information (CERI). CERI's primary efforts involve the sponsorship of seminars and workshops dealing with various research activities. CERI currently is planning 10 workshops on emerging technologies in drinking water. The emerging technologies dicussed will be the "best available technologies" to be prescribed for contaminants removal in forthcoming EPA drinking water regulations.

The AWWA Research Foundation also is becoming more active in the area of technology transfer. As the Foundation's research agenda grows, more emphasis is being placed on the dissemination of information through seminars, workshops, and publications.

Technical Assistance

In its most basic form, technical assistance involves emergency response to water contamination. Proactive programs include the transfer of information on "hardware" areas such as new technology and equipment. Some programs also include "software" areas such as management techniques, operator training, operator certification, technical guidance, recordkeeping, dissemination of information on legal requirements, and administrative procedures. Further, TT&TA may also include continuing research programs to develop new technology, demonstration projects to show what works and what does not, and educational programs such as college programs, book publications, materials in professional journals, and other types of training activities.

A very small number of larger systems supply water to a vast majority of the population and vice-versa. Larger systems are able to obtain the needed technologies and assistance because of their size and financial base. Providing technical assistance is primarily a problem affecting small community systems. They not only do not have the financial base necessary to support the operations, treatment process and staff to supply safe drinking water, but are also ill equiped to research the necessary technologies and management practices. Further, they do not have the managerial and technical competence to make best use of their limited resources to solve problems.

3.3. Baltimore's Water Supply

Water Sources

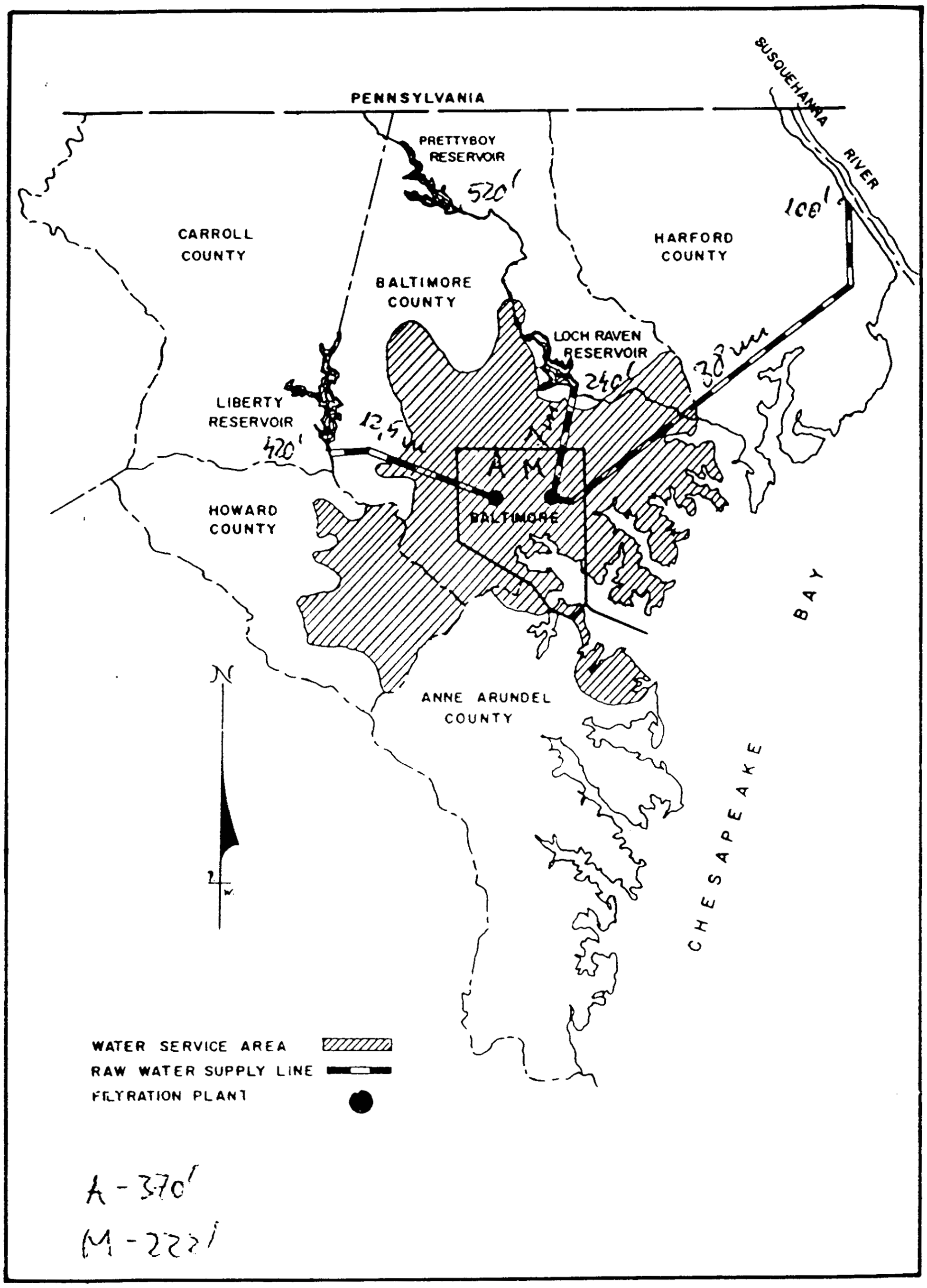
The water supplied by the Department of Public Works to residents of Baltimore City and adjacent territory is obtained from three sources: the Gunpowder Falls, the North Branch of the Patapsco River, and the Susquehanna River. They are classified as surface supplies. A general map for the water supply area in Baltimore is presented in fig. 3.3.

GUNPOWDER FALLS and PATAPSCO RIVER

The Gunpowder Falls development has a watershed above Loch Raven Dam of 303 square miles (784.77 Km^2). Two dams located on this stream, one at Loch Raven and the other farther upstream near the mouth of Prettyboy Creek, impound water and store it in the reservoirs formed by them. These reservoirs have a combined capacity of 43 billion gallons (162,755 mil. m^3), most of which can be delivered by gravity to the Montebello Filtration Plants through a 12 foot diameter tunnel (3.66 m).

The development on the Patapsco River with a watershed of 164 square miles (424.76 Km^2), consists of the Liberty Dam located near Falls Run on the North Branch of the river, and the Liberty Reservoir with a capacity equal to that of the two reservoirs on the Gunpowder Falls, namely 43 billion gallons. Most of this water can be delivered by gravity to the Ashburton Filtration Plant through a 10-ft diameter tunnel (3.05 m).

Fig. 3.3. Baltimore's Water Supply Area.



Map shows how raw water is gathered from three outlying sources, then flows to three filtration plants in Baltimore City, and is delivered through water mains to customers in the large water service area.

PRETTYBOY DAM and RESERVOIR

Prettyboy Dam is a concrete gravity dam located on the Gunpowder Falls, about three miles southwest of Parkton. The crest of the dam is 520 feet above sea level. A reinforced concrete arch bridge, with a roadway 20 feet (6 m) wide and a footway on each side, crosses this dam.

Other data is as follows:

- spillway length .... 274 feet (83.52 m)
- total length .... 845 feet (257.56 m)
- height of crest above stream bed ..... 130 feet (39.62 m)
- capacity of reservoir .... 20 bil.gal. (75,700 mil.m^3)
- flooded area at crest elevation .. 1,500 acres (60.70 Km^2)
- length of shore line
  at crest elevation ...... 46 miles (74.03 Km)
- area of land owned .... 7,380 acres (29.87 Km^2)
- water overflowed crest for the first time: Sept.23, 1933

LOCH RAVEN DAM and RESERVOIR

Loch Raven Dam is a concrete gravity dam, located on the main stream of the Gunpowder Falls below the mouths of all the large tributaries. The dam was raised to its present elevation, 240 feet above the sea level, in 1923, by adding 52 feet to the structure erected in 1914.

Other data is as follows:

- spillway length .... 288 feet (87.78 m)
- total length .... 650 feet (198.12 m)

- height of crest above stream bed ...... 82 feet (25.00 m)
- capacity of reservoir .... 23 bil.gal. (87,055 mil.m^3)
- flooded area at crest elevation .. 2,400 acres (97.13 Km^2)
- length of shore line at crest elevation ...... 50 miles (80.47 Km)
- area of land owned .... 8,000 acres (32.38 Km^2)
- water overflowed crest for the first time: May, 1923

LIBERTY DAM and RESERVOIR

Liberty Dam also is a concrete gravity dam. It is located on the North Branch of the Patapsco River at a site approximately two miles south of Liberty Road. The crest of the dam is at an elevation of 420 feet above sea level.

Other data is as follows:

- spillway length .... 480 feet (146.30 m)
- total length .... 740 feet (214.58 m)
- height of crest above stream bed ..... 160 feet (48.77 m)
- capacity of reservoir .... 43 bil.gal.(162,755 mil.m^3)
- flooded area at crest elevation . 3,100 acres (125.46 Km^2)
- length of shore line at crest elevation ..... 82 miles (131.97 Km)
- area of land owned .... 9,200 acres (372.33 Km^2)
- water overflowed crest for the first time: Feb.06, 1956

Liberty Dam, located on the North Branch of the Patapsco River, sends raw water by gravity to the Ashburton Filtration Plant.

Water Impound

Under normal operating conditions, water flows by gravity from the Loch Raven Reservoir to the Montebello Filtration Plants through the Gunpowder Falls-Montebello Tunnel, a concrete lined tunnel, 12 feet (3.66 m) in diameter, and approximately seven miles in length (see Fig.2.6). This tunnel was constructed through solid rock.

When the water level in Loch Raven Reservoir is lowered a few feet below the crest of the dam, the discharge valves at Prettyboy Dam are operated. The water released flows down the bed of the Gunpowder Falls into Loch Raven Reservoir, thus maintaining the water level in the latter reservoir at a predetermined elevation.

If the level in the Loch Reservoir drops too low for gravity flow, water can be pumped from the Loch Raven Reservoir to the Montebello Filtration Plants by a pumping station located at the plants. The station, called the Montebello Raw Water Distribution Center, was constructed in 1958 in conjunction with the Susquehana Water Supply Project. The station contains three pumps, each having a capacity of 120 million gallons per day (465,000 m^3/day) and appurtenant equipment.

Water from Liberty Reservoir flows through a concrete-lined tunnel, 10 feet (3.05 m) in diameter, to the Ashburton Filtration Plant, a distance of approximately 12.5 miles (20.12 Km). This tunnel was constructed through solid rock.

At some future time, when pumps are placed in the Ashburton Filtration Plant, it will be possible to pump water from the Liberty Reservoir whenever the water level falls too low for gravity flow.

The Susquehana Water Supply Project includes:

1. The Conowingo Intake with an initial capacity of 250 million gallons per day (946,250 m^3/day). This structure has an ultimate design capacity of 500 million gallons per day (1,892,500 m^3/day).

2. The Deer Creek Pumping Station, where three 50 million gallons per day capacity pumps were initially installed and provision was made for the future installation of two pumps of the same capacity. The ultimate design capacity of the station is 243 million gallons per day (919,755 m^3/day).

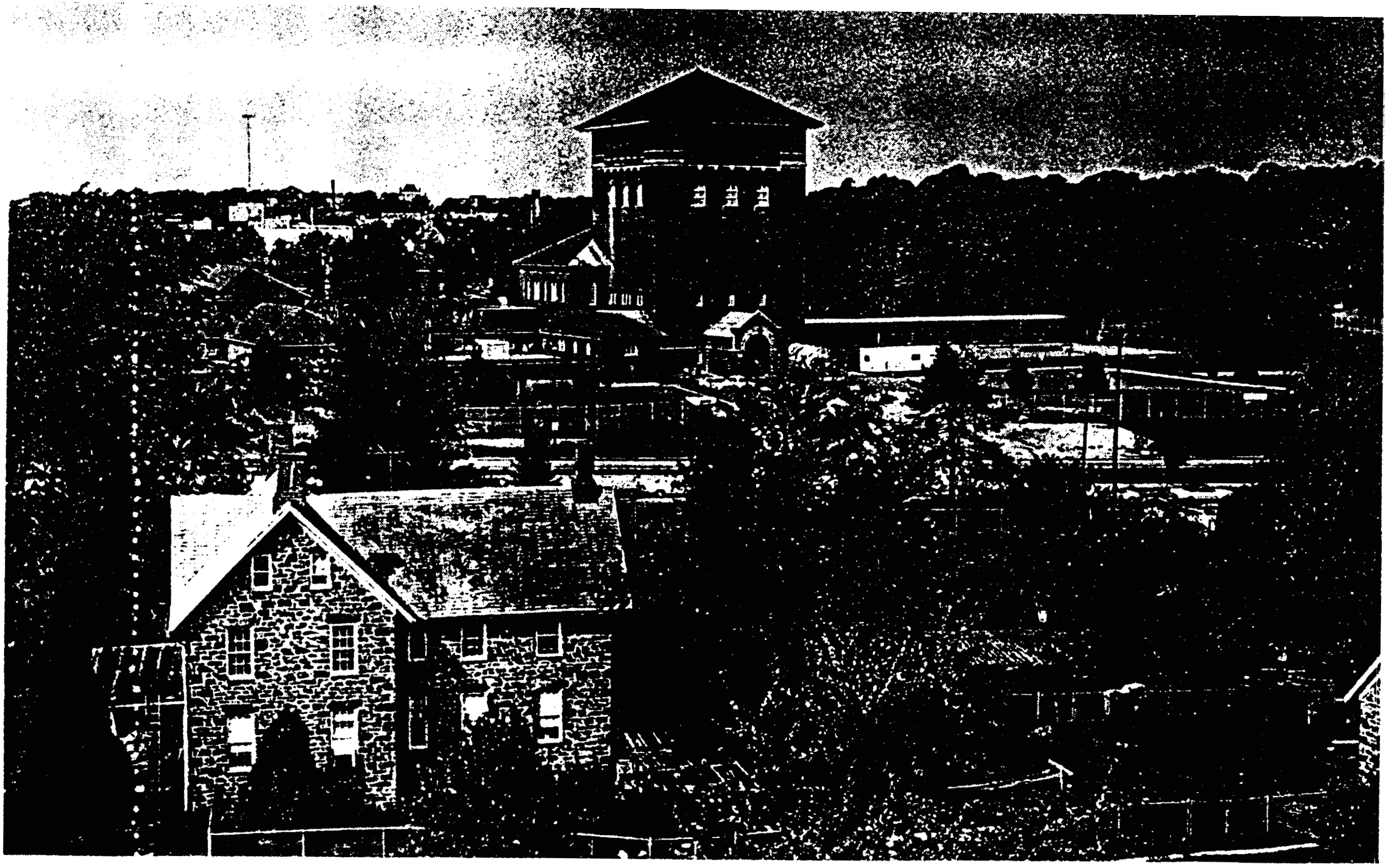
3. The connecting tunnel and pipelines, a transmission system 202,096 feet or 38.27 miles (61.6 Km) long, were constructed as:

2,370 feet	(722.85 m)	of 144-inch tunnel	(3.657 m)
12,100 feet	(3,690.5 m)	of 108-inch tunnel	(2.743 m)
150,136 feet	(45,791.5 m)	of 108-inch pipe	(2.743 m)
37,490 feet	(11,434.5 mm)	of 96-inch pipe	(2.438 m)

Water Treatment

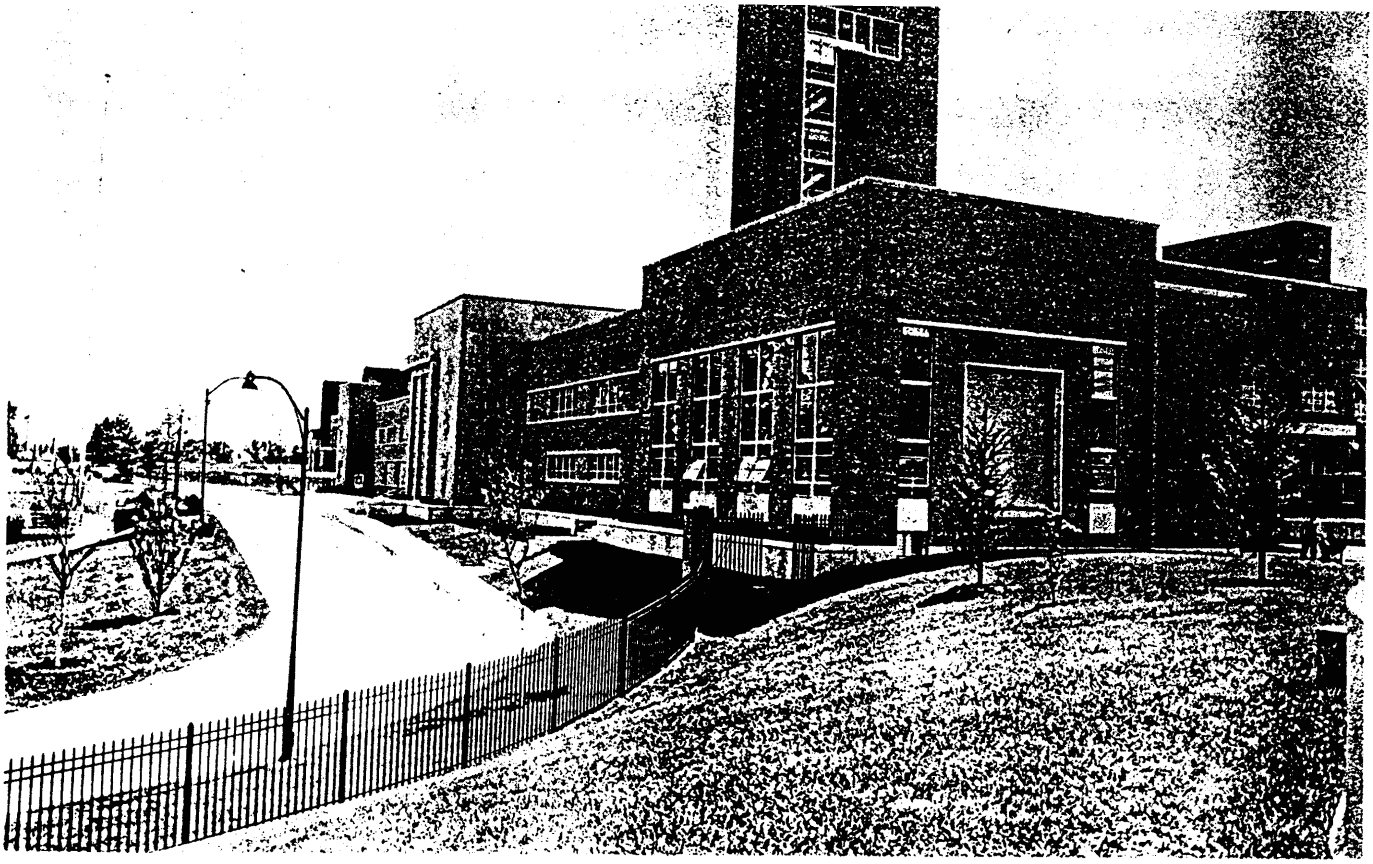
In order to produce water that will meet accepted standards for public drinking water, the following treatment processes are performed: chlorination, coagulation, sedimentation, filtration, flouridation, and pH adjustment.

Accepted standards require the finished water to be free of all organisms of a patogenic nature. In addition, there are limitations on the concentration in the finished water of chemical constituents which are considered harmful or otherwise undesirable. In some localities where the raw water has a high mineral content, it is necessary, in addition to the above mentioned processes to soften the water as well.



Montebello Filtration Plant II, on the west side of Hillen Road, north of 33rd. Street, was placed in service in 1928.

There are three water treatment plants for potable water in Baltimore. The first, placed in service in 1915, is Montebello Filtration Plant 1, near the Montebello Lake in the north-east side of the City. The second, Montebello Filtration Plant 2, is just across the street to Montebello Filtration Plant 1, on the west side of Hillen Road, north of 33rd Street, and it was placed in service in 1928. The third, Ashburton Filtration Plant, is the most recent one. The plant is near Liberty Heights Avenue and Druid Park Drive, and it was activated in 1956. All of them have the same conventional stages of treatment as describe further.



