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Economic Impact Analysis Of The Promulgated Trihalomethane Regulation For Drinking Water

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ECONOMIC IMPACT ANALYSIS OF THE PROMULGATED TRIHALOMETHANE REGULATION FOR DRINKING WATER

by

Temple, Barker & Sloane, Inc.
33 Hayden Avenue
Lexington, Massachusetts 02173

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Project Officer

David W. Schnare
Office of Drinking Water
U.S. Environmental Protection Agency
Washington, D.C.

OFFICE OF DRINKING WATER
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C.

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PREFACE

This report has been submitted to the United States Environmental Protection Agency in partial fulfillment of Contract Number 68-01-4778 by Temple, Barker & Sloane, Inc. This report supercedes the report "Economic Impact Analysis of a Trihalomethane Regulation for Drinking Water," submitted August 1977. The current version has been prepared in support of the promulgation of a trihalomethane regulation.

TBS appreciates the contributions to this effort made by several members of EPA's Office of Drinking Water, including David Schnare, Joseph Cotruro, Arnold Kuzmak, Craig Vogt and Victor Kimm. Also appreciated is the assistance provided by staff members of EPA's Municipal Environmental Research Laboratory on technical issues related to the methods and costs of complying with a THM regulation. These individuals include Jim Symons, Tom Love, Bob Clark and Gordon Robeck. Finally, the consulting firm of Culp/Wesner/Culp, and especially Bob Gumerman, were particularly helpful in providing information on the use of their database containing individual system treatment costs.

I. SUMMARY AND INTRODUCTION

SUMMARY

This report presents the economic impact of the promulgated regulations limiting trihalomethane(s) (THM) in drinking water. The regulation applies to the estimated 2,685 community water systems serving more than 10,000 people. Some 167 million people are covered by the regulation, approximately 80 percent of the public served by community water systems.

Based on preliminary monitoring, some 515 (of these 2,685 water systems covered) are expected to exceed the promulgated maximum contaminant level (MCL) of 0.10 milligrams per liter of THM. Based on an estimate of which treatments will be used by these utilities, total one-time capital expenditures of $85 million (1980 dollars) will be required. The combination of increased operating and maintenance costs ($10 million) and the annualized capital costs will require utilities exceeding the MCL to increase annual revenues by $19 million. This represents an average annual cost of $.70 per person served by those systems which exceed the MCL. For those same systems, the average increase in a typical residential customer bill for annual water service is projected to be $1.40.

Since the costs of the treatments which utilities may select range broadly, some residential customer bills will increase by several times this average, while others will not experience any increase. For customers served by very large utilities, annual residential bills will increase by $.00, $.30, $.90, $2.10, $3.60, or $4.80 depending on the selection of treatments. In utilities serving 10,000 to 25,000 people, residential bill increases for these same treatments will range from $.00 to $12.00 per year.

INTRODUCTION

This report presents the economic impact of the promulgated regulations limiting THM in drinking water. A prior report, Economic Impact Analysis of a Trihalomethane Regulation for Drinking Water (hereafter referred to as the 1977 THM Economic Impact Report; see Appendix D for full citation), was published in August 1977 based on regulations which were proposed early in 1978. The present report incorporates several revisions since the previous study and also shows the economic effects of changes in the regulation itself from the proposal to the promulgation.

The major changes in the regulation which affect costs are listed below and each has been incorporated in the analysis:

- Coverage of smaller systems, those serving between 10,000 and 75,000 people, which were formerly excluded,

- Reduced monitoring frequency for groundwater systems, and

- Relaxation of limits on the use of alternate disinfectants.

In addition, several other inputs to the analysis have been refined in this report. These include:

- Updated engineering cost estimates for each treatment from the August 1978 EPA study by the consulting firm of Culp/Wesner/Culp (C/W/C), entitled "Estimating Costs for Water Treatment as a Function of Size and Treatment Plant Efficiency" (hereafter referred to as the EPA Unit Treatment Cost Report),

- Revised sets of compliance choices by water systems exceeding the MCL based upon recent experience by utilities in the control of THM. The resultant estimates show fewer systems selecting adsorbents and more choosing alternate disinfectants, and

- More refined estimates of the present operating and financial characteristics of water systems.

In combination, these modifications have substantially lowered the estimate of the national economic impact of this regulation. The balance of this report presents these revised estimates in the three chapters and four appendices which follow:

- Chapter II, entitled "Analytic Structure and Procedure," describes the seven components of the development of a national cost estimate. Phase I of the analysis, which consists of the first three elements below, determines the number and characteristics of systems exceeding the MCL. Phase II builds on these results and includes the remaining four points below. These seven components are shown in Exhibit II-1 and are listed below:

--The regulatory criteria. These are the parameters defined by the regulation; they determine which water systems are covered.

--The number and characteristics of community water systems and the populations they serve. Those systems exceeding the MCL are divided into several size categories for analytic and presentation purposes.

--The water quality data analysis based on the National Organics Monitoring Survey (NOMS). This data is used to estimate the number of systems exceeding and the extent to which they exceed the MCL.

--Available treatment alternatives. These are the treatments and procedures which water systems could implement to comply with the regulation.

--The derivation of selected unit treatment costs for individual systems using the information from the EPA Unit Treatment Cost Report.

--Estimates of which treatment strategies utilities will adopt based on available treatments, cost of treatment, the degree to which the MCL is exceeded, and existing treatment practices.

--The above estimates result in a profile of system responses and are presented in the form of a decision tree. This decision tree is a principal input to the Water Utilities Policy Testing model (PTm) computer analysis which generates the national costs of the regulation.

- Chapter III, which deals with the economic impacts of the regulations, presents:

  --National costs of the regulation. Based on all of the elements just noted, this section presents estimates of the costs of compliance with the regulation at the national level for all systems affected by the regulation, including customer impacts and energy consumption.

  --Costs for a typical system for each alternative treatment. The additional capital and operating expenses required for each treatment are presented on a per system basis, including the impact on consumers.

  --Costs of the monitoring requirement, including specification of the costs for systems whose THM concentrations fall below the MCL.

  --The changes in national costs since the 1977 THM Economic Impact Report.

  --The availability of the materials and equipment required for adding the necessary treatments.

- Finally, Chapter IV presents the sensitivity analyses of the national costs, illustrating the range of compliance costs possible as a result of this regulation. These analyses were conducted to compare the above costs with costs of:

  --Alternative assumptions of treatment selections (decision trees).

  --Alternative MCLs.

  --Alternative size cut-offs for water systems covered by the regulation.

Finally, this document includes four brief appendices. The first describes the Water Utilities Policy Testing model (PTm) which has been used to develop the national cost estimates. Water quality data from NOMS are presented in Appendix B. The third appendix describes the model used for deriving per system costs for the various treatments as well as the resultant unit cost data. The final appendix includes references to the key documents used in carrying out this analysis.

II. ANALYTIC STRUCTURE AND PROCEDURE

This chapter identifies the basic information which was required and the manner in which it was used to develop the national cost estimates of the proposed THM regulation. A schematic diagram of the analytic procedure is presented in Exhibit II-1 on the following page. Phase I of the analysis deals primarily with estimating the number of systems exceeding and the extent to which they exceed the MCL. The second phase of the analysis considers the available methods of compliance and the associated costs.

PHASE I ANALYSIS

Regulatory Criteria

Naturally occurring organics have become a regulatory concern primarily because of the evidence that chlorine combines with precursor organic matter in water to form chloroform and other related compounds, some of which are suspected carcinogens. The regulation to reduce the level of these contaminants in drinking water contains the following parameters:

- Maximum Contaminant Level (MCL): 0.10 milligrams per liter of total trihalomethanes (THM) (chloroform, bromoform, etc.)