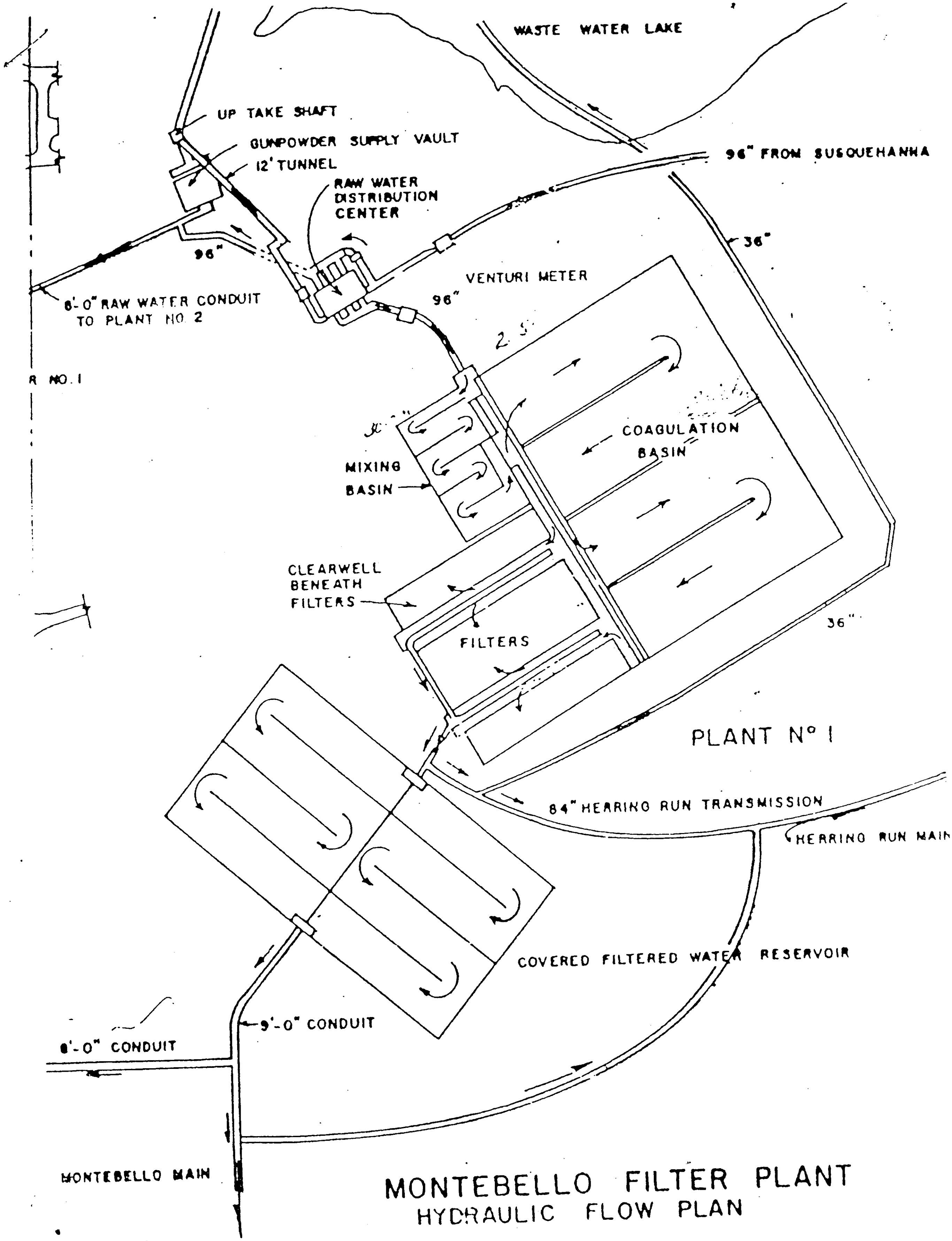
The Ashburton Filtration Plant, at Liberty Heights Avenue and Druid Park Drive, was activated on June 5, 1956.

In Baltimore, as in other sections of the U.S. where the mineral content of the raw water is low (reservoir raw water), the basic treatment procedure is like describe below for the two Montebello plants (very similar with Ashburton treatment procedures).

Montebello Filtration Plant Treatment Procedure

Fig.3.4. presents the hydrulic flow plan for Montebello Filtration Plant 1. The steps followed in order to make the water safe for drinking are:

Fig. 3.4. Montebello Plant 1. Hydrolic Flow Plan.



MONTEBELLO FILTER PLANT
HYDRAULIC FLOW PLAN

1. Source of Water:

Momtebello's main source of water comes from the 23 BG Loch Raven Reservoir, which flows thru a 7 mile (11.265 Km), 12 feet (3.66 m) diameter tunnel by gravity flow to the treatment plants. Loch Raven Reservoir is augmented by the 20 BG Prettyboy Reservoir located in Parkton, MD.

If the water level at Loch Raven Reservoir falls below the intake structure, gravity flow to the plant will cease. In this case, the three low lift pumps at Montebello, each with a pumping capacity of 120 MGD (454,260 m^3/day), are put into service to pump water in for treatment.

If enough water can not be brought in from Loch Raven, if a drought exists, or Loch Raven's supply is interrupted, than the Susquehana River can be brought into Montebello via the Deer Creek pumping station. At the present, Deer Creek has 4-50 MGD pumps; however, this capacity will be increased to 5-50 MGD pumps in the future. A fourth water plant, Fullerton, will be built after the year 2000 to treat the Suaquehana River and increase the size of water distribution system which currently supplies 1.6 million people per day. [Note that Susquehana does not flow by gravity to Montebello because the river intakes are at least 100 feet lower in elevation above sea level than the Montebello plants. The Susquehana intakes are located 38 miles from Montebello at the Conowingo Hydroelectric Dam].

2. <u>Water Treatment</u>

After the water is received at Montebello, it goes thru the following water treatment processes:

a) Chlorination

Chlorine gas, in ton cylinders, is used to disinfect the raw water immediately as it enters the plant. The chlorine dose applied to the raw water varies in dose thru the year; enough is added to keep the chlorine level at 1.0-1.2 mg/l after the water is filtred. Higher doses are seen in the summer because of the higher algal counts of the water, along with increased rates of chlorine evaporation due to the warm temperatures of the water and air. High doses are also generally seen during November when the reservoir turnover occurs. The turnover occurs when the surface waters are colder (and thus, denser) than the bottom waters, causing mixing of the reservoir. When this mixing occurs, iron and especially manganese, which are normally found in the lower levels of the water, drastically reduce chlorine levels thru oxidation - thus, the need exists for higher chlorine doses.

If the chlorine levels in the treated water falls below acceptable levels, more chlorine is added by post-chlorination as the water enters the plant reservoirs so that the free chlorine residual in the treated effluent leaves at 1.0 mg/l.

b) Coagulation

This process consists of treating the water with chemicals (usually alum or ferric chloride) to bring the light non-settleable particles together into larger, heavier masses of solid material, which are then comparatively easy to remove. The alum is added to the water and mixed well to produce particles called flocs (a jelly-like precipitate) at the rapid mixer. At this point in time, the floc is very small (pinhead). In order to produce a setteable floc it is necessary to pass the water thru the flocculator mixing basin.

c) Flocculation

This process consists of gentle agitation of the water for a period of time (about 30 minutes at Montebello). Thiscauses the pinhead particles of floc to collide with each other. They then stick together, collecting dirt and organic materials with it.

The flocculation/mixing basins at Montebello hold about 7 MG (26,495 m^3) of water and contains very slow moving paddles that resemble those on paddle-boats. These paddles beat the floc and dirt together into a settleable mass so that the next step of sedimentation can occurs.

d) Sedimentation

The sedimentation basins are large rectangular tanks that hold a little less than 7 MG of water. The average depth is about 25-30 feet (7.625-9.150 m). At present there are 2 basins in each plant that need to be drained and washed mannualy four times each year to remove the accumulated sludge. The basins are being remodeled to place mechanical scrapers that turn to gather sludge daily for removal - about 0.5 MGD (1,892.75 m^3/day) so that basins do not have to be taken out of service, sometimes during peak demand.

The water is in the sedimentation basins about 2-4 hours depending on raw water flow. After the sludge settles from the slow moving water into the basins, about 80-90% of all solids should be removed.The remaining solids are removed by filtration.

e) Filtration

The last step in clarifying the water is acomplished by passing the water thru rapid sand filters that filter 2 gal/minute/square foot (4.888 m/h) of filter surface area.

The sand filters contain 18-20 inches (0.45-0.5 m) of uniform sized sand and supported by about 18 inches (0.45 m) of gravel. Solids are collected in the top couple inches of sand while the water passes thru the gravel, and then, thru tiles that support the gravel, into the filtered water pipes leading to the plant reservoir.

Each filter is equipped with a rate controller - so that only as much water that leaves the filter, is added to the filter from the settling basins. This controls filter back-ups that would occur as the filter gets dirtier. After the filter is in service about 24 hours, it is taken out of service, drained, and then backwashed with 120,000 gallons (454.2 m^3) of filtred water.

The solids are removed via the washwater troughs to the waste-lake. These troughs are designed such that the filter sand on backwashing is not washed away when the sand bed is lifted by washwater. Usually 3-5 MGD (11,356.5-18,927.5 m^3/day) of filtered water is used to wash the filters in service in each plant.

After filtration, the water passes thru a pipe to the plant reservoir. While on its way, other chemical addition occur.

f) Fluoridation

Hydrofluosilicic acid (22-25% pure) is added at a concentration of 1 mg/l (1 gallon acid per MG of water). This is added to inhibit tooth decay and build strong bones. Generally 6,000 gallons (12.71 m^3) of acid are stored in each plant in fibreglass lined tanks.

g) pH Adjustment

The application of chlorine and alum increases the acidity of the water and lowers the pH. Lime, a form of chalk, is added to the filtered water to increase the pH of the finished water to a non-corrosive level of about 8.0 - 8.2.

h) Post-Chlorination

If the chlorine level of the filtered water falls below 0.8 mg/l, additional chlorine is added via cylinders to increase the level to 1.0 mg/l as the water enters the plant reservoirs.

i) Algae Control

During the months from May - October, copper sulfate is added to open plant and finished water reservoirs to kill algae.

j) Taste and Odor

Sometimes it is necessary to add potassium permanganate to the mixing basins to oxidize organic odors caused by algae. In the future, this task will be accomplished by the addition of a layer of activated carbon to each filter.

3. Water Storage and Distribution

After the finished water leaves the 25 MG (94,625 m^3) plant reservoirs, the water is fed thru the distribution system by gravity to elevations lower than the treatment plant, and pumped to higher elevations and stored at the 10 open finished water reservoirs and 20-30 tanks. Water is rechlorinated as the water enters the resrvoirs to keep the water sterile and stop algal growth.

4. Laboratory Control

Samples are collected at each stage of the treatment process for analyses as a check on the treatment process. Samples are collected from the water-sheds to monitor incoming water, as well as from the distribution system for analyses to insure that the drinking water conforms to all State and Federal regulations for potability. All treatment chemicals are analysed for purity and contract specifications.

Even if all three Baltimore's filtration plants use old and conventional treatment processes, the water seems to be of a good quality and safe to drink, and conforms to the most exigent standards in the world, like the Federal regulations in the U.S. are (in Appendix IV there are presented the treated water analyses annual average in 1992 and 1993). This could be explained only by the very good quality of the raw water and proper operation in the treatment plants, because on the other hand, the treatment processes are not only conventional, but sometimes "unusual" (or even unthinkable) for the European concept of drinking water treatment; for example operating at high rates of pH with the risk of congestion in the distribution system, and store water in open reservoirs just before entering the distribution system.

5. Water Cost

The average price of drinking water in the United States is about $ 1.30 for 1,000 gallons. At this price, a gallon of water costs less than one penny. The bill covers the costs of treating and distributing the water. Sometimes, a utility must buy water and all these costs and the wages for the utility's staff must be met. In Baltimore, at the Montebello Filtration Plant, only the water treatment costs were in 1993 about $0.37 for 1,000 gallons.

Water Deliver

The distribution system which serves an area of approximately 234 square miles (606 km^2), consists of a network of mains varying in size from three inches to nine feet in diameter. The majority of these mains are of cast iron, but some of the larger sizes, that is, 24 inches (~600 mm) and larger in diameter, are of steel or reinforced concrete. More than 3,100 miles (4,989 km) of mains were in service in the distribution system at the end of 1979. Mains installed since 1956 are concrete lined.

These mains connect a series of pumping stations, reservoirs and elevated storage tanks, which supply water to Baltimore City and parts of three adjacent counties: Baltimore, Howard and Anne Arundel. Within this network of mains, five zones of service are maintained to supply adequate water pressure to the consumers. Each zone is designed to meet the limiting ground elevations in a particular area of the distribution system.

Under the present operating system, the Montebello Filtration plants supply water to the First Zone by gravity, and to the Second and Third zones by pumping. The Ashburton Filtration Plant supplies water to the Second Zone by gravity, and to the Third, Fourth and Fifth zones by pumping.

The First and Second zones contain about half of the land in the distribution system but consume about 67% of the filtered water supply. Most of the heavy industry within the Baltimore Metropolitan region is located in the First Zone.

The Second Zone supplies water to many commercial and light industrial developments. Both the First and Second zones however, supply water to large residential developments within their limits.

The Third, Fourth and Fifth zones contain the remaining half of the land in the distribution system, but consume about 33% of the filtred water supply. The consumers in these zones are predominantly residential in nature.

The data and statistics for the 1979 year show that the system supplied an average of 255,000,000 gallons of water per day (965,175 m^3/day) to 1,610,000 consumers, an average of 158 gallons per person per day (599.5 litres per person per day).

More recent statistics - 1990 American Water Works Association - show that in the United States and Canada, each day, about 42 billion gallons (159 billion litres) of clean drinking water are produced by public water systems. As an average value 176 gallons (666 litres) are treated in the U.S. for each person every day. A typical structure of this rate is as follows:

- residential .... 68 gallons (257 litres)
- industrial .... 48 gallons (182 litres)
- commercial .... 33 gallons (125 litres)
- pubic use .... 9 gallons (34 litres)
- *unaccounted water* .. 18 gallons (68 litres)

TOTAL ..... 176 gpd or 666 l/day

The unaccounted water or water losses in the water supply system has a very good rate, about 10.23% of the total amount of water supplied.

Consumers Charge for Water Service

Water furnished to the consumers is sold on both the metered and unmetered basis. In general, some residential properties in the central part of the city are unmetered, while dwellings in the outlying districts of the City and those in the adjacent counties are metered.

The Bureau of Water and Wastewater converts more than 4,000 of the unmetered services to metered services every year, and this practice will continue until all such properties are metered. Water used for fire fighting is furnished free of charge.

An unmetered rate is based on the width of the property. A minimum quarterly charge is assessed for a metered service, depending on the size of the meter, with an allowance of water to cover this minimum charge. Any additional water above the allowed consumption is charged at the regular scheduled rates. Consumers in the Baltimore County also pay a fixed service charge based on the size of the meter.

Water consumers in the Howard County are supplied through three master meters. Two of those are located in the vicinity of Elkridge, the other in the vicinity of Ellicott City. In Anne

Arundel County, consumers located in the Third Election District and parts of the Fifth Election District are supplied by individual water supply services, while other areas in the county are supplied through master meters.

The Baltimore Water Service Area in the year 2000 will probably contain a land area of 700 square miles, more or less. The planning, which resulted in the construction of the Susquehanna River Project, used this area as a basis for estimates of future water demands.

The water distribution system must be enlarged as development of open land in the defined area takes place. New filtration, pumping and storage facilities must be constructed, and new large diameter water mains must be installed. Planning and scheduling for these waterworks is a complex procedure.

3.4. Conclusions and Policy Issues

This first set of conclusions refers mainly at the U.S. Public Water Supply Systems. It is out of any question that important lessons could be drawn from such a vast and diverse experience, but all of these will be emphasized in the last section of this report.

* Technologies practices necessary to provide a higher level of service at a lower cost are available. They are not used widely for a variety of reasons - barriers to introduction of new technologies, lack of acceptance by utilities, less than effective technology transfer efforts, or lack of affordability by small systems.

* Research efforts in the water supply area are increasing, primarily through the efforts of the AWWA Research Foundation. Federal research, especially in EPA, is continuing, but is largely confined to health effects research and contaminant removal techniques for substance known to have chronic health risks. There is less research in management practices, pricing and economics, instrumentation and automation, distribution system replacement needs, and other important areas.

* The AWWA Research Foundation's research agenda needs to be broadened to include research on small systems, innovative planning and management techniques, regionalization, and equitable and efficient pricing structures.

* Technology transfer practices appers to be deficient (slow, and expensive especially for small systems). The only concerted technology transfer efforts are those of the AWWA-RF and CERI (Center for Environmental Research Information). CERI focuses on all environmental research and not just water supply; as a result its efforts are limited in this direction.

* Technical assistance and training also are deficient. The majority of small and medium sized water systems are poorly operated. This situation can be ameliorated in the short term through increased training and technical assistance. Another solution is the state and Federal encouragement and provision of incentives for the private sector to enter the small system "market".

The National Council on Public Works Improvement found that there are two important directions - demonstration projects and risk sharing - which could both promote new innovative or alternative technologies, and reduce or even eliminate the barriers to introduction of new technologies.

* Demonstration projects follow research, development, and pilot testing efforts and precede widespread application. They are designed to put technology into an operating environment. Demonstrations promote new technology by providing incentives for application, by monitoring and evaluating the installation, and by publicizing the results. A formal peer review increases the credibility of a project and the potential for wide acceptance and additional applications for the new technology.

The value of demonstration projects is illustrated by the problems encountered in early research on a revolutionary wastewater treatment concept - the research involved rotating biological contactors (RBC). Small-scale pilot units were inaccurate in predicting performance. Because of this, early full-scale units were undersized. A demonstration of a full-scale operating unit would have provided accurate data before additional units were designed and build.

Monitoring and evaluation are essential to a demonstration project; proper planning and evaluation protocol are imperative. Once the evaluation is complete, results must be disseminated so that other professionals can benefit from the project.

* Unproven technology involves considerable risks for the manufacturer or builder, as well as the funding and operating agencies. Demonstrations generally are a response to this risk. Council research has suggested overcoming this barrier to innovation through some formal risk-sharing arrangement; often no single party can afford to accept all the risk. European experience has led to a similar conclusion. This need to spread the risk result from the lack of a credible, authoritative institution in the U.S. to test and aprove new technologies and from the nation's litigious character.

Risk-sharing can involve the locality, the design engineers, the manufacturer, the contractor, and other level of government. Risk analysis techniques are available to assess many new technologies, including water/wastewater treatment, toxic-waste storage and many others.

As a final suggestion, I think that a Public Works Data Base (PWDB) should be created. This is not necessary only because of the importance of public works for one nation's infrastructure, but it will be a fidel miror and an useful support for performance evaluation. For the begining, the data base should contain data and descriptions for the followings: location and size, physical assets, flow diagram, short description of the processes, O&M practices and problems, annual quality and quantity achievements, and costs and investment efficiency. Adding technical data would made PEDB an useful instrument for technological transfer, too.

CHAPTER 4

4. THE ROLE OF GOVERNMENTS

4.1. Introduction

Public Water Supply - A Natural Monopoly

Public water supply is an example of a "natural monopoly". Under conditions of natural monopoly it would not be efficient to have more than one supplier competing to build, operate, and maintain multiple systems of pipelines, reservoirs, wells, and other facilities. It is more efficient that a single entity perform these functions under public control.

While not a pure "public good" in the economic sense, water supply is nonetheless a "publicly provided good" in the sense that there is a significant government role in the pricing and production decisions of this industry. "Public" water supplies are typically eihter publicly owned and operated as a routine function of local government, or privately owned and pubicly regulated as a routine function of state government. This chapter reviews all forms of goverment involvement in the provision of public water supply.

In the United States, like in many other countries, water supply has historically been a function performed by local institutions. Therefore, the first part of this chapter presents an analysis of local institutions and after that the question of appropiate roles for state and federal governments.

Multiple Attributes of Public Water Supply

Centrally supplied potable water is a "multi-attribute good" which has multiple uses. There are two major classes of attributes: quantity features and quality features. These may also be referred to as "pressure" and "purity".

Keeping the pressure in the pipes is a day-to-day responsability which is met by maintaining adequate capacity and reliable performance throughout the water system, from the raw water source (or sources) all the way through treatment and distribution. In addition to the economic benefits of having a central water supply for a multitude of residential, commercial and industrial uses, the pressure in the pipe also serves a public safety purpose in providing fire fighting capability. Overlaid on these use-specific attributes is another, more general attribute, reliability. As in all categories of infrastructure, there is an implied warranty that the system will not fail. Reliability of water service is taken for granted.

The purity of the water delivered to water system customers is assured by adequate capacity and performance of the treatment facilities. The purity attribute has four important dimensions: 1) aesthetic appel - taste, odor and appearance; 2) safety from acute health risks; 3) safety from chronic health risks; and 4) public confidence that the water is safe to drink. This last attribute constitues another implied warranty. Similar to other categories of infrastructure that affect public safety, the safety of potable water is largely taken for granted.

In order to assure provision of the optimal level of each of these multiple attributes of public water supply, each must be given appropiate weight in the production decisions of local water systems. Despite the fact that most consumers have taken all of these attributes for granted for many years, the weights assigned in local decisionmaking processes have not always been optimal. The performance of water system is commonly regarded as adequate as long as most "visible" attributes (pressure, aesthetic appel and protection from acute health risks) are delivered from one day to the next. These most "visible" attributes are accorded the greatest weight in decisionmaking. Problems involving planning for long term needs (e.g., infrastructure maintenance and replacement; chronic health risks) or low potability events (e.g., drought, waterborne diseases outbreak) have much less visibility in the local "public choice" environment and tend to be under-weighted in decisionmaking.

Service versus Commodity Nature of Public Water Supply

As discussed before (see section 2.1), provision of water supply has historically been regarded as a "service delivery function". In a final analysis, water supply is both a service and a commodity; both characteristics are inherent in the quantity and quality attributees of the good. Over the historical period of relative abundance, however, a service orientation of "meeting requirements" has predominated in local decisionmaking processes. To adjust to conditions of relative scarcity, however, a majority of industry observers agree that a commodity orientation towards pricing and capacity planning must also be incorporated in local decisionmaking.

Looking to the future, there is an approaching convergence involving the factors which have historically been under-weighted in local decisionmaking. Increased relative scarcity will make "raw" (untreated) source water (the basic commodity) more expensive. Treatment requirements imposed by the Safe Drinking Water Act Amendments of 1987 will increase the cost of producing "finished" water at the treatment plant. Deteriorated infrastructure, manifest in leaky distribution systems, will increase the cost of "delivered" water at the consumer's tap either through continued leakage of increasingly valuable treated water or through the cost of making overdue repairs.

4.2. Roles of Local Institutions in Pricing and Production Decisions

The Social Production Function for Water Supply

Economist employ the concept of a "production function" to specify conceivable combinations of inputs to a production process which can be employed to produce alternative combinations of outputs. The range of combinations can be regarded in both quantitative and qualitative terms; for example, more expensive inputs may produce better quality outputs. In competitive markets, producers attempt to find the optimal combinations of inputs and outputs to suit prevailing market conditions. Thus, the physical options in production are fixed by technical factors (defined by the production function), but the choise between them is market driven.

A natural monopoly such as water supply is an example of "market failure". The competitive forces that would normally shape production decisions "fail" to perform in the presence of a single monopoly price. The production function for publicly provided goods - the "social production function" - therefore embodies not only physical production relationships between input and output combinations, but also a method for choosing among them. There are two esential questions that must be answered to make optimal production decisions for publicly provided goods:

- o What price should be charged to assure optimal utilization of any given level of service?
- o What is the optimal level of service to provide?

In answer to these two questions, economic theory recommends, in the ideal, that prices be set equal to marginal cost and that decisions regarding the level of service be determinated on the basis of comparisions of benefits and costs. In order for water systems to perform optimally, the institutions through which public control is exercised must allow them the opportunity to follow this economic prescription.

This prescription generally lacks practical appeal when interpreted too literally. Marginal cost pricing, for example, is feasible and has been demonstrated to have valuable potential in water supply, but it may not be easy to implement and may not always be appropriate. Nonetheless, there are various "second best" or even "third best" approximations to this ideal which have merit in terms of both economic and practical considerations

Both marginal cost pricing and benefit/cost analysis are part art and part science. The underlying principle, however, is simply that social production decisions will be more optimal if they are based on correct concepts of the true social cost. This principle maintains regardless of whether it is a service or a commodity that is being publicly provided.

From a practical standpoint, the most important aspect of the economic prescription that must be buit into instutional structures is the underlying principle that pricing and production decisions must be based on the full-costs. If public water supply is priced below its full-cost, it will be consumed in wasteful quantities and require excessive investment in source development and treatment facilities.

Institutionally, water systems must have the ability to generate sufficient revenues to cover all costs through user fees. If this principle of "full-cost pricing" is in place, then the framework is established for incorporation of further improvements such as adoption of marginal cost pricing concepts (or practical appromaximations of these concepts) in rate design and benefit/cost analyses of system requirements. The ability to cope with increased relative scarcity will be in place.

There are approximately 26,424 publicly owned community water systems. The majority of these are small systems serving fewer than 3,300 people. For the most part, they are part of a multi-purpose local government and their fiscal affairs are "comingled" with the affairs of local government. This arrangement often makes full-cost pricing difficult to implement and causes distortions in social production decisions. Among roughly 5,948 larger systems serving more than 3,300 people, a variety of more autonomous or quasi-autonomous institutional forms are present which permit varying degrees of fiscal separation from the affairs of local government. Institutional approaches to achieving fiscal autonomy range from simply applying enterprise fund accounting to the water supply unit of local government to the establishment of completely or quasi-independent water commissions or districts. The relationship of fiscal autonomy to system size is by no means uniform; however, "co-mingled" fiscal arrangements have persisted in many places, including several of the largest urban systems serving older cities in the Northeast.

There are approximately 32,647 privately owned community water systems. Less than 10,000 (i.e., 8,844) of these are investor owned utilities or subsidiaries of larger companies active in the water utility field. Among these are 761 of the 836 privately owned systems which serve more than 3,300 people. The remainder are small systems. Among the other privately owned systems, there are roughly 12,511 serving mobile home parks, 4,974 serving subdivisions and homeowners associations, and 6,318 serving institutional facilities and other small entities.

Rate schedules and revenues of private water systems are regulated by state public utility commisions in most states. The largest private systems may have the sophistication to approch this regulatory process effectively and recover full-costs. The smaller private systems generally do not.

4.2.1. Publicly Owned Water Systems

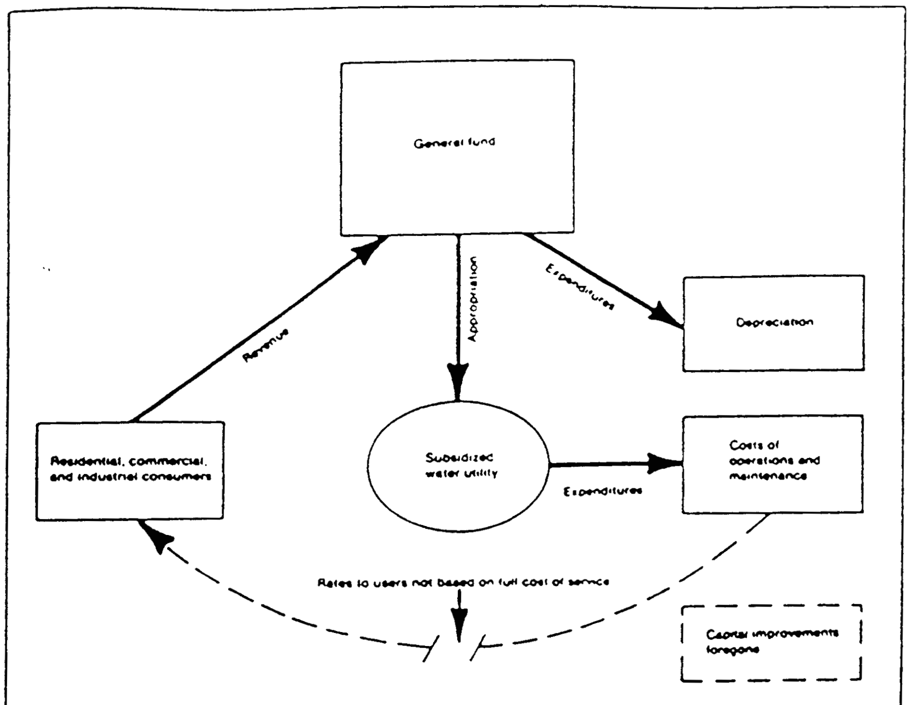
A. Issues

In institutional settings where the water system is fiscally co-mingled with the affairs of local government, the multiple attributes of public water supply have varying degrees of visibility in the multi-purpose decisionmaking environment. As a result of the more broadly focused "objective function" of multi-purpose government, fiscal outcomes tend to be sub-optimal from the standpoint of providing water supply. Factors "external" to water supply (e.g., the need to repair potholes) are competing for financial resources. Certain aspects of water supply are less "visible" than their public works rivals (e.g., leaking pipes buried under the street) and may, in fact, be viewed as "external" in the optimizing framework of local politics. Also, optimal mixes of preventive maintenance and replacement investment are missed in the co-mingled setting because operating and capital expenditures are often considered in separate parts of the local buget contest and are thus "external" to one another.

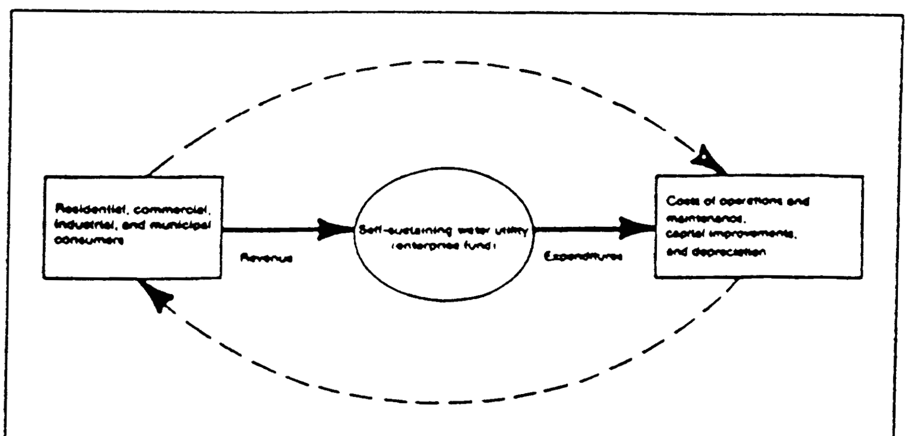
"Public choice failure" in co-mingled situations has contributed to excesses as well as to deficiencies in the management of public water supplies. By far the most visible attribute of public water supply in the local political setting is the quantity aspect, "pressure". It is political very visible because water supply is an important element of the infrastructure required to support economic growth. In localities where economic growth is an objective, over-expansion of water supply capacity can easily result.

In sum, co-mingled institutional arrangements have caused many water systems to be unable to make production decisions that are consistent with an optimal level of service. Co-mingled budgeting precludes establishment of a rational relationship between the revenues generated by the water system and its level of expenditures. When revenues are wholly or partially contributed to the general fund, the water system is left to complete for subsidies along with other public needs through a process unrelated to the amount of revenues generated through user fees (i.e., water rates). These aspects of the co-mingled model are summarized in the top half of the illustration presented in Figure 4.1. The bottom half of the illustration shows the contrasting model based on full-cost pricing.

The separation of revenues from expenditures produces not only arbitrary and sub-optimal patterns of expenditure, but arbitrary pricing policies as well. General fund financing creates an air of uncertainty which fosters "fiscal illusion" - the precieved relationship between the cost of the service and the level



Subsidized municipal water utility



Self-sustaining municipal water utility

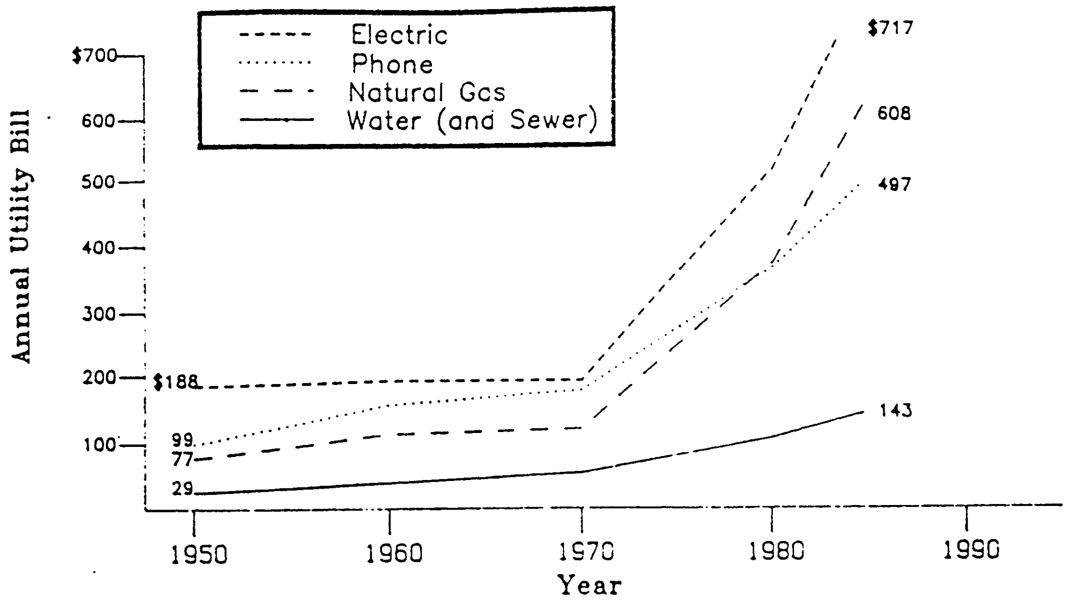
[17] Beattie, B.R. and Foster, H.S., "Can Prices Tame The Inflationary Tiger?" Journal of the American Water Works Association, August 1980, Vol. 72, No. 8.

Fig. 4.1. A. Co-mingled model
b. Full-cost pricing based model

of service provided. In this regard, water supply is generally preceived as an excellent bargain. It has been historically priced at very low levels that do not reflect the full-cost of the service. As long as the most visible attributes ("pressure", aesthetic appeal, and safety from acute health risks) are reliably delivered, a sense of complacency prevails which acts as a barrier to rate increase.

The top panel of Figure 4.2 presents a comparision of annual family utility bills over the period from 1952 to 1984. The bottom panel presents the same comparision in terms of the percentage of median family income. It is clear from these diagrams that water and sewer rates - the only ones largely under local government control - have grown at a markedly slower pace than those of all other utilities. In fact, the proportion of median family income consumed by water and sewer charges declined over the period. Several researchers have analyzed such data and confirmed that the real price of water supply services has actually declined.

Almost 90 percent of the people on public water systems pay less than $1/1,000 gallons for water service. This is illustrated graphically in the bottom panel of Figure 4.3. The top panel shows, however, that only 30 percent of water systems charge less than $1/1,000 gallons. About half of all systems charge more than $1.50/1,000 gallons and the other half charge less. Taking usage rates into account, an average annual household water bill today for Selected Utilities 1952–1984



Percent of Median Family Income Spent on Selected Utilities 1952–1984

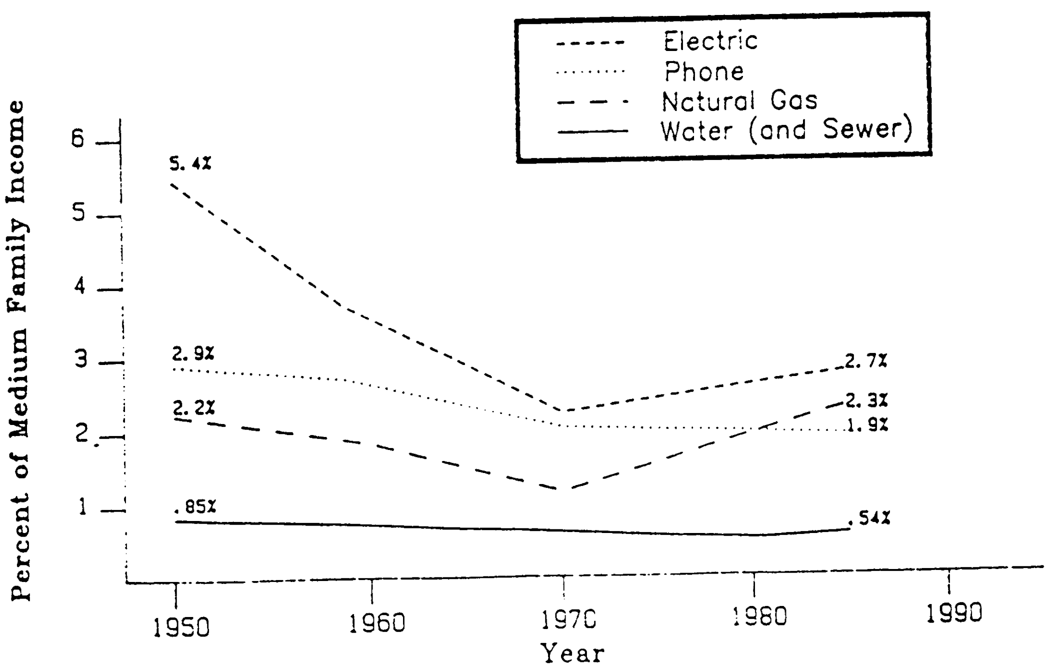
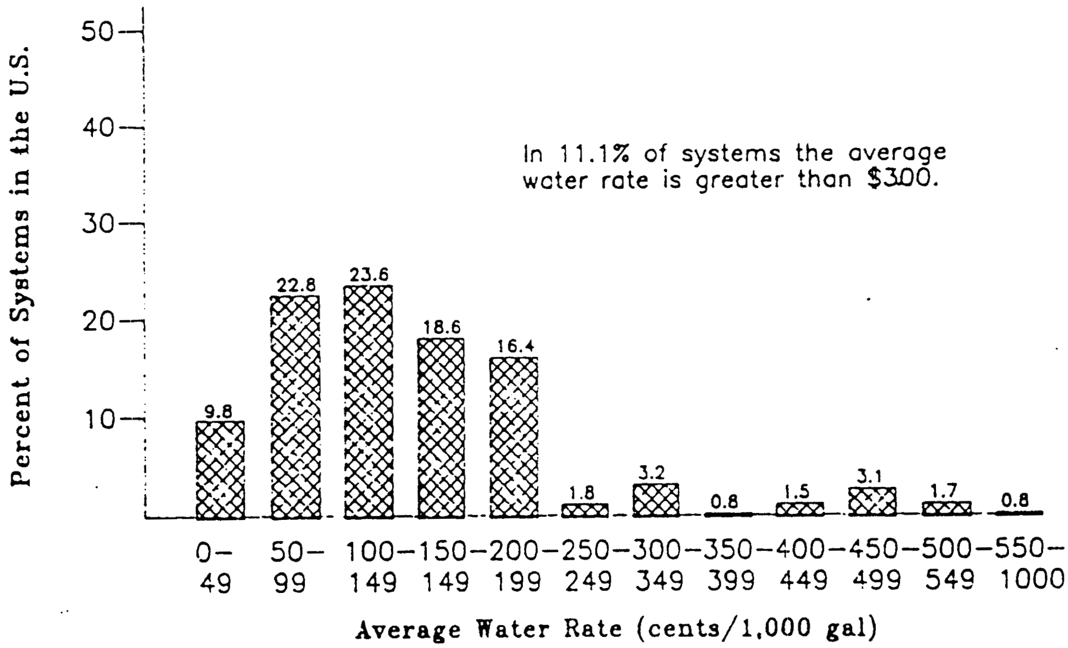