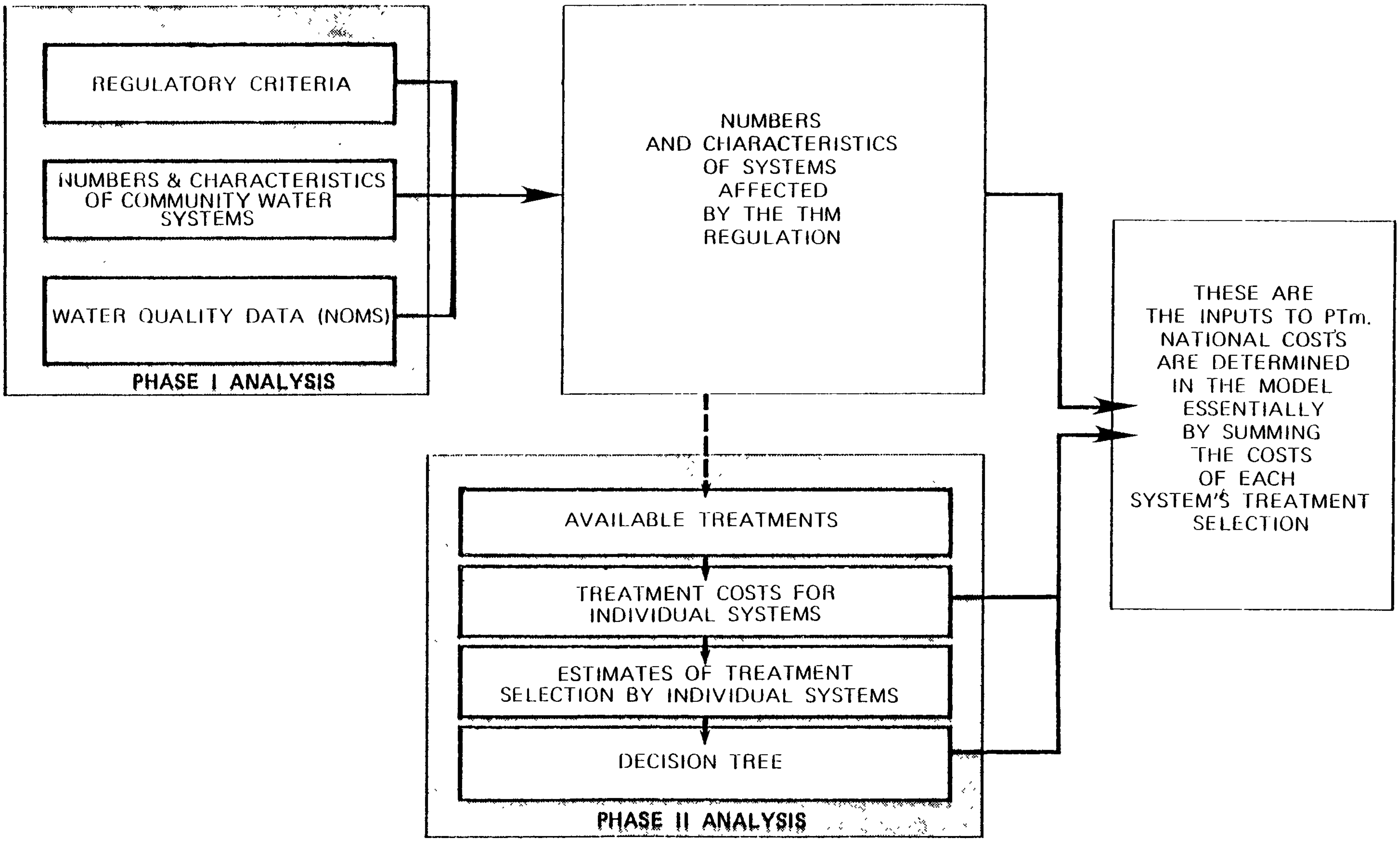
  --applicability: community water systems that add disinfectant to the treatment process.

  --schedule for implementation: systems serving populations greater than 75,000--two years after promulgation; systems serving populations between 10,000 and 75,000--four years after promulgation; and systems serving less than 10,000 people--at state discretion.

- Monitoring requirements: Running annual average of quarterly samples, four samples per quarter taken on same day for surface systems and one sample per quarter for ground systems.

Exhibit II–1

THM REGULATION ECONOMIC IMPACT ANALYSIS PROCEDURE



Numbers and Characteristics of Community Water Systems

This analysis, and the associated THM regulation, encompasses all water systems serving more than 10,000 people. These systems represent 5 percent of the total number of community water systems and serve 79 percent of the total population that receives water from community water systems. To provide a perspective, Exhibit II-2 illustrates the percentage of water systems in each size category and the related portion of the population which they serve.

The systems serving over 10,000 have been subdivided into six size groupings: 10,000 to 25,000; 25,000 to 50,000; 50,000 to 75,000; 75,000 to 100,000; 100,000 to 1 million; and over 1 million. In all, nine size categories were used for estimating national costs under varying assumptions. These size categories permit the cost analysis to reflect such differences among systems as the economies of scale associated with the sizing of equipment for new treatment processes. The economic analysis is, therefore, conducted on the basis of average system characteristics. While economies of scale can be factored in, site-specific costs attributable to unusual or unique circumstances at any particular utility are not reflected in the results. Therefore, lacking site-specific knowledge about exactly which water systems will be affected and what treatments they would use, these size categories allow the best estimation possible.

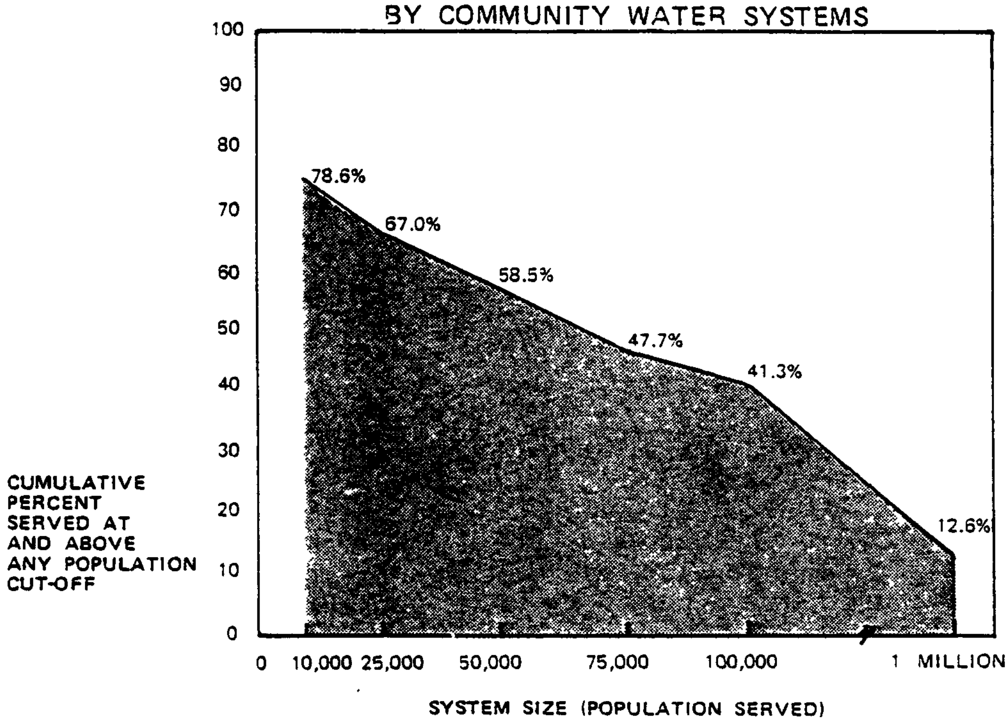
Water Quality Data Analysis

National Organic Monitoring Surveys of organic contaminants in drinking water have been conducted during 1976 and 1977 by EPA's Municipal Environmental Research Laboratory (MERL) and the Office of Water Supply, Technical Support Division Laboratory. The information from those surveys, while not completely representative of the industry, has been used to estimate the type and degree of water supply contamination by organic chemicals across the country. Consequently, these estimates were used to determine the proportion of water systems likely to exceed specified maximum contaminant levels for THM and therefore likely to require additional treatments. Additional detail on the NOMS data is included as Appendix B.