Fig. 4.2. Annual family bills and percent of family income spent on selected utilities

Distribution of Systems by Average Water Rate



Distribution of Population by Average Water Rate

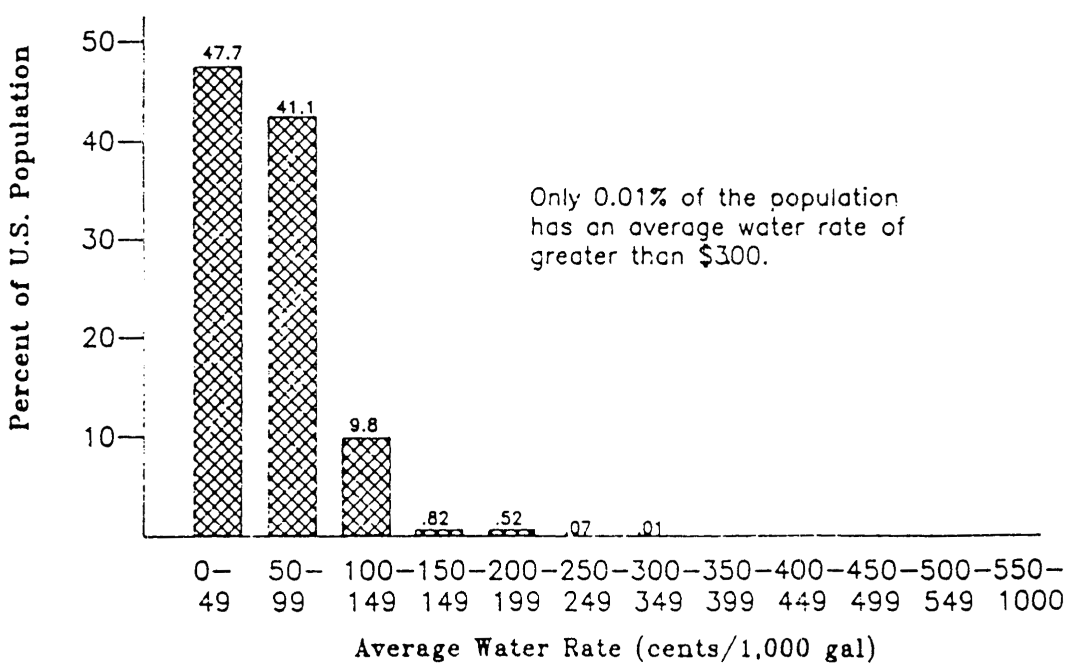


Fig. 4.3. Population payments on public water systems

is in the range of $100 to $150. At the extreme high end of the range, there are a few places, primarily in the Southwest, where charges of almost $5.00/1,000 gallons prevail.

In a number of places throughout the U.S., publicly owned water systems have managed to attain some fiscal autonomy from local government. Some of these have been successful in implementing the principle of pricing on the basis of full-costs. A gradient of autonomous and semi-autonomous institutional forms exists, including state chartered corporations or commissions serving metropolitan areas, special water districts, and enterprise fund accounting systems.

The state chartered corporations have the most autonomy from local government. This form is popular in major metropolitan areas encompassing multiple local jurisdictions where it is efficient to perform water resources related functions at a regional level. Rates and budgeted expenditures are approved by a commission or board of appointed or elected citizens.

Special water districts may be similar in institutional form and effectiveness to state chartered corporations in the large system size range, but are sometimes unable to make optimal pricing and production decisions in the smaller system size ranges. In some places, the capital budgets and rate proposals of small special districts must be put to a vote in regular referendums. Still, this democratic process introduces enormous potential for "public choice failure", especially where the geographic distribution of votes creates conflicts between newer and older parts of the water system.

Enterprise fund accounting may make it possible for water systems to attain fiscal autonomy while remaining a part of the local government. Under this approach the water department has a separate budget with a dedicate revenue source. It is possible to equate revenues and costs in this framework if the principles of enterprise fund accounting are adhered to firmly despite the close proximity to local politics.

B. Policy Options

In order to assure sufficient revenues to support an optimal level of service, publicly owned water systems must be coverted from co-mingled budget status to some form of budget autonomy which will permit water rates and water system revenues to be based excluclusively on the cost of providing the service with no external interferences. At the local level, this may be viewed as too sweeping an institutional reform. There is a real reluctance on the part of local officials to surrender control over the water system because it is critical to economic growth and in many places is an object of civic pride. Some local officials will admit that their major reason for wanting to maintain control is to continue to be able to decide whether water revenues should be spent on the water system or on other municipal services. To others,the source of resistance is doubt over the accountability of autonomous/semi-autonomous institutional arrangements

Despite these objections, full-cost water pricing must be installed in order for there to be any chance of meeting long-terms needs of publicly owned water systems on a self-sustaining basis. There are successful precedents for the concept of full-cost pricing. In the early 1970's, the British created a system of ten regional water and sewer authorities based on the concept of full-cost pricing. Having survied an initial "rate shock", they now have a self-sufficient water management system.

In addition to full-cost pricing, another feature of the British example worthy of note is the regional form of organization. Thogh there is a natural geographic rationale for regionalizedmanagement of water resources, it is not clear that the British concept of creating separate institutions is an adaptable overlay to the federal/state system of government in the United States. In the U.S., the need for regionalized management of water presents quite an institutional challenge. A key to regional cooperation and coordination is full-cost pricing. It has been demonstrated that in cooperative regional undertakings, such as the development and allocation of new supplies, all participating water systems must be charging efficient prices in order for the allocation of the resources between them to be equitable and efficient.

In the U.S., the states appear to be best positioned to encourage full-cost pricing and regionalization. Two options deserve consideration. First, state legislation to create state chartered corporations, commissions, or districts to serve large, growing metropolitan areas may be an appropriate means of instituting both full-cost pricing and regionalized management. Second, changes in state enabling legislation, redefining the powers of local governments with regard to water supply, may be an effective means of forcing full-cost pricing via enterprise fund accounting.

The only negative factor in relying on state legislation to promote a nationwide commitment to full-cost pricing is that there is no action-forcing mechanism behind this idea. States currently have the authority to take such action, yet such lows are not prsent in most places. It is conceivable that appropriate federal legislation could serve this action-forcing purpose through an amendment to the Safe Drinking Water Act (SDWA).

The alternative to mandating full-cost pricing through legislation would be to try to induce full-cost pricing and attendant reforms in financial management by making these eligibility requirements for sate and federal financial assistance. There is a successful precedent for this approach. The grant and loan programs administrated by the Farmers Home Administration have been successful in reforming financial management practices in small rural water systems. The major drawback in this approach is that needs assessed in the absence of full-cost pricing may include as much inefficiency as true need. In the British example, financial assistance was initially provided by the national government; however, the objective was not to meet the immediate financial needs, but to create self-sustaining institutions. This principle must be kept foremost in any consideration of financial assistance.

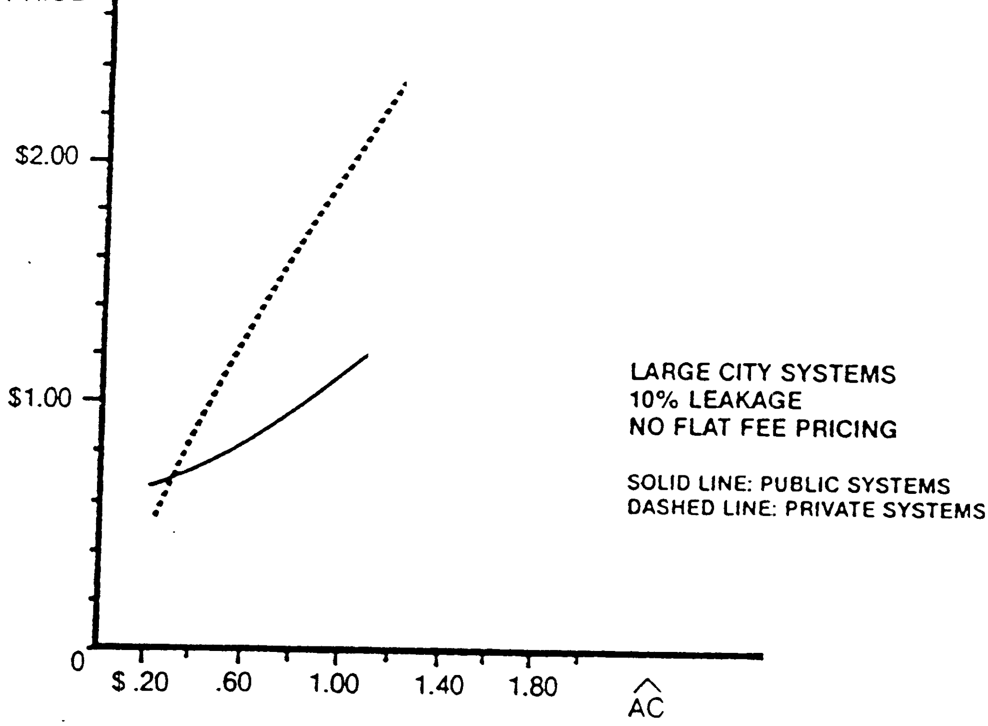
4.2.2. Privately Owned Water Systems

A. Issues

In 45 states, privately owned water systems must obtain approval of the rates they charge from state public utility commissions (PUCs). Ideally, the principles of public utility regulation would be expected to establish a full-cost basis in the relationship between prices, costs and revenues. In practice, however, there are flaws in this system and, in particula, flaws in its application to water utilities.

There are two major classes of privately owned water systems: 1) investor owned systems operated by professional management as public utilities; and 2) small systems without professional management belonging to homeowner associations, trailer parks and similar non-municipal entities. In general, the first class of systems tends to have relatively good success in obtaining rate relief through the PUC approval process. The smaller private systems often appear with poorly documented rate proposals and many such systems simply do not even apply for rate increases.

Figure 4.4. presents comparisions of rates charged by larger size investor owned water utilities and those of their publicly owned counterparts. It is clear from these diagrams that the larger, investor owned systems are charging consistently higher



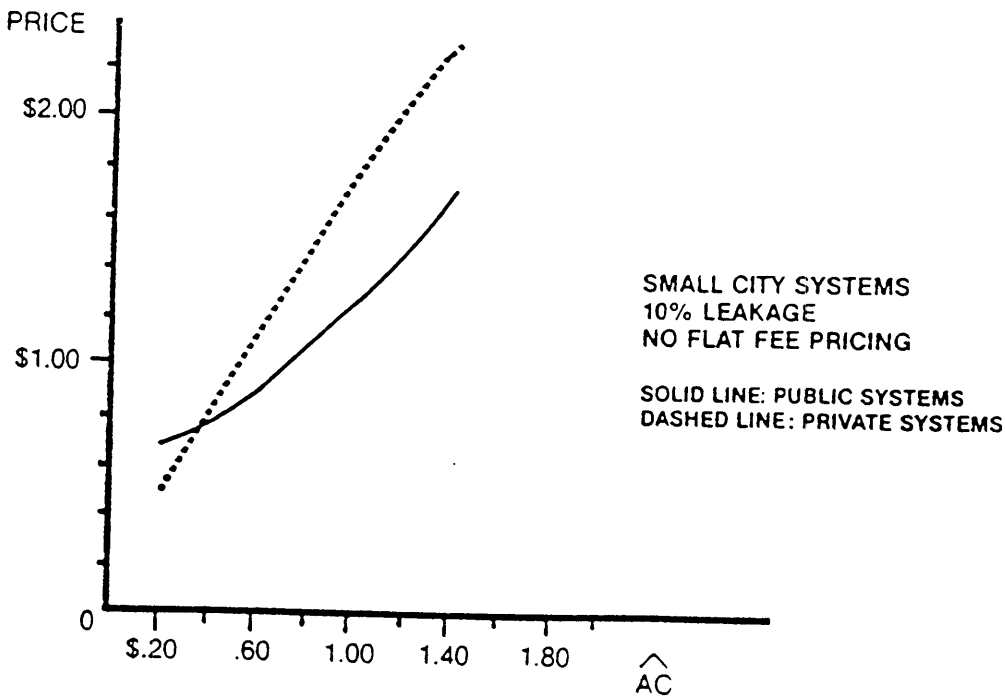


Fig. 4.4. Comparison of rates charged.
Investor owned versus publicly owned water utilities.

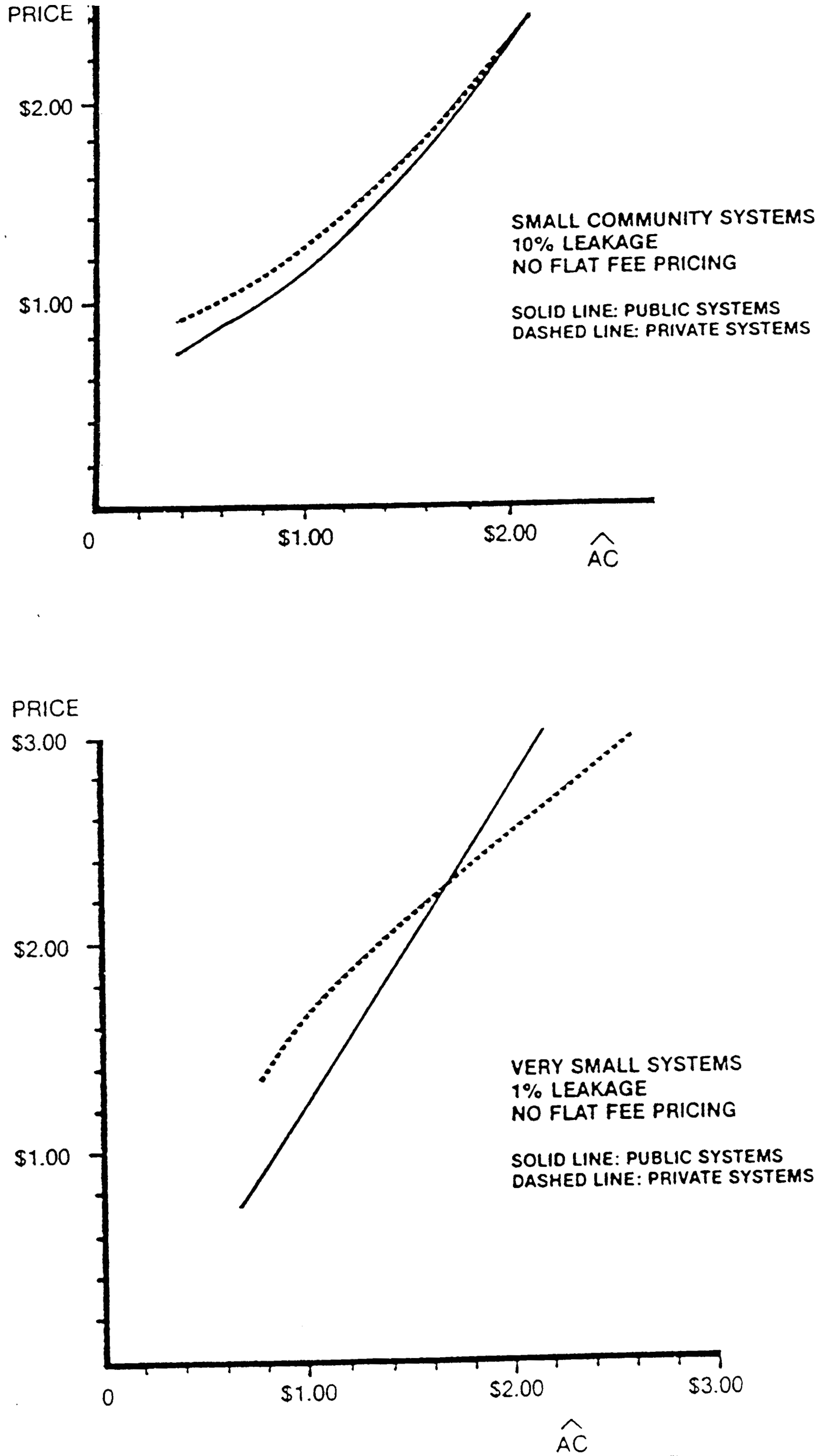


Fig. 4.4. Continued

rates than their publicly owned counterparts. Some of these reflect the higher cost of capital and the fact that investor owned systems pay taxes. Part of this difference is also due to greater cost recovery being achieved by larger investor owned private systems.

Cost recovery under PUC regulation is by no means optimal even for large systems. The most classic problem is known as "regulatory lag" - the time lapse between final rate approval and the period during which the costs forming the basis for the rate request were actually incurred. Regulatory lags become mare significant problems during periods of rapidly escalating costs. The inflationary spiral of the previous decade was one such period; another cost spiral is being anticipated by investor owned utilities as a result of the forthcoming wave of new drinking water standards to be promulgated by the Environmental Protection Agency under the 1986 Amendments to the Safe Drinking Water Act.

Another classic problem in public utility regulation concerns the method of computing the basis for the rates charged. Though the guiding principle for regulated monopolies to allow full-cost recovery plus a "fair rate of return on investment", this has proved a difficult concept to put into prctice. The predominant feature of the computation is to apply a percentage reflecting the investor's rate of return to the "rate base" of the utility. The rate base is an estimate of the gross value of the utility's capital investment. In most states, it is computed on the basis of the historical or "original cost" that was incurred when the capital plant of the utility was first installed. Various procedures are than applied to adjust the "original cost" estimate taking account of depreciation, replacement cost in current dollars, and the needs for working capital. These methods are fraught with difficulties and imperfections. The resulting estimate is termed the "fair value".

B. Policy Options

The PUC regulatory process, while aligned with the correct principles of basing prices and revenues on costs, is not succeeding in implementing these principles in the regulation of small water systems. Small water system problems must be accommodated in the regulatory process and barriers to enlisting the aid of larger investor owned systems should be eliminated.

A first step already taken in many states is estabishment of a dedicated water supply office within the state PUC coupled with simplification and streamlining of the rate approval process for water systems. A number of approaches to simplification are being employed, including stipulated proceedings, short forms, routinized timing and automatic adjustments. More radical solutions include the use of "safe harbor" ranges within which rates can be increased without commission approval and outright deregulation in cases where the threat of abuse of monopoly power is thought to be slight. In addition to modified rate proceedings, several states have programs to provide technical assistance to facilitate better understanding of the regualtory pracess by small systems,and thus,better performance in obtaining rate approvals.

A second approach being implemented in some states is to prevent the creation of additional small non-viable private water systems through such measures as denying certificates of convenience and necessity, and requiring mergers with larger systems.

Thirdly, modifications to traditional rate making procedures have been implemented to lessen the barriers to private acquisitions of water systems. For example, use of the operating ratio has been proposed as a substitute for the rate base in small systems where accurate computation of the rate base is difficult. In another example, a regionally based private company in West Virginia was allowed to develop a composite water rate averaging together several of its smaller systems with a number of larger ones.

4.3. Roles of State and Federal Levels of Government

Four classes of federal and state intervention can be identified: 1) facilitating the decisionmaking process by improving the information used in the process; 2) mandating certain decisions by regulation where information and "visibility" problems are especially difficult; 3) providing financial assistance where there is a genuine need; and 4) providing a leadership role in planning, construction, ownership and operation of regional facilities.

4.3.1. Information Functions

The simpliest form of intervention are those which attempt to improve the level of information available for decisionmaking.

These encompasses development and provision of technical information pertaining to problems to be solved and also management information regarding such things as accessing the bond market or how to approach the state public utility commission. This category also includes public education efforts to make certain factors more "visible" in local decisionmaking processes.

As discussed before, there is much technical potential to maximize the efficiency of meeting water supply needs. It is efficient to conduct the research, development and demonstration needed to realize this potential at the national level through eighter the federal government, the academic community, or industry groups such as the American Water Works Association Research Foundation. Also, it is necessary to provide effective programs for transfer of technology from the laboratory to the field. The final step is direct technical assistance and training which is particularly valuable to small water systems. This is undertaken by both federal and state government agencies. Issues and policy options concerning these programs for development and dissemination of technical information are covered in section 2.7.

4.3.2. Regulatory Functions

Aside from PUC regulation of rates in private water systems, regulatory intervention exists primarily in the area of water treatment, distribution and storage. State drinking water programs perform a traditional role of reviewing and approving plans for new water facilities and major modifications. This process employs design standards which are somewhat unique to every state There is some informal consensus around a generic document called "The Ten States Standards" which was developed by 10 northweastern/midwestern states; parts or all of these design guidelines have been adopted by at least 16 other states.

On the one hand, state plan review and design standards are an efficient intervention because the subtleties of engineering judgment necessary to assess adequate public health protection might not be properly appreciated at the local level. On the other hand, as discussed in Chapter II, these regulatory reviews have proved to be a barrier which impede the introduction and acceptance of new technologies.

In addition to the plan review process, all but two states have accepted primacy under the Safe Drinking Water Act (SDWA) and therefore have primary enforcement responsibility for federal drinking water standards established by the U.S. Environmental Protection Agency. This too, is an efficient intervention because the information requirements necessary to assess subtle health risks in sufficient depth to evaluate alternative levels of protection are enormous.

The major deficiency in the Federal drinking water program has been the slow pace at which it has evolved. In the original SDWA, Congress authorized EPA to regulate contaminants that posed "a threat to the health of persons" and to set goals for removal at levels which no longer posed such a "threat". The goals were then used as the basis for setting enforceable "maximum contaminant levels" as the basis for settig enforceable "maximum contaminant levels" as close to the goals as posssible, taking costs into consideration. Because the legal basis for regulatory action was the determination of levels which induce health effects, EPA spent over a decade struggling to push a few regulatory initiatives through an intimidating legal gaunt let.

The 1986 SDWA amendments provided EPA with a new mandate. In the meantime, several states have developed their own standards for certain classes of chemicals such as volatile organics. These chemicals have received significabt public attention through various hazardous and toxic chemical episodes.

An issue left out of both the original and amended SDWA concerns the regulation of drinking water additives. Direct additives include all water treatment chemicals such as alum and lime which are added during treatment for beneficial purposes. Indirect additives include paints and coatings, as well as a number of other miscellaneous categorie of products which come into contact with finished water. Some of these products contain coal tar derivates and other potential carcinogens.

4.3.3. Financial Assistance

A number of states have assumed active roles as facilitators, assisting local water systems in accessing capital resources, thereby improving the efficiency of capital markets. This form of assistance can range from direct management assistance to small water systems to statewide programs that pool the capital needs of many small entities. State bonding authorities which pool needs in this way provide access to capital markets for issues that might otherwise be too small and too poorly rated.

Institutional designs vary considerably, but in some states the issues of the bond authority or bond bank are backed by the full faith and credit of the state. This can have a negative effect on the stae's own credit rating, however, and thus limit the size of such programs. Oklahoma has devised an interesting solution to this problem via state funded premiums for provision of private bond insurance.

Another approach to facilitating financing is to encourage mergers, takeovers, and regionalization schemes. Many states are active facilitators in this area, endeavoring to eliminate small, troubled systems through consolidation. Public Utility Commissions in some states have mandated takeovers and mergers.

Direct financial involvement of state and federal government agencies through grants, loans, or direct ownership and/or operation is present in a variety of forms. The level of this financial involvement has not been nearly as great as in other categories of infrastructure.

Over the past several years, states have been developing increasingly active assistance programs to support construction of treatment facilities. Some states emphasize facilitating strategies, described above, versus actual financial assistance. Others are engaged in various sorts of loan and grant programs.

The federal assistance programs, especially the Farmers Home Administration program, have served a useful purpose in identifying and characterizing the types of small rural systems which have genuine financial difficulties. Some states have modeled their assistance programs after this one. But the existance of a federal program distorts local and state behavior. Local governments have been known to simply substitute grant funds for the capital they otherwise would have budgeted, thus producing no net infrastructure improvement.

One of the benefits claimed for state financial assistance programs is that they can be designed to give the state significant leverage over the affairs of the water system being assisted Grants or loans can be tied to changes in pricing practices, improvements in capital budgeting, or reductions in system losses. In this way, these mechanisms can produce more lasting solutions.

4.3.4. Planning, Construction, Ownership and Operation

State and federal governments have played a traditional role in planning, construction, ownership and operation of major multi-purpose water development projects. At the Federal level, this has been conducted through programs administered by the U.S. Army Corps of Enginners and the Bureau of Reclamation. There is a physical rationale for Federal and state intervention to mediate allocation of the resource across jurisdictional boundaries. Economies of scale also can be achieved by cooperative regional development of water resources.

An interesting example is in the Washington D.C. metropolitan area, where several water systems relying on the Potomac River recently launched a supply management effort to jointly operate storage facilities for optimal flow during low flow periods. The participants further agreed to share in the cost of future expansions of storage capacity in proportion to their shares of the peak period demand. This is an extremely efficient cost allocation formula. Over time, the participants that adopt special peak period rates will obtain the greatest benefits. This incetive structure is beneficial as it has been demonstrated that a peak period rate structure provides the most optimal allocation of the resources.

State involvement in regional water resources development provides states with enormous leverage to improve the efficiency of local water systems. As in the case of Washington D.C., the opportunity exists to set the price of the new supply in an efficient manner. In addition, some states have required certain conditions to be met by local water systems to be eligible for participation. These include institution of water rates tied to the level of use and initiation of leak detection and repair projects to reduce system losses.

4.4. Baltimore's Water Public Work Departament. Current Organization.

The Bureau of Water and Waste Water is responsible for the operation of a water distribution system which supplies potable water to more than 1.6 million customers; the operation and maintenance of three watershed systems (Loch Raven Reservoir, Liberty Reservoir and Prettyboy Reservoir); three filtration plants (Montebello Filtration Plant I, Montebello Filtration Plant II and Ashburton Filtration Plant) and pumping stations with 3,000 miles of water mains; the collection and treatment of waste water along with the operation and maintenance of the Back River and Patapsco Waste Water Treatment Plants, 1,800 miles of conveyance lines, ten pumping stations, and the City's system of underground conduits.

Maintenance of water mains, tanks, pumping stations, reservoirs, filtration plants and other facilities that comprise the water supply system of Baltimore City is the responsability of the Bureau of Water and Waste Water in the Department of Public Works. In addition to meeting the needs for water by city residents and industries, the City also provides water to Baltimore County and parts of Anne Arundel, Howard and Carroll Counties. Beginning in 1994, the City will complete the water supply project to Harford County.

Under Public Works' current organization, responsability for developing the capital program for water supply facilities is

MUNICIPAL ORGANIZATION CHART

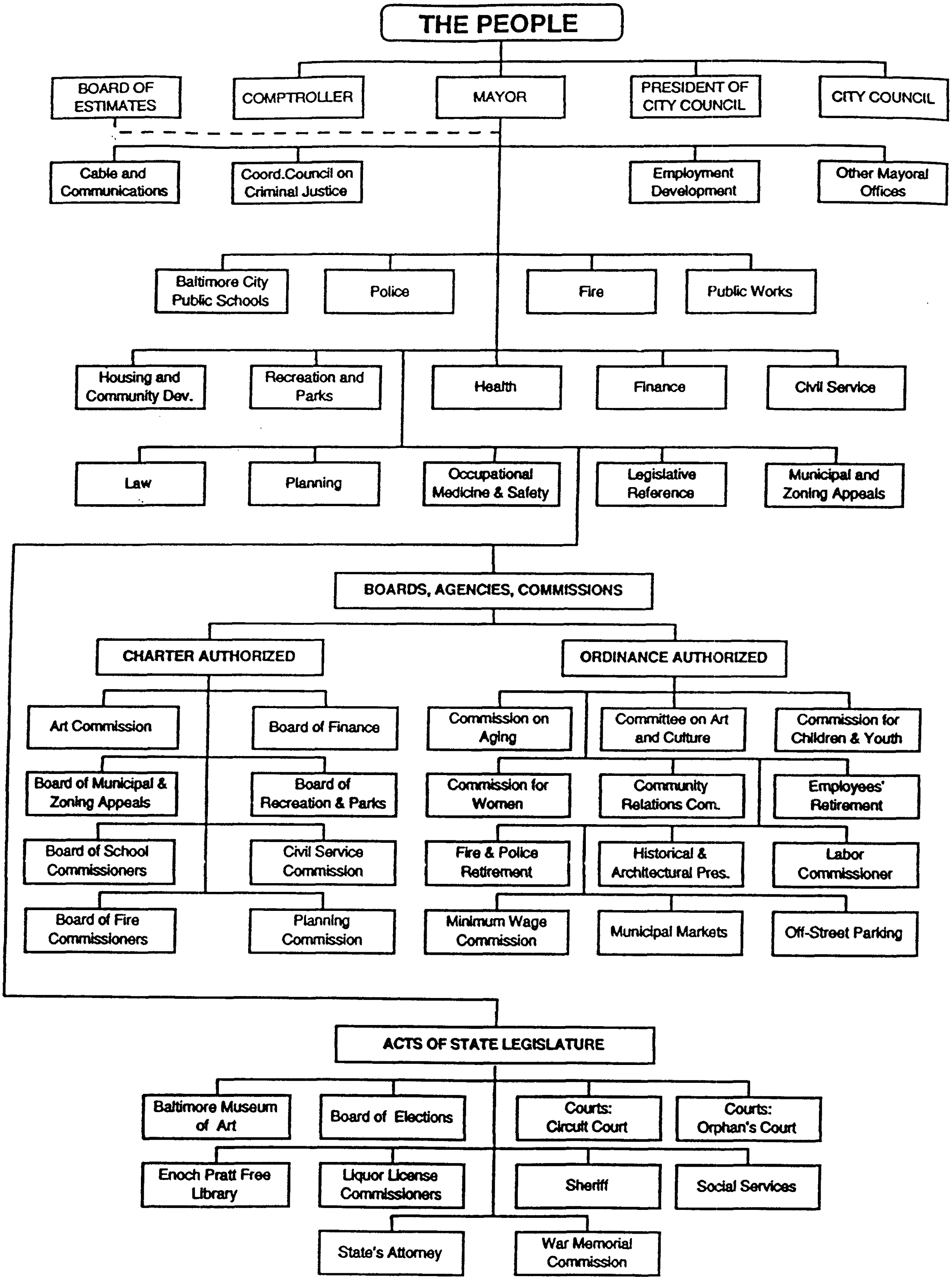


Fig. 4.5.

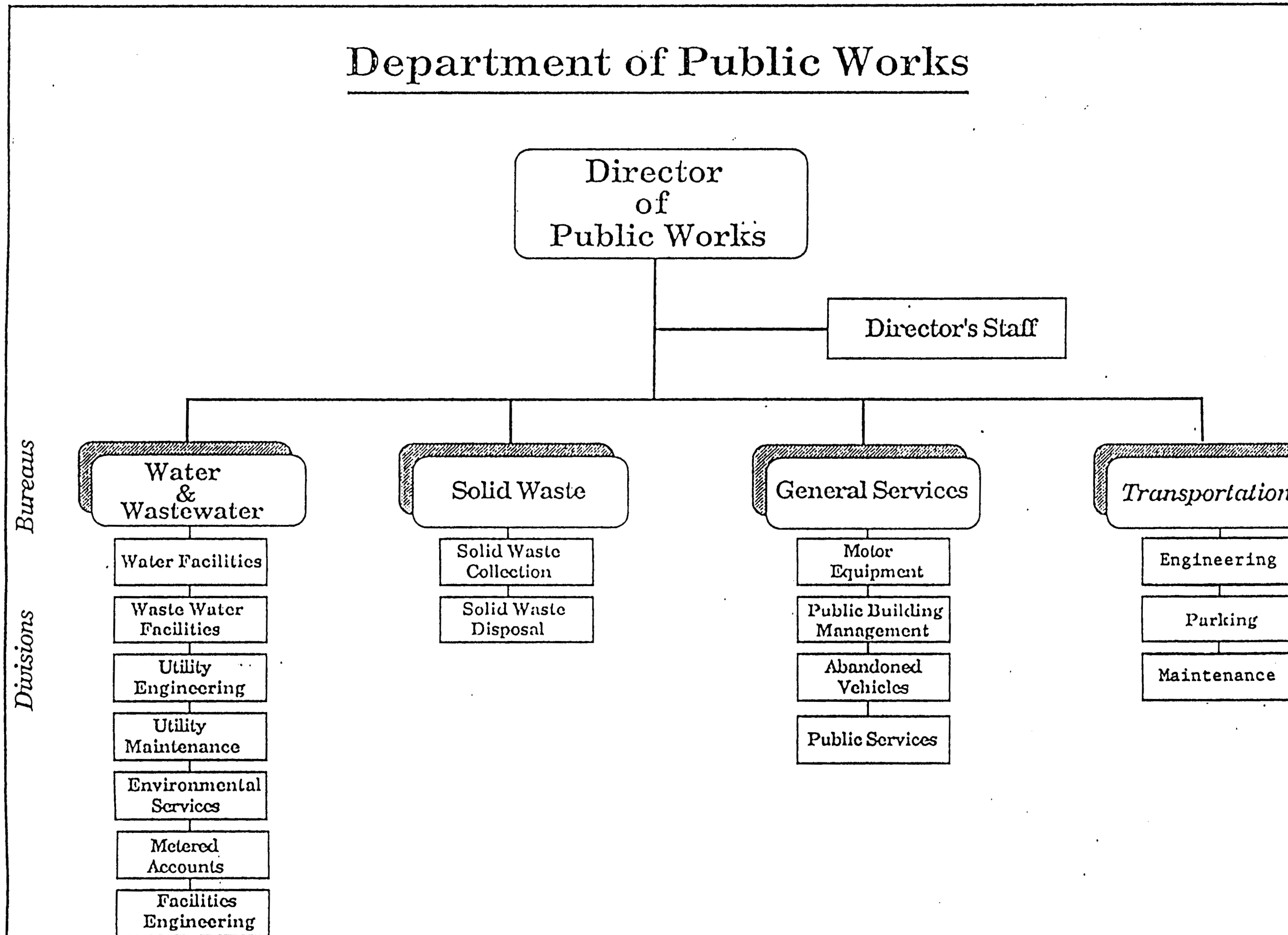

Department of Public Works
Director of Public Works
Director's Staff
Bureaus
Divisions
Water & Wastewater
Water Facilities
Waste Water Facilities
Utility Engineering
Utility Maintenance
Environmental Services
Metered Accounts
Facilities Engineering
Solid Waste
Solid Waste Collection
Solid Waste Disposal
General Services
Motor Equipment
Public Building Management
Abandoned Vehicles
Public Services
Transportation
Engineering
Parking
Maintenance

Fig. 4.6.

divided among the Utility Engineering Division, the Water Facilities Division and the Facilities Engineering Division (see Figure 4.5 and 4.6).

Request totaling $31,075,000 were received for fiscal year 1994; a total of $148,235,000 in request was received for the entire six-year program, 1994-1999. Derived from the request, the Planning Commission recommendations for funding were:

SOURCE of FUNDS	**1994**	**1994 - 1999**
FEDERAL	$ 5,600,000	$ 5,600,000
REVENUE LOAN	16,272,000	73,329,000
WATER UTILITY	175,000	10,800,000
COUNTY	7,318,000	50,506,000
TOTAL	$29,365,000	$142,235,000

The strategy inherent in these funding recommendations is:

* Fully fund water main cleaning and lining program and valve/hydrant replacement program;

* Expedite improvements at Montebello Filtration Plants as much as possible;

* Schedule work at Ashburton as soon as possible (completion of Montebello should allow concentration on Ashburton); begin with short-term, manageable improvements; develop flexible,yet precise, implementation plans for major phases of the work (incorporate meth ods to enhance efficiency in implementation);

* Defer and/or seek alternative fund sources for pro jects that do not benefit City users; seek State and/or County takeover of maintenance for through roads in watersheds; seek State and/or County funding for dam repairs mandated by State/Federal governments

* Continuously monitor and reassess changes in health and environmental regulations, participate in process to obtain resonable outcomes.

A total of $29.4 million in capital funding for the water supply system is recommended in the budget year; $142.2 million is recommended in the total six-year program. Major budget year projects include:

- Montebello Water Center - Rehabilitation
- Zebra Mussel Control
- Water Infrastructure - Rehabilitation
- Water Supply System - Annual Improvements
- Eastside Maintenance Yard - Construction
- Paper Mill Road Bridge - Replacement
- Park Terminal - Garage Renovation
- Watershed Roads and Bridges - Maintenance
- Chlorine Leak Detection & Telemetry System
- Mapping Program - Water Supply System
- Water Main Cleaning Program
- Water Mains - Installation
- Lead Paint Abatement - Water Supply System
- DPW Water Supply - Construction Program

Major projects to be financed with City water revenue bonds include Water Infrastructure Rehabilitation, and the Zebra Mussel Control. The Paper Mill Road Bridge is the only project in the budget year to be financed with federal funds. A total of $7.3 million in county grants or 24.9% of the budget year funding is recommended to finance water capital projects. Figure 4.7 presents the programs under Bureau of Water and Waste Water Utilities.