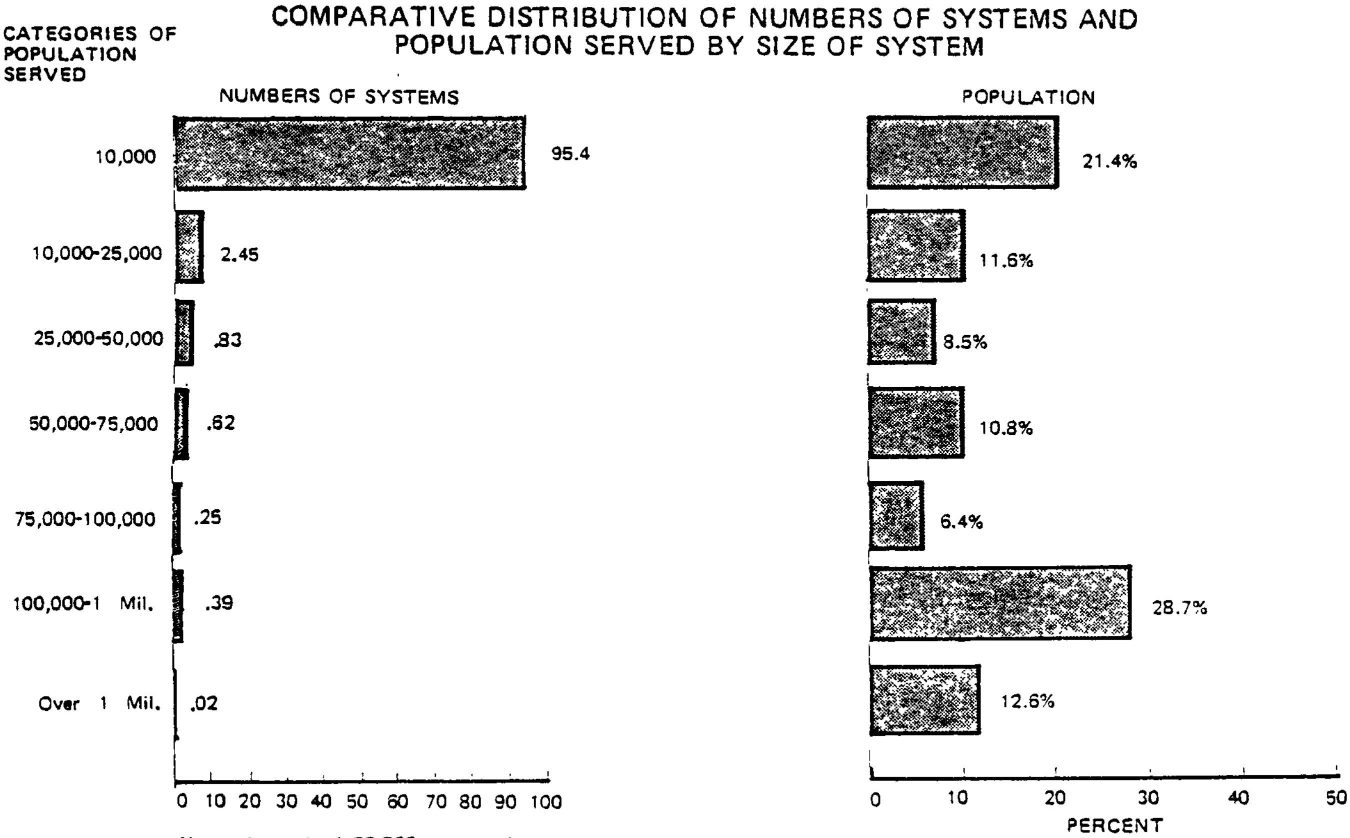
By combining the NOMS database on water quality with the analysis of the number and characteristics of community water systems and the regulatory criteria, the number of systems exceeding the MCL and the extent to which they exceed it was

Exhibit II–2

CUMULATIVE PERCENT OF POPULATION SERVED BY COMMUNITY WATER SYSTEMS



COMPARATIVE DISTRIBUTION OF NUMBERS OF SYSTEMS AND POPULATION SERVED BY SIZE OF SYSTEM



Note: A total of 58,768 community water systems as of 1981 are used as a base for these percentages.

Note: Total population served by community water systems equals 213 million in 1981.

determined. The result, then, was a compilation of the number of systems according to: (1) the water source, (2) the extent to which the MCL is exceeded, and (3) the population category.

The second phase of the analytic procedure, discussed below, relates to the analysis of treatment alternatives and compliance strategies likely to be selected by those systems exceeding the MCL.

PHASE II ANALYSIS

Available Treatment Alternatives

There are three general categories of treatment possibilities. The selection of the appropriate category for a specific water system depends in part upon the magnitude of the system's THM level, the system's existing treatment practices, and the costs associated with the treatment alternative. Systems are expected to select the alternative which is lowest in cost and least disruptive to their current practices, and which will bring them into compliance with the regulation.

The major treatment options which are available to meet a THM regulation are described below:

- The first alternative consists of minor modifications to current procedures. These modifications include moving the point of disinfection, adjusting the chlorine dosage, or improving existing conventional coagulation and sedimentation practices. This approach would enable systems which exceed the MCL only by a small amount to comply at minimal cost.

- The second alternative involves changing disinfectants. Since it is the use of chlorine which causes the formation of THM, some systems may choose to use other chemicals for disinfection. The alternatives considered are: chloramines, ozone, and chlorine dioxide.

- The third alternative, using an adsorbent, is the most complex and costly of the options. Systems with the most serious organic contamination may select treatment techniques which require the use of granular activated carbon (GAC), resins, or an equivalent. This analysis has used the costs of replacing existing filter media with GAC since this technique is the treatment method most likely to be employed in this category. Also included were the costs of biologically activated carbon (BAC), based on ozone in combination with GAC.

Treatment Cost Analysis

Under contract to EPA's MERL, the firm of Culp/Wesner/Culp developed a database for deriving individual system costs for various water treatment processes. Appendix C provides a full set of costs per system derived from the model as well as an example of the model's cost printout. This model, which resulted from the EPA Unit Treatment Cost Report, requires as inputs the design and operating flow rates of both the treatment plant and the process being considered, chemical costs, and operating characteristics such as utilization rates. These characteristics must then be translated into operating and design parameters useful for input to the model, such as pounds of chlorine, square feet of surface area of contactors, etc. In addition, the model requires specification of unit cost factors, capital cost factors, and cost (price) indices. As output, the model yields total costs for construction, capital (which includes construction costs plus fees and contingencies, interest, and land costs), and the components of total annual operation and maintenance expenses. The model employs cost curves with the system capacity and average flows as the primary determining factors. Unique, site-specific considerations are not explicitly accounted for beyond the inclusion of contingency costs.

Given the treatment options available to meet the THM regulation, this model was used to generate unit treatment costs for each option for each of the nine system size categories considered. This procedure was not used in the 1977 THM Economic Impact Report, the model not being available at that time. The cost data from the EPA Unit Treatment Cost Report are a key element in determining whether a given treatment is likely to be used by a utility in meeting the MCL.

Regulatory Compliance Strategies

As previously discussed, water systems which exceed the THM MCL have three major options available to satisfy the regulatory standard--modifying chlorination or other treatment procedures, changing disinfectants, and adding an adsorbent. In order to complete the basis for estimating the total national costs of the regulation, the number of systems likely to select each of the treatment options must be established.