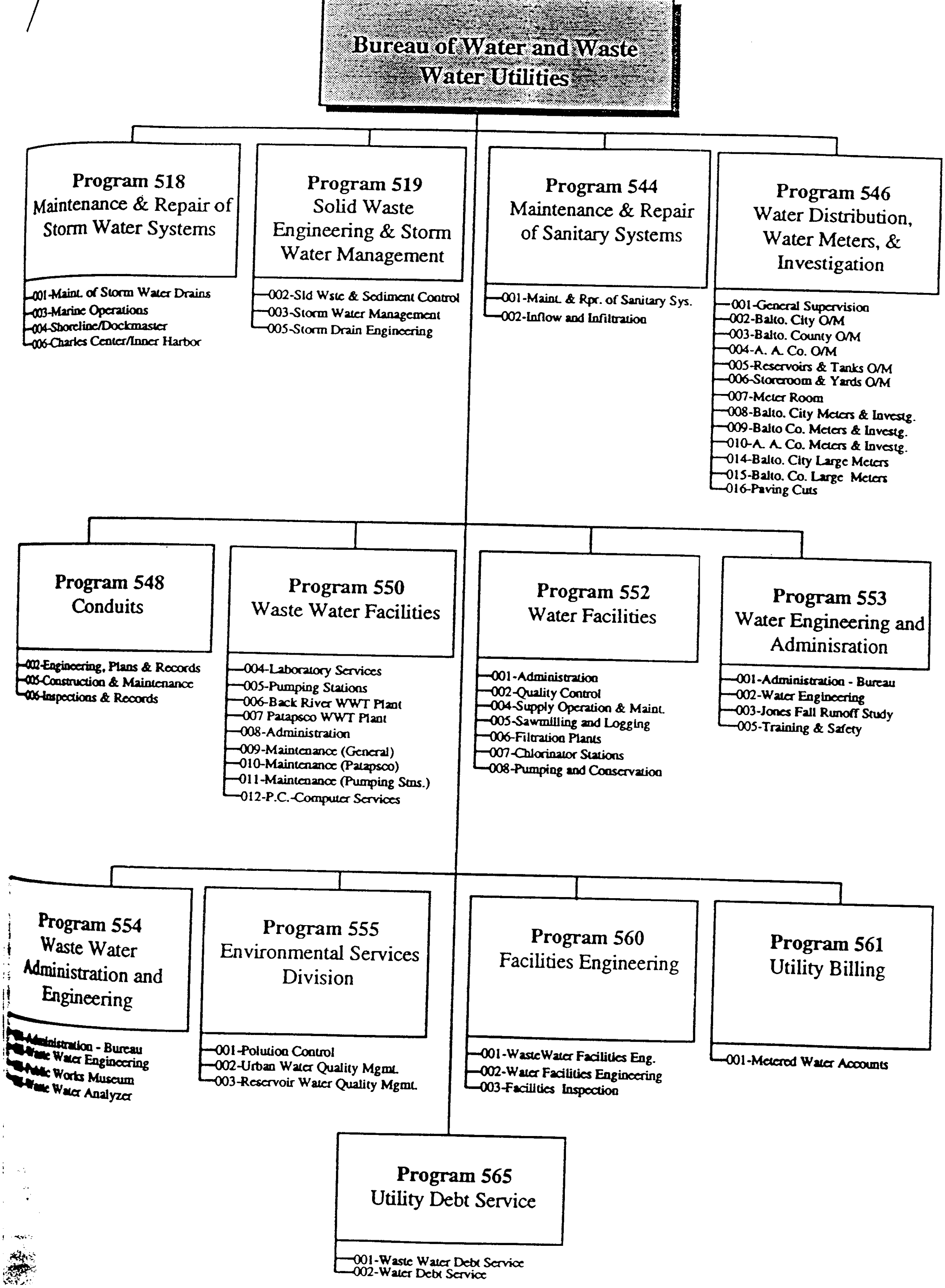

Bureau of Water and Waste Water Utilities
Program 518
Maintenance & Repair of Storm Water Systems
001-Maint. of Storm Water Drains
003-Marine Operations
004-Shoreline/Dockmaster
006-Charles Center/Inner Harbor
Program 519
Solid Waste Engineering & Storm Water Management
002-Sld Wste & Sediment Control
003-Storm Water Management
005-Storm Drain Engineering
Program 544
Maintenance & Repair of Sanitary Systems
001-Maint. & Rpr. of Sanitary Sys.
002-Inflow and Infiltration
Program 546
Water Distribution, Water Meters, & Investigation
001-General Supervision
002-Balto. City O/M
003-Balto. County O/M
004-A. A. Co. O/M
005-Reservoirs & Tanks O/M
006-Storeroom & Yards O/M
007-Meter Room
008-Balto. City Meters & Investg.
009-Balto Co. Meters & Investg.
010-A. A. Co. Meters & Investg.
014-Balto. City Large Meters
015-Balto. Co. Large Meters
016-Paving Cuts
Program 548
Conduits
002-Engineering, Plans & Records
005-Construction & Maintenance
006-Inspections & Records
Program 550
Waste Water Facilities
004-Laboratory Services
005-Pumping Stations
006-Back River WWT Plant
007 Patapsco WWT Plant
008-Administration
009-Maintenance (General)
010-Maintenance (Patapsco)
011-Maintenance (Pumping Stns.)
012-P.C.-Computer Services
Program 552
Water Facilities
001-Administration
002-Quality Control
004-Supply Operation & Maint.
005-Sawmilling and Logging
006-Filtration Plants
007-Chlorinator Stations
008-Pumping and Conservation
Program 553
Water Engineering and Adminisration
001-Administration - Bureau
002-Water Engineering
003-Jones Fall Runoff Study
005-Training & Safety
Program 554
Waste Water Administration and Engineering
Administration - Bureau
Water Engineering
Works Museum
Water Analyzer
Program 555
Environmental Services Division
001-Polution Control
002-Urban Water Quality Mgmt.
003-Reservoir Water Quality Mgmt.
Program 560
Facilities Engineering
001-WasteWater Facilities Eng.
002-Water Facilities Engineering
003-Facillities Inspection
Program 561
Utility Billing
001-Metered Water Accounts
Program 565
Utility Debt Service
001-Waste Water Debt Service
002-Water Debt Service

Fig. 4.7.

4.5. Conclusion

Provision of water supply in the U.S. has historically been a local government service delivery function and this arrangement contnues to serve well in present too. Therefore, role changes found thru this research are only evolutionary and there are not proposed revolutionary ones.

Even so some changes are. For example, water regulations or water resources allocation are becoming more rather than less intergovernamental. Thus it is unlikely that a major public work, as water supply is, will live its functions exclusively within a single level of government. The challenge in sorting through these mixed responsabilities is to clarify the roles. If the roles are clear, authority and accountability can match responsability.

This is more true for Romania and this report, containing a brief ower view on American model, could br a good start for an instutional refofm in Romanian water supply management.

CHAPTER 5

5. GENERAL CONCLUSIONS

5.1. Major Findings

Even the time for completing the research was very short in order to investigate such a large and developed category of public works like water supply is in the U.S., thanks to the availability of already existing documents, for example "Fragile Foundation: A Report on America's Public Works", and the outstanding colaboration with U.S.EPA's Center for Environmental Research Information, there is possible to outline some major findings for the U.S. water supply. These are as follow:

o The water supply industry is characterized by a long history of self-sufficiency and local government control over management and finances.

o A national water supply "infrastructure gap" of the magnitude that would require a substantial federal subsidy does not exist. Water utilities experiencing revenue shortfalls generally do not charge rates which cover full-costs of the utility.

o A problem does exist for small water systems. The majority of small water systems are poorly managed due to 1) a lack of understanding of the water supply function, 2) lack of technical training, 3) inappropriate rates structures, 4) lack of access to capital, and 5) no economies of scale.

o The proper implementation of the Safe Drinking Water Act Amendments will have significant impacts on both water utilities and state public water supply supervision programs. The primary costs and workload impacts will be felt by medium and smaller systems.

o There appears to be sufficient water available in western states, but due to allocation practices, water resources are not distributed efficiently

o Contamination and depletion of groundwater supplies is a major problem facing the water industry. Additional costs can be expected to result from groundwater protection and reclamation activities.

From the studies evaluated by this research it was found that a few areas in the U.S. water supply are to be extent or emphasis. Among them the most important are: full-cost pricing, regionalization as a problem of efficient allocation, technological transfer and technical assistance, and public education.

5.2. Lessons and Policy Options for Romania

For Romania water supply systems there is not simplly a question of lessons and policy options in order to improve the system performance, but a necessity for radical changes esspecially in the managerial area.

Since the technical solutions are available, and in most part wellknown (but unfortunately not applied) in my country too, this section will present only the necessary steps to be taken for an institutional reform and a better management of Romania water supply systems.

1) the first step is to create the legal frame for further

activities; the U.S. Safe Drinking Water Act (SDWA) should be consider and separate laws for water, waste water and air are much better than a global one.

2) the place of water supply in nation's infrastructure should be proper defined and the roles of state and local governments are to be established; water supply systems are to be placed under local governments control.

3) there are changes to be made in actual organization and institutions' responsabilities; others are to be created, for example - National Drinking Water Advisory Council.

4) new Drinking Water Regulations are to be established and enforced and by whom.

5) finaly, the cost of these changes should be evaluated; the source for financing could be state loans and grants and the water systems should operate on a full-cost pricing base.

Other useful models or important topics for Romania are presented along this report in Chapter 2,3 and 4.

Like a final suggestion drop from this study theri is a group of potential research issues:

- a workshop of experts in the field of water pricing to further evaluate the plausibility of a national mandate for full-cost pricing.

- coordinate the development of a national policy agenda for solving the deficiencies related to technology and its use in water supply.

- conduct research on mechanism to resolve the financial and management problems of small water systems.

- workshop of state water management offficials to explore ways of maximizing the effectiveness of state leverage through coordination of water resources management, public utility regulation, drinking water regulation, financial assistance and local government regulatory functions.

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APPENDIX

1. THE COPSA MICA INDUSTRIAL PLATFORM

Short presentation of the industrial activity in the area:

1. SOMETRA S.A.- Copsa Mica non-ferous metallurgy producing Zn, Pb, Ca, bismuth, stibium, Au, Ag, Cu and other chemical derivates
2. CARBOSIN S.A. prodeces soot black, methylic metacrylate, stiplex, oxalic acid etc.

Major emissions: air-flow containing SO_2, Pb, Ca, As, CO_2 and soot black.

The water quality (Tirnava Mare) is affected by a high flow of waste water containing high concentrations of Pb, Zn, Ca, Fe, ammonium, cyanide and oil products.

Effects on the soil - the soil pollution is very high caused by the noxius emissions which surpass 2-5 times the maximum accepted concentrations of Pb, Ca etc. on an area of about 25 Km around the platform (around 15.6 miles).

Effects on forestry and agriculture; large surface of forests, farming land are affected. Tirnava River is polluted with heavy metals.

Effects on human health: it is belived that most of the recorded diseases in this area like: respiratory and eyes infections, skin alergies, tuberculosis, pneumonia timors and anemia are coused by the pollution of the environement. Over 40% of the children have deficiencies in musculo-skeletal system.

2+3. BAIA MARE - ZLATNA AREA

Short presentation of the industrial activity in the area:

1. "Baia Mare" Non-ferrous Metallurgical Factory - specialized in producing electrolytic cooper, lead, sulphurous acid and organic and anorganic compounds.
2. "Firiza" Non ferrous Metallurgical Factory - specialized in producing the lead concentrates, manganese and gray iron foundry.
3. "Zlatna" Non ferrous Metallurgical Plant - specialized in producing foundered cooper, sulphurous acid and anorganic compounds.

Major emissions: SO_2, SO_3, aerosols with a high concentration of Pb, Cu, Cd, As, Sb, are dissipated in the air. The water quality is affected by suspensions which contain heavy metals and organic compounds.

The soil and the forest are affected by aerosols, acid rains and heavy metals in an area estimated at 70 Km^2(27 sqm). No reliable emission information available. Waste handling is partly in operation.

Effect on the air: the ambient air figures surpass the national standards in 70% of the samples for some elements.

Effect on the ground and surface water: there is a frequent surpass of national standards for some of the above mentioned polluants.

Effect on human health: it is belived that most of the recorded diseases in this area, like pulmonary diseases, rachitis, neuropsychical malfunctions are coused by the pollution of the environmental factors. In a population of about 110,000 inhabitants under constant impact of pollution, the rate of acute and chronic pulmonary diseases for an example is 35% higher than in other areas.

4. PLOIESTI - BRAZI - TELEAJEN AREA

Short presentation of the industrial activity in the area:

1. Petrobrazi S.A.- Brazi - specialized in oil refining and petrochemical products (gasoline, oil etc.)
2. PEtrol S.A. Teleajen Company - specialized in oil reining and produces fuels, lubricants and petrochemical products.

Major emissions: residual gases containing phenol, SO_2, CO, sulphurate hydrogen etc.

Effects on the soil: an area of 8 - 10 Km (5 - 6.25 miles) around these complexes is completely affected by high concentrations of polluants.

Effects on the air: the ambient air figures surpss the National standards for phenol, SO_2, sulphur hydrogen, CO.

Effects on the water: frequent surpass of the National standards for some of the above mentioned polluants. The water quality (Prahova and Teleajen Rivers) is affected by waste water containing high concentrations of organic substances, oil products, suspended matters, fluorides. Around this area five small localities are affected; the Ploiesti town and Prahova River are completely polluted.

The soil and the ground water are contamineted with oil substances. Due to the pollution of Teleajen River, the Danube and its ecosystem (especially Danube Delta) are endangered.

Effets on human health: the local branch of the Ministry of Public Health suspects tha several mortality cases are caused by or can be correlated to the environmental situation. The rate of pulmonary disease among children is common and higher compared with other areas which are not under a constant impact of this type of pollution.

5. THE ONESTI - BORZESTI AREA

Short presentation of the industrial activity in the area:

1. The Petrochemical Plant Onesti - specialized in refined oil and chemical products.
2. The Borzesti Chemical Plant - specialized in syntetic anorganic and organic chemistry.

Major emissions: SO_2,NH_3, fluoride, Cl_2, HCl, phenols, formaldehyde, oil into the air, water and sol.

The ambient quality figures exceed the National standards for some elements, in about 36% of the samples.

The water quality is affected by oil pollution and the soil is affeted on a surface for about 80 sqm.

Effects on human health: several mortality cases suspected to be correlated to the environmental situation. The rate of pulmonary disease among children is two - three times higher comparative with the rest of local population.

6. THE BACAU AREA

Short presentation of the industrial activity in the area:

1. sofert S.A. Bacau - specialized in fertilizers such as ammonia, ureea, sulphuric acid etc.
2. Celohart S.A. Zarnesti - which produces chemical pulp for viscose and nitration, paper, fodder yeats and lignosulphonic products.

Major emissions: SO_2, NH_3, ammonia, chlorine.

Effects on the air: the ambient air figures surpass the National standards for SO_2, ammonia and chlorine.

The water quality is affected by ammonia, phosphorus, ureea, suspended and organic matters. As a result the Galbieni Lake and Birsa River waters can not be used even for industrial porposes.

The forest and the agriculture land are affected on an area amounting 90 Km^2 (35 sqm.).

Effects on the ground and surface water: ther is a frquent surpass of National standards for some above mentioned polluants.

Effects on human health: in adults, respiratory diseases (acute and chronic) as well as cancers were reported 1.4 - 1.6

times more frequently. Separate comparison with other non polluted areas indicates 1.2 times increase in respiratory diseases. In the children living in the area, chronic upper airways diseases were registred 2.5 times more than in non-polluted towns. No increase was seen for other diseases (except malnutrition, 2 - 3 times more prelevant than in other areas).

7. THE SUCEAVA AREA

Short presentation of the industrial activity in the area:

1. Ambro S.A. Suceava - specialized in manufacturing pulp and paper, sacks, paper bags etc.

Major emissions: gas residues with a high content of hidrogen sulphide, mercaptan, SO_2. The water quality is affected by waste efluents containing organic matters, suspended matters, phenols etc.

Effects on the air: the ambient air figures surpass the National standards between 3 to 14 times for different polluants such as: hydogen sulphide, SO_2, settling powders.

Effects on waters: ther is a frequent surpass of National standards for hydrogen sulphide, organic matters and phenol.

Effects on human health: cancinogenic substances exceeding 3 to 4 times the Romanian standards have been measured in water, air and food samples.

8. THE PITESTI AREA

Short presentation of the industrial activity in the area:

1. Arpechim S.A. Pitesti - specialized in crude oil refining and petrochemistry products such as gasoline, fuel, oil, ethylene etc

Major emissions: SO_2, hydrogen sulphide, flaing ashes, mercaptane and atrazine. The water quality (especially Dimbovita River) is affected by waste effluents discharge containing organic and suspended matters, phenols, oil products etc.

Effects on the air: the ambient air figures surpass the National standards for some elements such as SO_2, hydrogen sulphide and black sooth.

Effects on water: primarly Dimbovita River is affected, its water being included in the degradated river category, without the possibility to be used even for irrigation.

Effects on agriculture: an important agriculture area and large vegetable corps are ruined every year.

Effects on the National Economy are estimated at more than 60 mil. lei.

Effects on human health: among children aged 10-14 years old living in the Pitesti town, there was an 8 fold increase in respiratory and irritant symptoms compared to a control town.

9. THE TIRGU MURES AREA

Short presentation of the industrial activity in the area:

1. Azomures S.A. Company Tg.Mures - specialized in chemical products.

Major emission: ammonia, NO_x and chemical fertilizer powders The water quality (especially Mures River) is affected by ammonium, nitrites, ureea, chlorides, sulphates and arsenic.

Effects on polluted areas: the most affected localities are Tg. Mures town and villages as Sincrai, Ungheni, Cristesti and Mureseni.

Effects on water: Mures River is very strog polluted with negative consequences over water supply sources situated down stream.

Effects on soil: large areas of very good agriculture land are affected by large loads of ammonia, nitrogen oxides and phosphorous derivates.

Effects on public health: it is belived that most of the recorded diseases in the area (skin allergies, eyes infections, respiratory diseases, tuberculosis, a.s.o.) are caused by or linked with the pollution of the air and water.

10. TURNU MAGURELE AREA

Short presentation of the industrial activity in the area:

1. Turnu S.A. Turnu Magurele - Traiding Company specialized in chemical fertilizers manufacturing (ureea, ammonium nitrate and nitrolimestone)

Major emission: NO_2, ammonia, SO_2, CO_2, are disipated into the air.

Effects on the air: the ambient air figures surpass the National standards 3-4 times for ammonia and twice for SO_2.

Effects on the water: frequent surpass of National Standard for nitrogen, fluoride, Fe etc. The water of the Danube River is affected by a waste flow containing suspended matters, chloride, limestone, sulphates, phosphates, Cr and Fe.

Effects on agriculture and forestry: severe deterioration of the forest around this area, as well as damages produced to the agriculture land.

Effects on the National Economy: damages estimated at 300 mil.lei per year.

Effects on human health: charesteristic for this area are the frequent respiratory diseases.

11.THE TULCEA AREA

Industrial activity: Alum S.A.Tulcea, a state own company which produces roast alumina and alumina hydrate.

Discharges:

- in air: residual gas with a content of aluminum powders, alkaline aerosols, H_2SO_4 aerosols and ammonia.

- in water (Danube River): waste water containing suspended matters, fixed residue, sulphates and magnesium.

The impact of the polluants discharges has not been assessed becouse no analyses have been made for the substances exhausted into the air.

The polluants discharges in the water exceed the maximum admissible concentration for: suspended matters 4 times, fixed residue 3 times, sulphates 6 times, alumina and magnesium 2 times.

Effects on public health: the local Institute of Hygiene and Public Health reports frequent respiratory diseases correlated with the pollution of the air.

12. THE ISALNITA AREA

Industrial activity:

1. Doljchim S.A. Craiova, which produces: ammonium, nitric acid, nitrous fertilizers, complex fertilizers (NPK) and syntheses organic substances (acetylene gas, acetaldehyde, acetic acid, vinyl acetate etc.)
2. Cet I Isalnita Power Plant - produces electrs energy and thermo power based on gas and coal, with an installed capacity of 1000 MW.

Major emissions:

- in air; nitrogen oxides, ammonium, sulphur dioxide, carbon monoxide, fluorine, ashes also.

- in water: organic matters, ammonium, nitrates, oil products, copper, mercury, chloride.

Effects:

- on air: frequent surpass of National standards for some of the polluants (e.g. for ammonium 3-5 times, for sulphur dioxide 8-10 times).

- on water: the content of nitrates, copper, mercury, oil products frequently surpass the Maximum Admisible Content (MAC).

- on soil: several hundreds hectars of agriculture land are affected by high loads of nitrogen oxides, ashes and fluorine

on human health: anumber of diseases were found but the risk of the exposure was not assessed.

13. THE BRASOV AREA

Industrial activity:

1. The Colorom S.A. Chemical Plant in Codlea - specialized in synthetic anorganic and organic chemistry.
2. The CCA Zarnesti Plant - specialized in pulp and paper production.
3. The Victoria Factory in Fagaras - specialized in synthetic anorganic and organic chemistry.

Major emissions: SO_2, SO_x, NH_3, Cl_2, formaldehyde, oil components, nitroderivates, phenols and other organic polluants to air, water and soil.

The ambient quality figures exceed the National Standards in 42% of the samples for some elements. The water quality is hindered by oil products and the soil is damaged in an area of about 95 Km^2 (37 sqm).

Effects on human health: several mortality cases suspected to be correlated with the environmental situation; the rate of pulmonic diseases in a population of 200,000 inhabitants is increased two to three times compared with other less polluted areas.

14. THE GOVORA - RIMNICU VILCEA AREA

Industrial activity:

1. Oltchim S.A. Rm.Vilcea - specialized in chloro - sodic products, organic chlorurate products, pesticides and some others by-products.
2. Govora S.A. Rm.Vilcea specialized in: sodic products (calcinate soda, caustic soda) and other derivates (sodium silicate and moleculare site).