Since there is no empirical method for predetermining the choice which will be made by each water system exceeding the MCL, a more probabilistic and structured approach was necessary. The approach chosen, decision-tree analysis, is a step-by-step procedure which can be tracked easily and modified as new information becomes available. A logical sequence of decision points was designed to distribute the systems covered by the regulation according to the most likely path they would follow. The decision made at each point is consistent with certain criteria. The criteria are based upon:

- The treatments currently used: if a system does not use a disinfectant it will not be affected by a THM regulation and therefore will require no changes in its current treatment practices;

- Water source used: if a system uses surface water as its primary source, it is more likely to exceed a given level of THM contamination. Hence, the number of water systems using water from ground or surface sources affects the number of systems which will exceed a given level and therefore require treatment;

- Degree to which water quality exceeds MCL: if the presence of THM is only slightly in excess of the standard, then minimal modifications to existing treatment procedures will be adequate for compliance. As the level of contamination increases, a system must consider more significant (and costly) modification of its existing treatment techniques;

- Economic considerations: the presumption is that systems will adopt the least cost treatment strategy which satisfies the regulation;

- Treatment effectiveness: the presence of THM above certain levels can probably be controlled only by the use of adsorbents. This is because of the likelihood that water with a high disinfectant demand cannot be adequately disinfected without generating a considerable amount of byproducts of unknown risks. Consequently, those few systems with a very high level of THM are likely to require the addition of the most costly treatment.

The estimates presented below are the results of considering these criteria. The primary participants in the evaluation were:

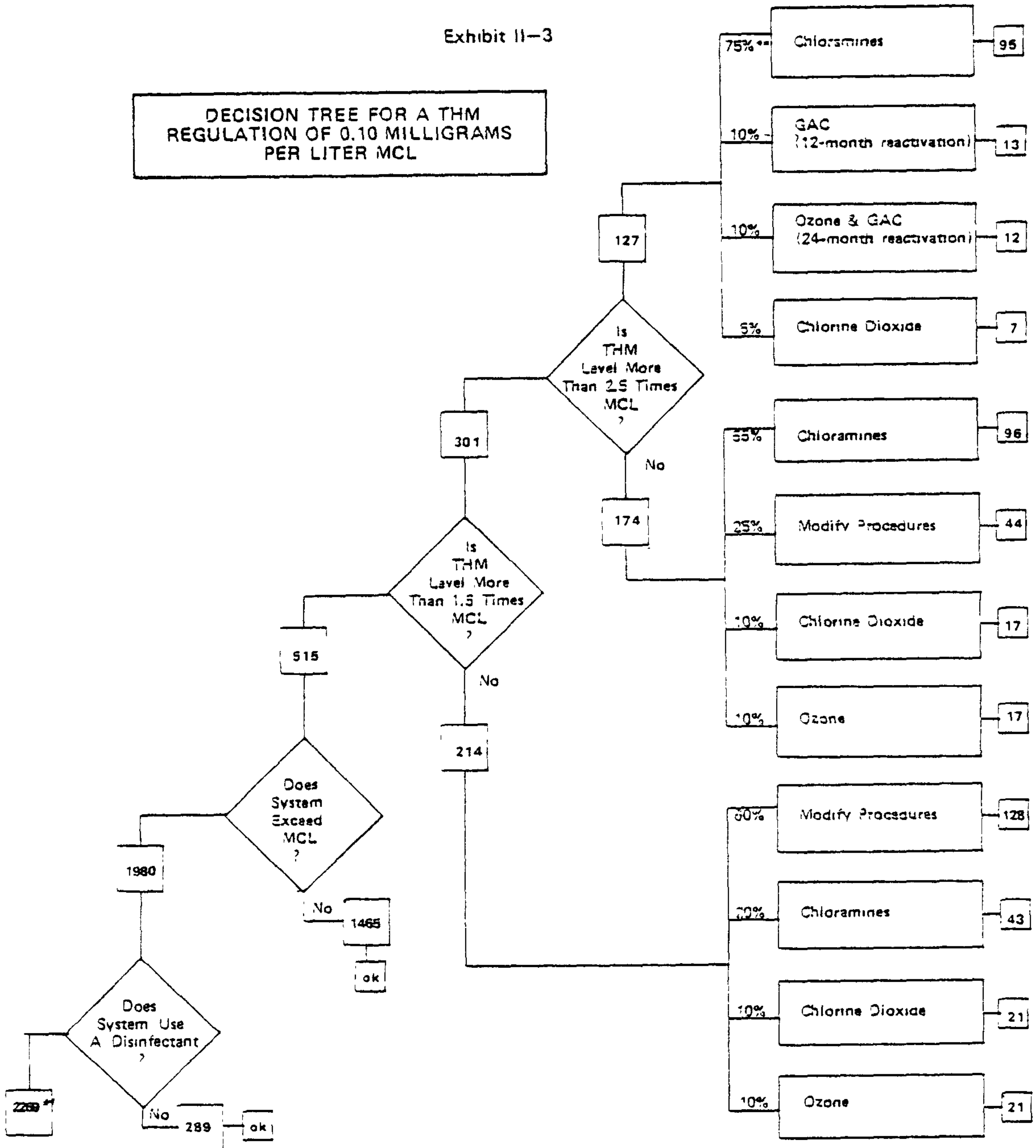
- The technical staff of EPA-MERL,
- EPA Office of Drinking Water (ODW) staff, and
- TBS staff.

The decision tree, shown in Exhibit II-3, illustrates the paths expected to be followed for compliance with the MCL at 0.10 milligrams per liter by each of the water systems which serve more than 10,000 people. Of the 2,685 community water systems that serve more than 10,000 people, 416 purchase the majority of their water from other systems that are presumed to provide treatment. Thus, a total of 2,269 systems would be initially affected, although 289 of these are excluded because they do not presently use a disinfectant. Of the remaining 1,980, some 515 systems are estimated to have THM levels above 0.10 milligrams per liter and hence would require changes in their treatment processes.

In general, of the systems estimated to be in the range of 1 to 1.5 times the MCL, 60 percent are expected to modify their existing disinfection procedures and 40 percent are expected to change disinfectants. Of the systems with THM levels in the range of 1.5 to 2.5 times the MCL, 25 percent are expected to change their disinfection procedures with 75 percent switching to a different disinfectant. Finally, of the systems exceeding 2.5 times the MCL, 80 percent are anticipated to change disinfectants and the remaining 20 percent will use an adsorbent. The results of these treatment selections are that 318 systems would change disinfectants and 25 would use adsorbents as a compliance strategy. The remaining systems of the original 515 would modify their existing disinfection procedures to achieve compliance with the regulation. Also, as Table II-1 shows, approximately 28.7 million people are served by the systems which would be likely to exceed the standard prior to any corrective measures.

Exhibit II-3

DECISION TREE FOR A THM REGULATION OF 0.10 MILLIGRAMS PER LITER MCL



*Represents the total number of systems serving over 10,000 people (2,685) minus those systems which purchase their water (416).

**Percentage of systems selecting a particular treatment option.

Source: EPA—MERL, EPA—ODW, and TBS.

Number contained in each box indicates the number of systems determined as likely to be on each path of the decision tree.

Table II-1

MOST PROBABLE TREATMENT SELECTION BY WATER SYSTEMS AFFECTED BY MCL REGULATION OF THM AT 0.10 MILLIGRAMS PER LITER

	Move Point of Disinfection and/or Adjust Dosage	Change Disinfectant	Use Adsorbent	Total
Number of Systems	172	318	25	515
Percent of Total Affected	33	62	5	100
Population Affected (millions)	12.1	14.9	1.7	28.7

Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

MODELING APPROACH

The two key intermediate outputs of the analytic procedure--the number and characteristics of the systems exceeding the MCL and the estimate of the particular compliance strategies selected by each--become the principal inputs to the PTm, which calculates the national economic impacts of the regulation. Simply described, the PTm first determines the number of systems which would select each new treatment as a result of the regulation being examined and then applies the relevant treatment costs. The model determines the financial impact of those additional costs on the utility's overall operating statements for a specified future year. A comparison of these new financial statements with the baseline reports yields an estimate of the economic impact of the regulation.

These computations require a complete recalculation of the financial flows of funds that take place in a water utility during a full year. A major element of these calculations centers on capital items. The model projects capital expenditures financing through a combination of available internal sources and external sources, which include both debt and equity at prevailing rates of return. The revenues required in a given future year by a system requiring a new treatment consist of the baseline revenues (those for normal operations) plus operating and maintenance costs for the new treatment plus the annualized costs (capital costs plus depreciation) of the capital expenditures for the new treatment.

Per capita costs have been calculated by dividing the additional revenues required for a given treatment (excluding the baseline revenues for normal operations) by the total resident population served. This method of assuming all costs would be passed along to residential customers tends to state per capita costs at their maximum level since a portion of the costs would normally be billed to commercial, industrial, and wholesale customers also served by the utility. However, the increased costs of goods and services produced by non-residential customers may, in some cases, be passed along to the residential population.

Residential bill impacts of the proposed regulation have been estimated to provide a closer approximation of the actual cost to be incurred by an average family. The additional required revenues are allocated both to residential customers and to non-residential classes of customers. That proportion of revenues presently received from non-residential customers varies from 50 percent of revenue requirements in the over-one-million-population-served category to 35 percent in the 10,000-to-25,000-population-served category. This proportion tends to decline as the size of the system decreases due to the declining number and size of commercial, industrial, and wholesale customers of those smaller systems. Monitoring costs are not included in either the residential bill or per capita cost calculations.

From the use of PTm, national and typical system cost estimates were developed for a 0.10 milligram per liter MCL regulation for THM. These data, along with energy impacts, supplier impacts, and sensitivity analyses are presented in the following chapters of this report.

III. THE ECONOMIC IMPACT OF THE REGULATION

This chapter presents the economic impacts of the THM regulation. The cost estimates are first discussed in terms of the national costs for all systems requiring treatment and, second, in terms of the costs to individual systems. Changes in the analysis and resulting cost impacts since the 1977 THM Economic Impact Report are also presented. Monitoring costs are then discussed separately since these will be incurred by water systems whether or not they exceed the MCL for THM. Estimates of the demand on supplying industries constitute the final section of the chapter.

NATIONAL COST ESTIMATES

The economic implications of a THM regulation at 0.10 milligrams per liter, covering community water systems serving 10,000 people or more, are summarized below in terms of six key measures:

- Capital expenditure requirements during the period are projected to be $85 million (1980 dollars).
- Annual operating and maintenance (O&M) expenses for the required treatments and for monitoring are estimated at approximately $10 million.
- Annual revenue requirements, reflecting the amortization of capital expenditures and the O&M expenses, are expected to increase by a total of $19 million for the 343 systems which are likely to have cost impacts.
- Per capita costs, in terms of total revenue impacts divided by the population served by systems with cost impacts, are projected to be $0.70 per year, ranging from $.00 to $6.20 per year.
- The average residential customer bill increase is projected to be $1.40 per year. This represents a range of $.00 to $12.00 per year.

- The projected annual energy (electrical, diesel, and natural gas) consumption as a result of this regulation is 510 billion BTUs or 0.0007 percent of the 1977 total U.S. energy consumption (76.3 quadrillion BTUs). Total annual energy costs in 1980 dollars are projected to be $2.3 million.

As Table III-1 indicates, over 54 percent of the aggregate costs of this regulation is expected to be borne by systems serving 75,000 people or more.

Table III-1

SUMMARY OF TOTAL COSTS FOR AN MCL REGULATION OF THM AT 0.10 MILLIGRAMS PER LITER

(millions of 1980 dollars)

	Systems Serving Populations of:		
	> 75,000	10,000-75,000	Total
Number of Systems Exceeding MCL	95 out of 390	420 out of 2,295	515 out of 2,685
National Costs			
Capital Expenditures	$ 45.6	$ 39.8	$ 85.4
Operating & Maintenance Expenses	$ 5.4	$ 4.6	$ 10.0
Consumer Charges			
Revenue Requirements	$ 10.1	$ 8.6	$ 18.7
Annual Per Capita Cost ($/year)	$ 0.60	$ 0.90	$ 0.70
Residential Bill Increase ($/year)	$ 1.20	$ 1.80	$ 1.40
Range of Residential Bill Increase ($/year)	$0-8.90	$0-12.00	$0-12.00

Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

These cost figures include the expenses of the 515 systems adding or altering treatment practices plus monitoring costs for all systems using a disinfectant. Table III-2 breaks down these costs into those attributable to each treatment category. Approximately 53 percent of the total capital cost is attributable to the 25 systems adding adsorbents, though these systems represent only 5 percent of the number affected by the regulation.

Table III-3 presents a comparison of the revised national cost estimates with those outlined in the 1977 THM Economic Impact Report.

Table III-2

SUMMARY OF COSTS BY TREATMENT CATEGORY
FOR AN MCL REGULATION OF THM
AT 0.10 MILLIGRAMS PER LITER

(millions of 1980 dollars)

	# Systems	Capital Expenditures	Annual O & M Expense*
Change Disinfectant	318	$40.3	$ 7.1
Use Adsorbent	25	45.1	1.8
No Cost Changes	172	0.0	0.0
Total	515	$85.4	$ 8.9

*Does not include monitoring costs.
Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

Table III-3

ECONOMIC IMPACT OF AN MCL REGULATION OF
THM AT 0.10 MILLIGRAMS PER LITER:
COMPARISON WITH THE 1977 THM ECONOMIC IMPACT REPORT*

(millions of dollars)

	Results from 1977 THM Report		Current Estimate
	(1976 dollars)	(1980 dollars)***	(1980 dollars)
Coverge According to Population Served	> 75,000	> 75,000	> 10,000
Number of Systems			
Covered	390	390	2,685
Impacted (exceed MCL)	86	86	515
Cost Impacted**	65	65	343
National Costs			
Capital Expenditures	$154.4	$209.8	$ 85.4
O&M Expenses	$ 25.9	$ 35.2	$ 10.0
Revenue Requirements	$ 36.0	$ 48.9	$ 18.7
Consumer Charges			
Average Cost Per Capita ($/year)	$ 2.10	$ 2.80	$ 0.70
Residential Bill Increase ($/year)	$ 3.70	$ 5.00	$ 1.40

*TBS report "Economic Impact Analysis of a Trihalomethane Regulation for Drinking Water" for EPA, August 1977.

**Cost impacted refers to those systems requiring different treatments--not just modification to existing procedures or monitoring.

***Inflated using the producer price index where 1976=1732 and 1980=2353.

Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

As is evident from Table III-3, a number of the analytic inputs used to derive the national cost estimates have been altered since the preparation of the 1977 THM Economic Impact Report. These include:

- Lowering the population cut-off from 75,000 to 10,000 people served.
- Changes in the decision tree which resulted in a smaller percentage of systems choosing an adsorbent to comply with the MCL. Table III-4 provides a summary of the number of systems choosing each treatment alternative, for both the present report and the 1977 THM Economic Impact Report.
- Changes in the assumptions regarding the use of adsorbents. In comparison to the previous TBS study, longer regeneration cycles were assumed as well as replacement of sand in conventional filters with carbon rather than post-filtration contactors.
- Changes in the individual system treatment costs. The 1979 estimates are derived from the EPA Unit Treatment Cost Report.
- The Survey of Community Water Systems (see reference in Appendix D) database was updated and reevaluated, resulting in a larger number of surface systems which use chlorine for disinfection.

Table III-4

NUMBER OF SYSTEMS CHOOSING EACH TREATMENT FOR AN MCL REGULATION OF 0.10 MILLIGRAMS PER LITER: COMPARISON WITH 1977 THM ECONOMIC IMPACT REPORT

	Treatments				
	Chloramines	Chlorine Dioxide	Ozone	GAC	GAC Plus Ozone
1977 Report Systems Serving Over 75,000 People	9	21	9	26	--
1979 Report Systems Serving Over 75,000 People	43	8	7	2	2
1979 Report Systems Serving Over 10,000 People	234	45	39	13	12

Source: Estimates based on inputs from EPA-MERL, EPA-OOW, and TBS.

- Update of the monetary basis of the analysis from 1976 dollars to 1980 dollars.

A more detailed summary of the treatment costs for an individual system in three of the six size categories over 10,000 people appears on the following page. A full description of individual system treatment costs is provided in Appendix C.