Effects:

a) upon the atmosphere: chlore, chlorhidric acid, carbon monoxide and carbon dioxide frequently despass the MAC;

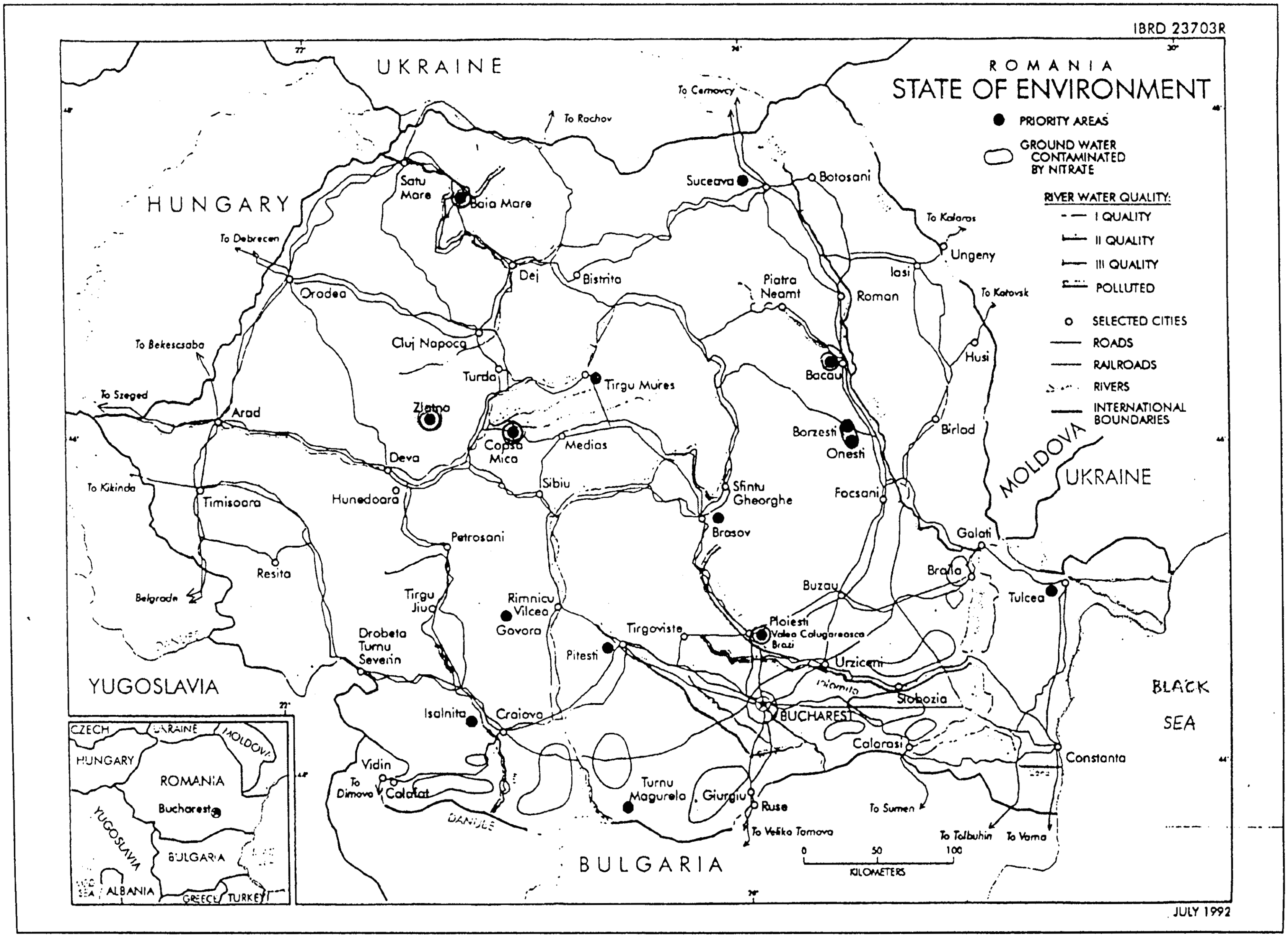
b) upon the water (Olt River): waste water with a high content of chlorures, organic substances, sulfates, ammonia, suspended particles, pesticide and mercury.

Impact:

The impact of noxes evacuated by these units determined, as a result, the increasing of polluants concentration into the air and water, overpassing on a regular basis the Maximum Admisible Levels. In this respect, the studies elaborated untill now stessed the existance of a pollution background in the chemical platform area, caused by chlor and amonia concentrations well over the admisible levels. The pollution affets an area of 25 Km^2 around the factory.

The Olt River, already polluted upstream the chemical platform, receives in its water a big quantity of polluants like: organic substances, mercury, chlorures and pesticides, much over the Maximum Admisible Levels for the waste water of the third category.

As a result of the pollution caused by these units, the population living in the adiacent villages (3,360 persons) as well as the people working on the industrial platform (18,000 persons) are under continuous impact, much of the diseases registred here being related to these high levels of pollution.


IBRD 23703R
ROMANIA
STATE OF ENVIRONMENT
PRIORITY AREAS
GROUND WATER CONTAMINATED BY NITRATE
RIVER WATER QUALITY:
I QUALITY
II QUALITY
III QUALITY
POLLUTED
SELECTED CITIES
ROADS
RAILROADS
RIVERS
INTERNATIONAL BOUNDARIES
UKRAINE
HUNGARY
MOLDOVA
UKRAINE
YUGOSLAVIA
BULGARIA
BLACK SEA
To Rochov
To Cernovcy
To Debrecen
To Bekescsaba
To Szeged
To Kikinda
Belgrade
To Kalaras
To Katovsk
Satu Mare
Baia Mare
Suceava
Botosani
Ungeny
Iasi
Dej
Bistrita
Piatra Neamt
Roman
Oradea
Cluj Napoca
Turda
Tirgu Mures
Bacau
Husi
Arad
Zlatna
Copsa Mica
Medias
Borzesti
Onesti
Birlad
Deva
Hunedoara
Sibiu
Sfintu Gheorghe
Focsani
Timisoara
Resita
Petrosani
Brasov
Galati
Braila
Tulcea
Buzau
Tirgu Jiu
Rimnicu Vilcea
Govora
Ploiesti
Valea Calugareasca
Brazi
Tirgoviste
Drobeta Turnu Severin
Pitesti
Urziceni
Slobozia
Isalnita
Craiova
BUCHAREST
Calarasi
Constanta
Vidin
To Dimovo
Calafat
Turnu Magurela
Giurgiu
Ruse
To Sumen
To Veliko Tarnova
To Tolbuhin
To Varna
DANUBE
0
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KILOMETERS
CZECH
UKRAINE
MOLDOVA
HUNGARY
ROMANIA
Bucharest
YUGOSLAVIA
BULGARIA
ALBANIA
GREECE
TURKEY
JULY 1992

Institutional framework

In late 1989 a Ministry of Water, Forestry and Environment (MoWFE) was created in response to public and "green" pressure over the desolate state of the environment in many regions of the country. After the elections in May, 1990 the Ministry of Environment (MoE) was created with the forty one subordinate Environment Survey and Protection Agencies (the Branch Agencies) throughout the country.

The functions as well as staffing levels of the MoE were set out in a Governmental Order which indicates the MoE as the central state environment authority empowered with setting guidelines for national environmental management. The Order designated the MoE as (inter alia) responsible for drafting environmental laws and regulations, evaluating environmental impacts,taking the lead on international environmental matters and is the main point of contact for NGOs. It is also responsible for enforcement of central government environment regulations.

The Moe was also specifically responsible for national strategy and enforcement of related regulations covering forestry, water resources, meteorology, and nuclear safety. In addition the MoE is responsible for the activities of the Research and Engineering Institute in Bucharest, the Danube Delta Biosphere Administration in Tulcea and the Institute for Marine Research in Constanta.

The MoE was funded from the central budget with a 1992 budget of about US $ 43 million out of which about 60 % of the funds were allocated for water resources management and only about 24% or US $ 10.4 million allocated for environment monitoring and protection.

In late 1992 the Ministry has regained its first name Ministry of Water, Forestry and Environmental Protection (MoWFEP). As it is now the MWFEP, is divided into three departments: water management, forestry and the environment in general, and has the same role and powers as the former MoE.

The central MoWFEP is empowered to have staff of 350 and, with the Branch Agency staffing set at about 60 each, (excluding forestry inspectorate and specialists in research institutes) environmental staffing is about 2.800.

From its very creation in late 1989 the Ministry under a name or another has assumed a leadership role in all the problems related to or in connection with environmental protection in Romania, acting as a regulatory body for all the anthropic activities.

However, the activity was and still is impeded by the lack of technical capability and experience, obsolete laboratory equipments, deficiency in the knowledge of state-of-the-art, more environmental friendly technologies.

TABLE 1
Schedule of USEPA drinking water regulations

Regulation	Action	Date*	*Federal Register* Citation
Promulgated Regulations			
VOCs (Phase I)	ANPRM	Mar. 4, 1982	47 *FR* 9350
	Proposed rule (RMCLs)†	June 12, 1984	49 *FR* 24330
	Final rule (RMCLs)	Nov. 13, 1985	50 *FR* 46880
	Proposed rule (MCLs)	Nov. 13, 1985	50 *FR* 46902
	Proposed rule (*para*-dichlorobenzene)	Apr. 17, 1987	52 *FR* 12876
	Final rule	July 8, 1987	52 *FR* 25690
	Final rule corrections	July 1, 1988	53 *FR* 25108
	Final rule (revised monitoring schedule)	July 1, 1991	56 *FR* 30266
	Proposed rule (analytical methods)	(Early 1992)	
	Final rule (analytical methods)	(Sept. 1992)	
Fluoride	ANPRM	Oct. 5, 1983	48 *FR* 45502
	Proposed rule (RMCL)	May 14, 1985	50 *FR* 20164
	Final rule (RMCL)	Nov. 14, 1985	50 *FR* 47142
	Proposed rule (MCL, SMCL)	Nov. 14, 1985	50 *FR* 47156
	Final rule	Apr. 2, 1986	51 *FR* 11396
	Request for information	Jan. 3, 1990	55 *FR* 160
Surface Water Treatment Rule	ANPRM	Oct. 5, 1983	48 *FR* 45502
	Proposed rule	Nov. 13, 1985	50 *FR* 46936
	Proposed rule	Nov. 3, 1987	52 *FR* 42178
	Proposed rule (extension)	Jan. 7, 1988	53 *FR* 1892
	Notice of options	May 6, 1988	53 *FR* 16348
	Final rule	June 29, 1989	54 *FR* 27488
Total Coliform Rule	Proposed rule	Nov. 3, 1987	52 *FR* 42224
	Notice of options	May 6, 1988	53 *FR* 16348
	Final rule	June 29, 1989	54 *FR* 27547
	Final rule (MMO-MUG for total coliform)	July 17, 1989	54 *FR* 29998
	Proposed rule (three *E. coli* methods)	June 1, 1990	55 *FR* 22752
	Final rule (two *E. coli* methods)	Jan. 8, 1991	56 *FR* 636
	Final rule (transfer protocol)	Jan. 15, 1992	57 *FR* 1850
	Final rule (MMO-MUG for *E. coli*)	(Early 1992)	
Lead and Copper Rule	ANPRM	Oct. 5, 1983	48 *FR* 45502
	Proposed rule (MCLG)	Nov. 13, 1985	50 *FR* 46936
	Proposed rule (MCLGs/MCLs and treatment technique)	Aug. 18, 1988	53 *FR* 31516
	Final rule	June 7, 1991	56 *FR* 26460
	Final rule correction	July 15, 1991	56 *FR* 32112
SOCs and IOCs (Phase II)	ANPRM	Oct. 5, 1983	48 *FR* 45502
	Proposed rule	Nov. 13, 1985	50 *FR* 46936
	Proposed rule (38 contaminants)	May 22, 1989	54 *FR* 22062
	Final rule (33 contaminants)	Jan. 30, 1991	56 *FR* 3526
	Reproposal (five contaminants)	Jan. 30, 1991	56 *FR* 3600
	Final rule (five contaminants)	July 1, 1991	56 *FR* 30266
Proposed Regulations			
SOCs and IOCs (Phase V)	ANPRM	Oct. 5, 1983	48 *FR* 45502
	ANPRM	Nov. 13, 1985	50 *FR* 16936
	Proposed rule	July 25, 1990	55 *FR* 30370
	Notice of availability	Nov. 29, 1991	56 *FR* 60949
	Final rule	(Mar. 1992)	
Radionuclides (Phase III)	ANPRM	Oct. 5, 1983	48 *FR* 45502
	ANPRM	Sept. 30, 1986	51 *FR* 34836
	Proposed rule	July 18, 1991	56 *FR* 33050
	Final rule	(Apr. 1993)	
Anticipated Regulations			
PQL alternatives	Proposed rule	(Apr. 1992)	
	Final rule	(Late 1992)	
Variances and exemptions	Proposed rule	(Unknown)	
	Final rule	(Unknown)	
Arsenic	Proposed rule	(Nov. 1992)	
	Final rule	(Nov. 1994)	
Laboratory certification	Proposed rule	(Dec. 1992)	
	Final rule	(Unknown)	
Groundwater disinfection	Proposed rule	(June 1993)	
	Final rule	(June 1995)	
D-DBP (Phase VIa)	Proposed rule	(June 1993)	
	Final rule	(June 1995)	
Balance of DWPL‡ 25 (Phase VIb)	Proposed rule	(June 1993)	
	Final rule	(June 1995)	
1994 DWPL	Final notice	(Jan. 1994)	

*Dates in parentheses are anticipated and subject to change.
†Recommended maximum contaminant levels
‡Drinking Water Priority List

TABLE 2
Contaminants regulated in USEPA rules

Rulemaking	Contaminants Regulated	Note
VOCs (Phase I)	Benzene*	MCLGs and MCLs have been established for eight VOCs.
	Carbon tetrachloride*	
	para-Dichlorobenzene*	
	1,2-Dichloroethane*	
	1,1-Dichloroethylene*	
	1,1,1-Trichloroethane*	
	Trichloroethylene*	
	Vinyl chloride*	
	Monitoring Only	
	List 1	The 34 compounds in List 1 must be monitored by all systems
	Bromobenzene	
	Bromodichloromethane	
	Bromoform	
	Bromomethane	
	Chlorobenzene	
	Chlorodibromomethane	
	Chloroethane	
	Chloroform	
	Chloromethane	
	o-Chlorotoluene	
	p-Chlorotoluene	
	Dibromomethane	
	m-Dichlorobenzene	
	o-Dichlorobenzene	
	trans-1,2-Dichloroethylene	
	cis-1,2-Dichloroethylene	
	Dichloromethane	
	1,1-Dichloroethane	
	1,2-Dichloropropane	
	1,3-Dichloropropane	
	2,2-Dichloropropane	
	1,1-Dichloropropene	
	1,3-Dichloropropene	
	Ethylbenzene	
	Styrene	
	1,1,1,2-Tetrachloroethane	
	1,1,2,2-Tetrachloroethane	
	Tetrachloroethylene	
	1,1,2-Trichloroethane	
	1,2,3-Trichloropropane	
	Toluene	
	p-Xylene	
	o-Xylene	
	m-Xylene	
	List 2	The two compounds in List 2 must be monitored by systems vulnerable to possible contamination.
	Ethylene dibromide (EDB)	
	1,2-Dibromo-3-chloropropane (DBCP)	
	List 3	The 15 compounds in List 3 may be monitored by systems at state's discretion.
	Bromochloromethane	
	n-Butylbenzene	
	Dichlorodifluoromethane	
	Fluorotrichloromethane	
	Hexachlorobutadiene	
	Isopropylbenzene	
	p-Isopropyltoluene	
	Naphthalene	
	n-Propylbenzene	
	sec-Butylbenzene	
	tert-Butylbenzene	
	1,2,3-Trichlorobenzene	
	1,2,4-Trichlorobenzene	
	1,2,4-Trimethylbenzene	
	1,3,5-Trimethylbenzene	
Fluoride	Fluoride*	MCLG and MCL have been revised.
Surface Water Treatment Rule	Turbidity*	Treatment technique requirements have been established for surface waters and groundwaters determined to be under the direct influence of surface water.
	Heterotrophic plate count*	
	Viruses*	
	*Giardia lamblia**	
	*Legionella**	
Total Coliform Rule	Total coliform bacteria*	Total coliform MCL revised based on presence–absence te[illegible]
	Fecal coliform bacteria	
	E. coli	
Lead and Copper	Lead*	Treatment technique requirements have been set in place of MCLs.
	Copper*	

*Included in the 1986 SDWA list of 83 contaminants

Contaminants regulated in USEPA rules

Rulemaking	Contaminants Regulated	Note
SOCs and IOCs (Phase II)	**Inorganics**	
	Asbestos*	
	Barium*	
	Cadmium*	
	Chromium*	
	Mercury*	
	Nitrate*	
	Nitrite*	
	Selenium*	
	Volatiles	
	cis-1,2-Dichloroethylene*	
	1,2-Dichloropropane*	
	Ethylbenzene	
	Monochlorobenzene*	
	o-Dichlorobenzene*	
	Styrene*	
	Tetrachloroethylene*	
	Toluene*	
	trans-1,2-Dichloroethylene*	
	Xylenes (total)*	
	Pesticides, Herbicides, PCBs	
	Alachlor*	
	Aldicarb*	
	Aldicarb sulfone*	
	Aldicarb sulfoxide*	
	Atrazine*	
	Carbofuran*	
	Chlordane*	
	Dibromochloropropane (DBCP)*	
	2,4-D	
	Ethylene dibromide (EDB)*	
	Heptachlor*	
	Heptachlor epoxide*	
	Lindane*	
	Methoxychlor*	
	PCBs*	
	Pentachlorophenol*	
	Toxaphene*	
	2,4,5-TP (Silvex)*	
	Treatment Chemicals	Treatment technique set in lieu of MCLs
	Acrylamide*	
	Epichlorophydrin*	
	Monitoring Only	
	Organics	All systems must monitor unless a vulnerability assessment determines the system is not vulnerable.
	Aldrin	
	Benzo(a)pyrene	
	Butachlor	
	Carbaryl	
	Dalapon	
	Di-2(ethylhexyl) adipate	
	Di-2(ethylhexyl) phthalates	
	Dicamba	
	Dieldrin	
	Dinoseb	
	Diquat	
	Endothall	
	Glyphosate	
	Hexachlorobenzene	
	Hexachlorocyclopentadiene	
	3-Hydroxycarbofuran	
	Methomyl	
	Metolachlor	
	Metribuzin	
	Oxamyl (vydate)	
	Picloram	
	Propachlor	
	Simazine	
	2,3,7,8-TCDD (dioxin)	
	Inorganics	
	Antimony*	
	Beryllium*	
	Cyanide*	
	Nickel*	
	Sulfate*	
	Thallium*	
SOCs and IOCs (Phase V)	Inorganics	
	Antimony*	
	Beryllium*	
	Cyanide*	
	Nickel*	
	Sulfate*	
	Thallium*	

*Included in the 1986 SDWA list of 83 contaminants

TABLE 2, Continued
Contaminants regulated in USEPA rule

Rulemaking	Contaminants Regulated	Note
	Organics	
	Dalapon*	
	Di (ethylhexyl) adipate*	
	Di (ethylhexyl) phthalate*	
	Dichloromethane (methylene chloride)*	
	Dinoseb*	
	Diquat*	
	Endothal*	
	Endrin*	
	Glyphosate*	
	Hexachlorobenzene	
	Hexachlorocyclopentadiene*	
	Oxamyl (vydate)*	
	PAHs (Benzo (a) pyrene)*	
	Picloram*	
	Simazine*	
	1,2,4-Trichlorobenzene*	
	1,1,2-Trichloroethane*	
	2,3,7,8-TCDD (Dioxin)*	
Radionuclides	Radon*	
	Radium-226*	
	Radium-228*	
	Uranium*	
	Alpha emitters*	
	Beta and photon emitters*	
Arsenic	Arsenic (total)*	
Groundwater disinfection	Viruses*	Treatment technique required by SDWA
	Heterotrophic plate count*	
D-DBP	**Disinfectants**	List of contaminants to be regulated has not yet been finalized.
	Chlorine	
	Chloramine	
	Chlorine dioxide	
D-DBP	**Inorganic By-products**	
	Chlorate	
	Chlorite	
	Bromate	
	Organic By-products	
	Total trihalomethanes	
	Chloroform	
	Bromoform	
	Bromodichloromethane	
	Dibromochloromethane	
	Cyanogen chloride	
	Haloacetic acids	
	Chloral hydrate	
Balance of the DWPL 25 (Phase VIb)	Selected from the 1991 DWPL	List of contaminants to be regulated has not yet been finalized.