COSTS TO AN INDIVIDUAL SYSTEM

The costs for the five types of treatments--ozonation, chlorine dioxide, chlorination/ammoniation, GAC, and GAC plus ozone (commonly referred to as BAC)--can best be compared on the basis of additional per capita costs for an individual water system. They are as follows:

- Ozonation (plus residual disinfectant) is the most capital intensive of the three alternate disinfectant treatments. Systems serving over one million people would need capital expenditures of about $7.2 million each. Annual per capita costs range from $1.40 to $3.00.

- Chlorine dioxide treatment requires only minor investment but cosiderable expense for the purchase of sodium chlorite. Per capita costs range from $0.60 to $1.20 per year.

- Chlorination/ammoniation is the least expensive treatment with annual per capita costs in the $0.20 to $0.30 range.

- Adding GAC as an adsorbent involves substantial capital expenditures (approximately $21 million for a typical system serving over one million people) as well as continuing operating expenses for reactivation. Per capita costs range from $2.40 to $3.70.

- The use of BAC results in per capita costs ranging from $3.20 to $6.20. BAC is the most capital intensive treatment with capital expenditures of $27 million for a typical system serving over one million people.

The capital expenditures, annual rèvènue requirements, and per capita costs are shown in Table III-5 for each treatment above and for each of three size categories over 10,000 (of the six size categories employed in the analysis). It is clear that the range of costs is broad across treatments and size categories. The use of an adsorbent (GAC or BAC) is considerably more expensive than any of the alternative disinfectants for all

Table III-5

COMPLIANCE COSTS FOR A TYPICAL WATER SYSTEM UNDER AN MCL REGULATION OF THM AT 0.10 MILLIGRAMS PER LITER

(1980 dollars)

	10,000-25,000	75,000-100,000	Over 1 Million
Average Population Served Per System	17,000	93,000	1,223,000
Ozone			
Capital Expenditures	$ 341,000	$ 1,471,000	$ 7,161,000
Revenue Requirements/Year	51,000	210,000	1,672,000
Annual Per Capita Cost	3.00	2.30	1.40
Chlorine Dioxide			
Capital Expenditures	$ 30,000	$ 38,000	$ 362,000
Revenue Requirements/Year	20,000	60,000	717,000
Annual Per Capita Cost	1.20	0.70	0.60
Chlorination/Ammoniation			
Capital Expenditures	$ 12,000	$ 22,000	$ 61,000
Revenue Requirements/Year	6,000	21,000	259,000
Annual Per Capita Cost	0.30	0.20	0.20
GAC			
Capital Expenditures	$ 435,000	$ 1,733,000	$21,063,000
Revenue Requirements/Year	64,000	266,000	2,902,000
Annual Per Capita Cost	3.70	2.90	2.40
GAC and Ozone (BAC)			
Capital Expenditures	$ 760,000	$ 3,141,000	$27,259,000
Revenue Requirements/Year	106,000	424,000	3,883,000
Annual Per Capita Cost	6.20	4.50	3.20

Source: Derived using a computer model based on EPA's Unit Treatment Cost Report with inputs provided by TBS in conjunction with Culp/Wesner/Culp and MERL staff members.

size categories.[1] Among the disinfectants, chlorine plus ammonia is always the least expensive. As discussed in Chapter II, the number of systems selecting each treatment and the system treatment costs represent the primary inputs into the analysis of the total national cost of the THM regulation.

MONITORING COSTS

In addition to the treatment costs which the 515 impacted water systems serving over 10,000 will incur, there are specific monitoring requirements included in the regulation. The costs associated with those requirements are included in the national cost estimates presented earlier in this chapter. All systems serving over 10,000 people and which use a disinfectant will be required to monitor for the presence of THM.

Sampling frequencies required by the regulation vary according to water source. Water systems drawing some or all of their water from surface sources will monitor at a minimum frequency of four samples per quarter taken on the same day. Systems with only groundwater sources which do not have high levels of total organic carbon (TOC) may reduce the frequency to one sample per quarter. Following the first year of monitoring, those systems not exceeding the MCL may reduce the monitoring frequency at their State's discretion.

Since monitoring may be carried out on a plant-by-plant basis, some utilities may sample more extensively than indicated above. However, it is not possible to make an accurate estimate of the exact number of samples. Hence the costs presented reflect costs to be incurred by single plant utilities.

The annual national monitoring costs for the 2,396 systems serving over 10,000 which do not use a disinfectant amount to about $1.1 million.[2] This estimate is based on a $50 per sample cost, assuming four samples per quarter for surface systems

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[1]However, the use of an adsorbent has the ancillary benefit of generally reducing the level of other organic chemicals in addition to THM. Its use may also result in reduced disinfectant demand.

[2]These 2,396 systems are those which remain after subtracting from 2,685 the 289 systems which do not use a disinfectant.

and one sample per quarter for groundwater systems. This amounts to annual costs of $800 and $200 respectively. Monitoring costs were computed based upon a survey of contract analytical laboratories currently performing THM analyses.[3] Per sample costs ranged from $25 to $100. After these regulations have been promulgated, the increased volume of business and competitive factors would be expected to reduce the analytical costs to well below $50 per sample. Therefore, the cost of monitoring can be expected to decline over time.

Although the monitoring costs are based on the use of commercial laboratories, EPA expects that a number of community water systems will choose to purchase the equipment and monitor for THM on-site more frequently than the minimum, for operational control as well as for compliance purposes. However, no capital costs are included in the national cost estimates for such laboratory equipment. An additional benefit from the on-site analytical capability is that the necessary equipment, which includes a gas chromatograph, is versatile and can be used to monitor for the presence of many other organic chemical contaminants besides THM.

SUMMARY OF DEMAND ON SUPPLYING INDUSTRIES

Aside from the costs of adding treatments to comply with the organics regulations, EPA has also considered the level of demand which would be placed upon industries supplying the required materials and equipment. The six areas examined include:

- Energy,
- Granular activated carbon,
- Regeneration furnaces,
- Chlorine dioxide,
- Ozonators, and
- Aqua ammonia.

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[3] The cost of equipping an existing laboratory with an appropriate gas chromatograph is dependent upon which analytical procedure is selected and the type of instrument. The basic (footnote continued on next page)

In general, the conclusion is that under the regulation, given the expected distribution of systems using each treatment, no significant problems exist at the present time for satisfying the demand in any of the areas listed above. With the exception of chlorine dioxide, an industry in which rapid expansion is possible, the estimated demands are well within the capacity of the industries providing the materials.

It should be noted, however, that these demand projections are based upon the needs of those systems assumed to be out of compliance. Demand could be somewhat higher under at least two conditions: (1) systems which do not exceed the MCL nevertheless decide to add a treatment which will reduce their THM levels, and (2) systems which do exceed the MCL add more treatment capacity to reduce THM levels considerably below the MCL. If both conditions occurred, the demand projections would be understated.

Energy

The regulation will have a negligible impact on annual U.S. energy consumption. The total annual energy requirements of the various treatment alternatives selected by utilities to meet the regulation are as follows: electric power, 40 million kilowatt-hours; diesel fuel, 64,000 gallons; and natural gas, 76 million cubic feet. In 1980 dollars these total annual energy requirements are estimated to cost $2.3 million per year. The annual electric power demand of 40 million kilowatt-hours is approximately 0.002 percent of 1977 total domestic electric power sales. The annual diesel fuel demand represents 0.00002 percent of the 1977 total domestic demand for refined oil products. At 76 million cubic feet, the annual natural gas demand represents less than 0.004 percent of the 1977 domestic natural gas demand. Together these energy requirements represent 0.0007 percent of total 1977 U.S. energy consumption, or 510 billion BTUs out of a total of 76 quadrillion BTUs. When

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(continued from previous page)
instrumentation for the "liquid-liquid" extraction method consists of a gas chromatograph with an "Electron Capture" detector and recorder; the basic cost is approximately $5,000 to $10,000. The basic instrumentation for the "purge and trap" method consists of a gas chromatograph, a "Hall" detector, purge and trap sample concentrator, and recorder; the basic cost ranges from $10,000 to $20,000. In either case, some additional expenditures for accessories would be added.

compared to estimates of 1980 energy consumption of 80 quadrillion BTUs, the portion of total consumption attributable to the THM regulation decreases to 0.0006 percent.

Approximately 87 percent of the electric power demand is due to ozone disinfection processes. GAC treatment and ozonation together represent 96 percent of the total electric power demand.

The diesel fuel and natural gas requirements are created by the GAC regeneration process. For those water utilities without on-site GAC regeneration, transport of GAC to a regional processing site will require diesel fuel. The regeneration process itself requires either oil or natural gas as an energy source. In preparing these energy demand estimates, it was assumed that only natural gas would be used in GAC regeneration furnaces.

Granular Activated Carbon

A THM regulation will result in some systems treating their water with adsorbents. The estimated demand for the initial fill of GAC would be 3.7 million pounds for the 25 systems expected to use adsorbents to comply with the regulation. This level of demand, along with the demand generated by the annual replacement of carbon (0.2 million pounds per year) lost in reactivation cycles, could easily be met by the carbon industry. Current available excess capacity in the GAC industry is over 100 million pounds per year.

Regeneration Furnaces

A THM regulation at 0.10 milligrams per liter would create a total demand of 8 to 26 regeneration furnaces for those systems employing adsorbents. The limits of this range should be viewed as the minimum and maximum since many of the smaller systems will share ownership and many of the larger systems, particularly those serving over one million persons, often have more than one treatment plant. At these larger sizes it is more economical to purchase a furnace at each plant rather than to transport large volumes of carbon to a central furnace location. Even if the upper limit estimate of 26 furnaces were increased substantially, the furnace industry could supply an adequate number of furnaces.[4] The furnace industry's current excess capacity exceeds 100 custom-designed furnaces per year.

Chlorine Dioxide

The use of chlorine dioxide treatment rather than chlorination to meet a THM regulation could create an annual demand for over four million pounds of sodium chlorite. Excess industry capacity of at least three to four million pounds presently exists. The industry claims rapid capacity expansion is possible if required by additional demand.

Ozonators

A second alternative to chlorination as a disinfection process is ozonation. Such a treatment will require the purchase of an ozonating system to produce the needed ozone with electrical energy. Since approximately 52 water systems are expected to use the ozone disinfection process, and since some large systems with more than one treatment plant would purchase several ozonating systems, the number of ozonating systems required will be higher than 52. Although ozonator demand is larger than projected in the 1977 THM Economic Impact Report, production capacity constraints are not likely to affect implementation of the regulation.

Aqua Ammonia

A third alternative method of disinfection is the use of aqua ammonia in combination with chlorine. The use of this treatment to meet the THM standard could create an annual demand of over seven million pounds (3,500 tons) of aqua ammonia. Given the 1976 domestic consumption of aqua ammonia of 659,000 tons, this demand level is minimal and creates no constraint to compliance.

The following table summarizes the estimated demand for the major equipment and materials likely to be needed by water systems exceeding the MCL.

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[4] A two-year lead time is generally required for the design, construction, and start-up of custom regeneration furnaces.

Table III-6

MATERIALS REQUIREMENTS FOR PROPOSED THM REGULATION

	Energy		Adsorbent			Chlorine Dioxide		Ozonators		Aqua Ammonia	
Regulation	Number of Systems Affected	Energy Demand in Billions of BTUs[1]	Number of Systems Affected	GAC Demand in Million Lbs.--Initial Fill[2]	Minimum Demand for Furnaces[3]	Number of Systems Affected	Annual Demand for $NaClO_2$ in Million Lbs.[4]	Number of Systems Affected	Minimum Number of Ozonators[5]	Number of Systems Affected	Annual Demand for Ammonia in Million Lbs.[6]
THM @ 0.10 Milligrams Per Liter	515	510	25	3.7	8-26	45	4.34	52	52	234	7.14

[1] Energy demand is drawn from individual system estimates and translated into BTUS using the following conversion factors: (a) electricity--10,500 BTU/KWH; (b) diesel fuel--138,700 BTU/gallon; and (c) natural gas--1,050 BTU/cubic foot.

[2] GAC demand based on nine-minute contact time and shared regeneration where practical.

[3] This is the range of furnace demand based on the number of systems that would require furnaces. Systems with multiple plants would require multiple furnaces.

[4] $NaClO_2$ demand based on dosage of 1.5 milligrams per liter of ClO_2.

[5] Each system will use one or more ozonators, with only the largest systems requiring more than one.

[6] Ammonia demand based on 9.5 pounds per million gallons treated.

Source: Estimates drawn from outputs of the model of EPA's Unit Treatment Cost Report.

IV. SENSITIVITY ANALYSES

There are several variables in the economic analysis which, if changed, produce significant differences in the results. The following section summarizes the effect of:

- Varying the mix of treatments which systems would be expected to select,
- Changing the MCL to a higher or lower THM level, and
- Including system size boundaries above and below 10,000 people in the regulation.

ALTERNATIVE DISTRIBUTION OF TREATMENT SELECTION

The analysis of economic impacts of the THM regulation has assumed a specific set of treatment choices for systems exceeding the MCL, as outlined in Chapter II. If the same systems were to choose a different mix of treatments, the level of total costs would change. Total national costs are especially sensitive to the number of systems using an adsorbent. If only one additional system chose BAC to comply with the regulation and that system served over one million people, total national costs would increase by approximately $27 million or 32 percent. Since the behavior of systems is uncertain, an example of the costs for a different mix has been presented below, along with the costs of the most likely mix of treatments.

As indicated above, the major factor determining the total economic impact of a change in treatment mix is the percentage of systems which would use adsorbents instead of changing disinfectants. In the example given in Table IV-1, the number of systems using adsorbents has been increased from 5 percent of the systems which exceed the MCL to 30 percent. The projected economic impacts of the regulation change accordingly: annual revenue requirements increase from $18.7 million to $43.8 million, a 134 percent increase. Capital expenditures display a similar sensitivity to the assumed mix of compliance treatment strategies; they increase by 219 percent to $272.7 million.

Table IV-1

SENSITIVITY OF COSTS TO MIX OF COMPLYING TREATMENTS FOR AN MCL OF THM AT 0.10 MILLIGRAMS PER LITER

(millions of 1980 dollars)

	Best Estimate	Higher Use of Adsorbent (GAC)*
Number of Systems		
Exceeding the MCL	515	515
Installing Adsorbents	25	153
National Costs		
Capital Expenditures	$ 85.4	$272.7
O&M Expenses	$ 10.0	$ 16.3
Revenue Requirements	$ 18.7	$ 43.8
Consumer Charges		
Average Cost Per Capita ($/year)	$ .70	$ 1.80
Residential Bill Increase ($/year)	$ 1.40	$ 3.30

*No change in the number of systems choosing BAC was assumed.

Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

ALTERNATIVE MCLs

The maximum contaminant level of THM at 0.10 milligrams per liter was selected on the basis of the protection it would afford through a considerable reduction of THM in water consumed by a large proportion of the population. This protection could be achieved while minimizing the negative effect on the microbiological quality of the water. Two alternative MCLs were examined in order to illustrate the sensitivity of total costs to a change in the MCL. One case represents a somewhat more stringent MCL of THM at 0.05 milligrams per liter. The second case represents a less stringent MCL of THM at 0.15 milligrams per liter.

Given a mix of treatment selections, the most important variable in determining the economic impact of these alternative MCLs is the number of systems exceeding those levels. In the first case of THM at 0.05 milligrams per liter, 35 percent--or 944--of the systems serving over 10,000 people would exceed that level. In the second case (THM at 0.15 milligrams per liter), only 11 percent--or 301 systems--would exceed that MCL.

The treatment options and their associated costs are assumed to be the same as those used in estimating the national costs for an MCL at 0.10 milligrams per liter. However, the mix of treatments varies for the 0.05 milligram per liter case in that more systems would select adsorbents to comply with the more stringent MCL. The decision criteria for selecting a particular treatment in the 0.15 milligram per liter case are the same as those assumed for the MCL at 0.10 milligrams per liter.