*Included in the 1986 SDWA list of 83 contaminants

*USEPA drinking water standards and BAT for regulated contaminants**

Contaminant	Standards				Best Available Technology		Reference
	Regulation	Status	MCLG *mg/L*	MCL *mg/L*	Conventional Processes	Specialized Processes	
Organics							
Acrylamide	Phase II	Final	zero	TT	Polymer addition practices		37
Adipates[di(ethylhexl)adipate]	Phase V	Proposed	0.5	0.5		GAC; PTA	43
Alachlor	Phase II	Final	zero	0.002		GAC	37
Aldicarb	Phase II	Final	0.001	0.003		GAC	39
Aldicarb sulfone	Phase II	Final	0.001	0.002		GAC	39
Aldicarb sulfoxide	Phase II	Final	0.001	0.004		GAC	39
Atrazine	Phase II	Final	0.003	0.003		GAC	37
Benzene	Phase I	Final	zero	0.005		GAC; PTA	9
Carbofuran	Phase II	Final	0.04	0.04		GAC	37
Carbon tetrachloride	Phase I	Final	zero	0.005		GAC; PTA	9
Chlordane	Phase II	Final	zero	0.002		GAC	37
2,4-D	Phase II	Final	0.07	0.07		GAC	37
Dalapon	Phase V	Proposed	0.2	0.2		GAC	43
Dibromochloropropane (DBCP)	Phase II	Final	zero	0.0002		GAC; PTA	37
p-Dichlorobenzene	Phase I	Final	0.075	0.075		GAC; PTA	9
o-Dichlorobenzene	Phase II	Final	0.6	0.6		GAC; PTA	37
1,2-Dichloroethane	Phase I	Final	zero	0.005		GAC; PTA	9
1,1-Dichloroethylene	Phase I	Final	0.007	0.007		GAC; PTA	9
cis-1,2-Dichloroethylene	Phase II	Final	0.07	0.07		GAC; PTA	37
trans-1,2-Dichloroethylene	Phase II	Final	0.1	0.1		GAC; PTA	37
Dichloromethane (methylene chloride)	Phase V	Proposed	zero	0.005		PTA	43
1,2-Dichloropropane	Phase II	Final	zero	0.005		GAC; PTA	37
Dinoseb	Phase V	Proposed	0.007	0.007		GAC	43
Diquat	Phase V	Proposed	0.02	0.02		GAC	43
Endothall	Phase V	Proposed	0.1	0.1		GAC	43
Endrin	Phase V	Proposed	0.002	0.002		GAC	43
Epichlorohydrin	Phase II	Final	zero	TT	Polymer addition practices		37
Ethylbenzene	Phase II	Final	0.7	0.7		GAC; PTA	37
Ethylene dibromide (EDB)	Phase II	Final	zero	0.00005		GAC; PTA	37
Glyphosate	Phase V	Proposed	0.7	0.7		GAC	43
Heptachlor	Phase II	Final	zero	0.0004		GAC	37
Heptachlor epoxide	Phase II	Final	zero	0.0002		GAC	37
Hexachlorobenzene	Phase V	Proposed	zero	0.001		GAC	43
Hexachlorocyclopentadiene	Phase V	Proposed	0.05	0.05		GAC; PTA	43
Lindane	Phase II	Final	0.0002	0.0002		GAC	37
Methoxychlor	Phase II	Final	0.04	0.04		GAC	37
Monochlorobenzene	Phase II	Final	0.1	0.1		GAC; PTA	37
Oxamyl (vydate)	Phase V	Proposed	0.2	0.2		GAC	43
PAHs[benzo(a)pyrene]†	Phase V	Proposed	zero	0.0002		GAC	43
Pentachlorophenol	Phase II	Proposed	zero	0.001		GAC	38
Phthalates[di(ethylhexyl) phthalate]‡	Phase V	Proposed	zero	0.004		GAC	43
Picloram	Phase V	Proposed	0.5	0.5		GAC	43
Polychlorinated byphenyls (PCBs)	Phase II	Final	zero	0.0005		GAC	37
Simazine	Phase V	Proposed	0.004	0.004		GAC	43
Styrene	Phase II	Final	0.1	0.1		GAC; PTA	37
2,3,7,8-TCDD (dioxin)	Phase V	Proposed	zero	5E-08		GAC	43
Tetrachloroethylene	Phase II	Final	zero	0.005		GAC; PTA	37
Toluene	Phase II	Final	1	1		GAC; PTA	37
Toxaphene	Phase II	Final	zero	0.005		GAC	37
2,4,5-TP (silvex)	Phase II	Final	0.05	0.05		GAC	37
1,2,4-Trichlorobenzene	Phase V	Proposed	0.009	0.009		GAC; PTA	43
1,1,1-Trichloroethane	Phase I	Final	0.2	0.2		GAC; PTA	9
1,1,2-Trichloroethane	Phase V	Proposed	0.003	0.005		GAC; PTA	43
Trichloroethylene	Phase I	Final	zero	0.005		GAC; PTA	9
Total trihalomethanes§	Interim	Final		0.1	AD; PR; discontinue pre-Cl_2		1
Vinyl chloride	Phase I	Final	zero	0.002		PTA	9
Xylenes (total)	Phase II	Final	10	10		GAC; PTA	37
Inorganics							
Antimony	Phase V	Proposed	0.003	0.01/0.005	C–F**	RO	43
Arsenic	Interim			0.05			1
Asbestos (fibers/1 >10 μm)	Phase II	Final	7 MFL	7 MFL	C–F;** DF; DEF; CC		37
Barium	Phase II	Final	2	2	LS**	IX; RO	37
Beryllium	Phase V	Proposed	zero	0.001	C–F**; LS**	AA; IX; RO	43
Cadmium	Phase II	Final	0.005	0.005	C–F;** LS**	IX; RO	37
Chromium (total)	Phase II	Final	0.1	0.1	C–F;** LS (Cr III)**	IX; RO	37
Copper	Lead and copper	Proposed	1.3	1.3	CC; SWT		32
Cyanide	Phase V	Proposed	0.2	0.2	Cl_2	IX; RO	43
Fluoride	Fluoride	Final	4	4		AA; RO	11
Lead	Lead and copper	Final	zero	TT	CC; PE; SWT; LSLR		32
Mercury	Phase II	Final	0.002	0.002	C–F (influent <10 μg/L);** LS**	GAC; RO (influent ≤10 μg/L)	37
Nickel	Phase V	Proposed	0.1	0.1	LS**	IX; RO	43
Nitrate (as N)	Phase II	Final	10	10		IX; RO	37
Nitrite (as N)	Phase II	Final	1	1		IX; RO	37

TABLE 3, Continued

*USEPA drinking water standards and BAT for regulated contaminants**

Contaminant	Standards: Regulation	Standards: Status	Standards: MCLG mg/L	Standards: MCL mg/L	Best Available Technology: Conventional Processes	Best Available Technology: Specialized Processes	Reference
Nitrate + nitrite (both as N)	Phase II	Final	10	10		IX; RO	37
Selenium	Phase II	Final	0.05	0.05	C–F (Se IV);** LS**	AA; RO	37
Sulfate	Phase V	Proposed	400/500	400/500	C–F	IX; RO	43
Thallium	Phase V	Proposed	0.0005	0.002/0.001		AA; IX	43
Radionuclides							
Beta-particle and	Interim	Final	zero	4 mrem	C–F		1
photon emitters	Rad	Proposed	zero	4 mrem	C–F	IX;RO	48
Alpha emitters	Interim	Final	zero	15 pCi/L	C–F		1
	Rad	Proposed	zero	15 pCi/L	C–F	RO	48
Radium-226 + 228	Interim	Final	zero	5 pCi/L	C–F		1
Radium-226	Rad	Proposed	zero	20 pCi/L	LS**	IX; RO	48
Radium-228	Rad	Proposed	zero	20 pCi/L	LS**	IX; RO	48
Radon	Rad	Proposed	zero	300 pCi/L		Aeration	48
Uranium	Rad	Proposed	zero	20 µg/L	C–F**; LS**	AX; LS	48
Microbials							
Giardia lamblia	SWTR	Final	zero	TT	C–F; SSF; DEF; DF; D		16
Legionella	SWTR	Final††	zero	TT	C–F; SSF; DEF; DF; D		16
Standard plate count	SWTR	Final††	NA	TT	C–F; SSF; DEF; DF; D		16
Total coliforms	TCR	Final	zero	‡‡	D		18
Turbidity	SWTR	Final	NA	PS	C–F; SSF; DEF; DF; D		16
Viruses	SWTR	Final††[5]	zero	TT	C–F; SSF; DEF; DF; D		16

*Abbreviations used in this table: AA—activated alumina; AD—alternative disinfectants; AX—anion exchange; CC—corrosion control; C-F—coagulation-filtration; Cl_2—chlorination; D—disinfection; DEF—diatomaceous earth filtration; DF—direct filtration; GAC—granular activated carbon; IX—ion exchange; LS—lime softening; LSLR—lead service line removal; PE—public education; PR—precursor removal; PS—performance standard 0.5–1.0 ntu; PTA—packed-tower aeration; RO—reverse osmosis; SWT—source water treatment; TT—treatment technique

†USEPA is considering establishing MCLGs and MCLs for six additional PAHs classified as probable human carcinogens—benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indenopyrene.

‡USEPA is considering regulating butylbenzl phthalate.

§The sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane, and trichloromethane

**Coagulation-filtration and lime softening are not BAT for small systems for variances unless treatment is already installed.

††Final for systems using surface water; also being considered for groundwater systems

‡‡No more than 5 percent of the samples per month may be positive. (For systems collecting fewer than 40 samples per month, no more than 1 sample per month may be positive.)

TABLE 4
USEPA secondary standards

Contaminant	Regulation	Status	SMCLs*
Aluminum	Phase II	Final	0.05 to 0.2
Chloride	Interim	Final	250
Color	Interim	Final	15 color units
Copper	Interim	Final	1
Corrosivity	Interim	Final	Noncorrosive
Fluoride	Fluoride	Final	2
Foaming agents	Interim	Final	0.5
Hexachlorocyclopentadiene	Phase V	Proposed	0.008
Iron	Interim	Final	0.3
Manganese	Interim	Final	0.05
Odor	Interim	Final	3 TON
pH	Interim	Final	6.5–8.5
Silver	Phase II	Final	0.10
Sulfate	Interim	Final	250
Total dissolved solids (TD)	Interim	Final	500
Zinc	Interim	Final	5

*Units of measure are milligrams per litre unless noted otherwise.

TABLE 5
1991 Drinking Water Priority List

Inorganics
- Aluminum
- Boron
- Chloramines
- Chlorate
- Chlorine
- Chlorine dioxide
- Chlorite
- Cyanogen chloride
- Hypochlorite ion
- Manganese
- Molybdenum
- Strontium
- Vanadium
- Zinc

Pesticides
- Asulam
- Bentazon
- Bromacil
- Cyanazine
- Cyromazine
- DCPA (and its acid metabolites)
- Dicamba
- Ethylenethiourea
- Fomesafen
- Lactofen/acifluorfen
- Metalaxyl
- Methomyl
- Metolachlor
- Metribuzin
- Parathion deradation product (4-nitrophenol)
- Prometon
- 2,4,5-T
- Thiodicarb
- Trifluralin

SOCs
- Acrylonitrile
- Bromobenzene
- Bromochloroacetonitrile
- Bromodichloromethane
- Bromoform
- Bromomethane
- Chlorination–chloramination by-products (misc.), e.g., haloacetic acids, haloketones, chloral hydrate, MX-2 [3-chloro-4-(dichloromethyl)-5-hydroxy-2 (5H)-furanone], *N*-Organochloramines
- Chloroethane
- Chloroform
- Chloromethane
- Chloropicrin
- *o*-Chlorotoluene
- *p*-Chlorotoluene
- Dibromoacetonitrile
- Dibromochloromethane
- Dibromomethane
- Dichloroacetonitrile
- 1,3-Dichlorobenzene
- Dichlorodifluoromethane
- 1,1-Dichloroethane
- 2,2-Dichloropropane
- 1,3-Dichloropropane
- 1,1-Dichloropropene
- 1,3-Dichloropropene
- 2,4-Dinitrophenol
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- 1,2-Diphenylhydrazine
- Fluorotrichloromethane
- Hexachlorobutadiene
- Hexachloroethane
- Isophorone
- Methyl ethyl ketone
- Methyl isobutyl ketone
- Methyl-*t*-butyl ether
- Naphthalene
- Nitrobenzene
- Ozone by-products, e.g., aldehydes, epoxides, peroxides, nitrosamines, bromate, iodate
- 1,1,1,2-Tetrachloroethane
- 1,1,2,2-Tetrachloroethane
- Tetrahydrofuran
- Trichloroacetonitrile
- 1,2,3-Trichloropropane

Microbials
- *Cryptosporidium*

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BUREAU OF WATER AND WASTEWATER
WATER QUALITY SECTION
TREATED WATER ANALYSES ANNUAL AVERAGES
ORGANICS - 1992

CONTAMINANT	MCL	ASHBURTON	MONTEBELLO
TRIHALOMETHANES			
TOTAL TRIHALOMETHANES	100	40	40
REGULATED PHASE I VOCs			
Benzene	5	<0.5	<0.5
Carbon Tetrachloride	5	<0.5	<0.5
p-Dichlorobenzene	75	<0.5	<0.5
1,1-Dichloroethylene	7	<0.5	<0.5
1,2-Dichloroethane	5	<0.5	<0.5
1,1,1-Trichloroethane	200	<0.5	<0.5
Trichloroethylene	5	<0.5	<0.5
Vinyl Chloride	2	<0.5	<0.5
REGULATED PHASE II VOCs			
trans-1,2-Dichloroethene	100	<0.5	<0.5
cis-1,2-Dichloroethene	70	<0.5	<0.5
1,2-Dichlorobenzene	600	<0.5	<0.5
1,2-Dichloropropane	5	<0.5	<0.5
Tetrachloroethylene	5	<0.5	<0.5
Monochlorobenzene	100	<0.5	<0.5
Toluene	1000	<0.5	<0.5
Ethylbenzene	700	<0.5	<0.5
Total Xylenes	10000	<0.5	<0.5
Styrene	100	<0.5	<0.5
REGULATED PHASE V VOCs			
Methylene Chloride	5	<0.5	<0.5
1,2,4-Trichlorobenzene	9	<0.5	<0.5
1,1,2-Trichloroethane	5	<0.5	<0.5
UNREGULATED VOCs			
Chloromethane		<0.2	<0.2
Bromomethane		<0.2	<0.2
Dichlorodifluoromethane		<0.2	<0.2
Trichlorofluoromethane		<0.2	<0.2
1,1-Dichloroethane		<0.2	<0.2
Dibromomethane		<0.2	<0.2
m-Xylene		<0.2	<0.2

CONTAMINANT	ASHBURTON	MONTEBELLO
1,1-Dichloropropene	<0.2	<0.2
trans-1,3-Dichloropropene	<0.2	<0.2
cis-1,3-Dichloropropene	<0.2	<0.2
1,1,2,2-Tetrachloroethane	<0.2	<0.2
1,3-Dichloropropane	<0.2	<0.2
2,2-Dichloropropane	<0.2	<0.2
o-Chlorotoluene	<0.2	<0.2
p-Chlorotoluene	<0.2	<0.2
Bromobenzene	<0.2	<0.2
1,2,4-Trimethylbenzene	<0.2	<0.2
Tert-butylbenzene	<0.2	<0.2
1,2,3-Trichlorobenzene	<0.2	<0.2
n-Propylbenzene	<0.2	<0.2
n-Butylbenzene	<0.2	<0.2
Naphthalene	<0.2	<0.2
Hexachlorobutadiene	<0.2	<0.2
Isopropylbenzene	<0.2	<0.2
1,2,3-Trichloropropene	<0.2	<0.2
1,2-Dibromo-3-Chloropropane	<0.2	<0.2
1,3,5-Trimethylbenzene	<0.2	<0.2
p-Isopropyltoluene	<0.2	<0.2
Sec-butylbenzene	<0.2	<0.2
Bromochloromethane	<0.2	<0.2
Dichloromethane	<0.2	<0.2
1,1,1,2-Tetrachloroethane	<0.2	<0.2
1,2-Dibromomethane	<0.2	<0.2
o-Dichlorobenzene	<0.2	<0.2
m-Dichlorobenzene	<0.2	<0.2
Chloroethane	<0.2	<0.2
Ethylenedibromide (EDB)	<0.2	<0.2
Dibromochloropropane (DBCP)	<0.2	<0.2
o-Xylene	<0.2	<0.2
p-Xylene	<0.2	<0.2

All values are in micrograms per liter (parts per billion).
MCL - Maximum Contaminant Level.
Montebello Analyses - THM's,EDB, DBCP, Phase I & Phase II VOCs.
Md. State Health Dept. analyses - Phase V & Unregulated VOCs.

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TREATED WATER ANALYSES ANNUAL AVERAGES
(All data listed in milligrams per liter unless otherwise noted)

	MCL	Ashburton	Montebello
INORGANICS			
Alkalinity		37	52
Ammonia		<0.01	<0.01
Bicarbonates		45	64
Chloride		21	27
Color, units		1	1
Cyanide	0.2	<0.01	<0.01
Fluorides	4	0.93	1.00
Hardness, EDTA		67	92
Nitrate, mg/l as N	10	2.2	1.6
Nitrites	1	<0.02	<0.02
pH, units		8.0	8.0
Phosphorus		<0.01	0.01
Silica		5.2	6.5
Specific Conductance (umho/cm)		196	250
Sulfate		12	20
Total Solids (103°-105°)		112	135
Turbidity, N.T.U.	1	0.13	0.16
Volatile Solids (500°-600°)		30	33
METALS			
Aluminum		0.091	0.080
Antimony	0.006	<0.002	<0.002
Arsenic	0.050	<0.005	<0.005
Barium	2.0	0.027	0.026
Beryllium	0.004	<0.0005	<0.0005
Cadmium	0.005	<0.0005	<0.0005
Calcium		17.8	22.6
Chromium	0.10	<0.0005	<0.0005
Copper	1.30 **	0.015	0.006
Iron		0.01	0.01
Lead	0.015 **	0.001	<0.001
Magnesium		4.5	6.5
Manganese		0.01	0.01
Mercury	0.002	<0.0005	<0.0005
Nickel	0.10	<0.001	<0.001
Potassium		2.5	2.7
Selenium	0.05	<0.005	<0.005
Silver	0.05	<0.001	<0.001
Sodium		8.0	9.4
Zinc	0.002	0.009	0.013
ORGANICS			
Total Trihalomethanes, ug/l	100	48	46
Endrin, ug/l	0.2	<0.05	<0.05
Lindane, ug/l	4.0	<0.002	<0.002
Methoxychlor, ug/l	100	<0.2	<0.2
Toxaphene, ug/l	5	<0.2	<0.2
2,4-D, ug/l	100	<0.05	<0.05
2,4,5-TP (Silvex)	10	<0.05	<0.05
Chlordane, ug/l	2	<0.5	<0.5
Aldrin, ug/l		<0.05	<0.05
pp'- DDT, ug/l		<0.05	<0.05
Total Organic Carbon		1.65	1.44

Note: MCL refers to the **M**aximum **C**ontaminant **L**evel allowed under the Safe Drinking Water Act. ** Action level -- not an MCL.