Table IV-2 below compares the total costs of these alternative MCLs to the cost for the MCL at 0.10 milligrams per liter. The impact in terms of capital expenditures is projected to be $314.8 million for the 0.05 milligram per liter level and $45.0 million for the 0.15 milligram per liter level versus the projections presented earlier of $85.4 million for a 0.10 milligram per liter regulation. The other aggregate impacts, such as annual operating and maintenance expenses and annual revenue requirements, vary similarly.

Table IV-2

SUMMARY OF TOTAL COSTS UNDER ALTERNATIVE MCLs FOR THM
(millions of 1980 dollars)

	MCL (milligrams per liter)		
	0.05	0.10	0.15
Number of Systems Exceeding the MCL	944	515	301
Capital Expenditures	$314.8	$85.4	$45.0
O&M Expenses	$ 22.0	$10.0	$ 6.0
Revenue Requirements	$ 53.8	$18.7	$10.6
Residential Rate Increase ($/year)	$ 2.30	$1.40	$1.40

Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

Table IV-3 summarizes the number of systems estimated to select each treatment alternative under three MCLs: 0.05, 0.10, and 0.15 milligrams per liter. In the 0.05 milligram per liter case, it is estimated that the largest portion (48 percent) of the 944 systems will elect to change disinfectants. At the 0.15 milligram per liter MCL, approximately 59 percent would elect to change disinfectants.

Table IV-3

SUMMARY OF TREATMENT SELECTIONS
BY SYSTEMS EXCEEDING ALTERNATIVE MCLs FOR THM

	THM @ .05 mg/l	THM @ .10 mg/l	THM @ .15 mg/l
Treatment Category	# Systems	# Systems	# Systems
Change Disinfectant	453	318	179
Use Adsorbent	153	25	12
Modify Procedures	338	172	110
Total	944	515	301

Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

ALTERNATIVE SYSTEM SIZES INCLUDED IN REGULATORY COVERAGE

The final example of cost sensitivity is the analysis of extending the coverage of a THM regulation to systems smaller than those serving 10,000 people. This section presents a summary of the number of systems exceeding the MCL and the related costs for four alternative system size boundaries in addition to the population cut-off in the regulation: (1) all community water systems serving over 1,000 people; (2) those serving over 10,000 (the regulation); (3) those serving over 50,000; (4) those serving over 75,000; and (5) those serving over 100,000.

This portion of the analysis assumes an MCL for THM at 0.10 milligrams per liter and determines the impacts under the five alternative size limitations indicated above. The number of systems which exceed the MCL increases substantially as the population cut-off is lowered. If the lower boundary were reduced to 1,000 people, more than three times as many systems would be out of compliance with the 0.10 milligrams per liter level of THM.

As shown in Table IV-4, the aggregated economic impacts would not increase substantially if the boundary were lowered to 1,000. In the case of those systems serving under 10,000 persons, the severity of the impact is at the individual system level, rather than at the national level. Capital expenditures, for example, would increase from $85.4 million with a 10,000 population cut-off to $131.4 million with a cut-off at 1,000. Annual revenue requirements would increase similarly from $19 million with a 10,000 cut-off to $28 million with a cut-off at 1,000 people.

Table IV-4

COSTS OF ALTERNATIVE SIZE LIMITATIONS
FOR AN MCL OF THM AT 0.10 MILLIGRAMS PER LITER

(millions of 1980 dollars)

	Population Served				
	Serving > 1,000	Serving > 10,000	Serving > 50,000	Serving > 75,000	Serving > 100,000
Number of Systems Exceeding the MCL	1,653	515	165	95	63
Capital Expenditures	$131.4	$85.4	$58.1	$45.6	$37.7
O&M Expenses	$ 14.8	$10.0	$ 6.7	$ 5.4	$ 4.6
Revenue Requirements	$ 27.9	$18.7	$12.7	$10.1	$ 8.5
Residential Rate Increase ($/year)	$ 2.90	$1.40	$1.20	$1.20	$ 1.10

Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

Appendix A

WATER UTILITIES POLICY TESTING MODEL

The Water Utilities Policy Testing model (PTm) was the primary computational tool used to estimate the national costs of compliance with the proposed THM regulation. Computations were performed by integrating the "building blocks" summarized in Chapter II. The following sections of this appendix describe the objectives of the model design, outline the general model structure, and list some of the key inputs used in the model.

MODEL DESIGN OBJECTIVES

PTm was developed for evaluating the economic and financial impact on community water systems of various proposed regulations under the Safe Drinking Water Act. Given the need for testing alternative treatments and costs and various assumptions about the industry, the model was designed to provide maximum flexibility and rapid turnaround for policy analysis. The specific model characteristics which are important in meeting this need include the following:

- All results can be available at the regional level (EPA regions) as well as at the national level;

- Separate projections are produced for the nine different sizes of water systems (population served) defined in the "Survey of Operating and Financial Characteristics of Community Water Systems," performed by TBS for EPA (hereafter referred to as the Survey of Community Water Systems);

- Added projections are available to provide more detail on systems serving between 10,000 and 100,000 people;

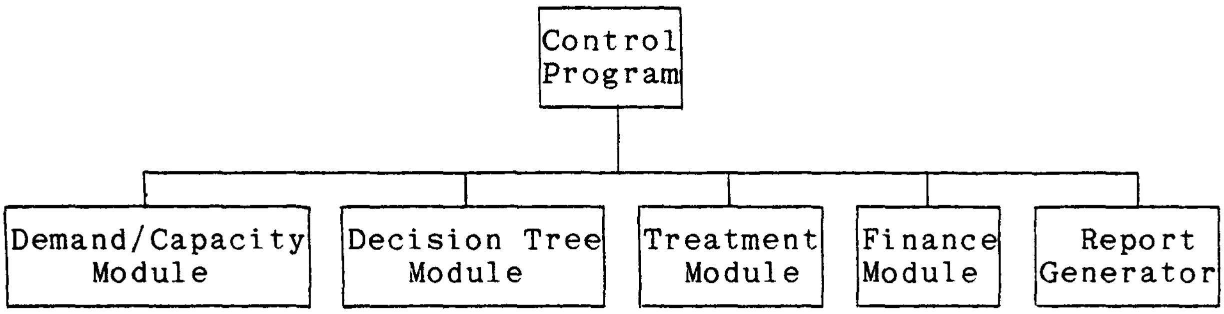
- Financial and other results are reported separately for public and private system ownership;

- Cost analyses are performed separately by system water source (ground, surface, and purchased); and

- Results are obtainable in aggregate for the nation or a region and also for a representative system of a given type (e.g., a privately owned system in EPA Region V serving a population of between 25 and 100 people).

MODEL STRUCTURE

The program elements in the superstructure of PTm are shown in the following diagram:



Each module has its own input files with each data item identified by a phrase in English. This feature greatly facilitates updating and assumption modification for sensitivity analyses. The input requirements and function of each of the above model components are described below.

- Control Program. This model component accepts as input a control file where the user has specified the parameters for the scope of the analyses (e.g., regions, system ownership, system size, and current or constant dollars). The Control Program executes the specified modules with the desired inputs.

- Demand/Capacity Module. Given the initial population, number of systems, production, and production capacity, this module calculates future demand, the necessary additions to production capacity, and the timing of those additions. Required inputs include growth rates for population and the number of systems in each size category, and the sources of future additions (surface, ground, and purchased water sources).

- Decision Tree Module. The strategy which any individual water system will select for compliance with a regulation depends upon many factors: the water source used, treatments currently in place, water quality, economic considerations, and treatment effectiveness. The various combinations of these factors are displayed in the form of a decision tree (a sample of which is included in Chapter II). The identification of the appropriate compliance strategy or strategies at the end of each pathway through the tree is determined exogenously, based upon engineering and other professional judgments. This program module accepts the specification of the decision tree as input and computes the total number of water systems which would, according to the decision tree, select each specific method of compliance.

- Treatment Module. Using the results of the Decision Tree Module, the Treatment Module projects capital expenditures and operating and maintenance expenses required to fund the compliance strategies for the regulation under analysis. Input variables include timing of compliance and costs per unit of capacity and production for each potential treatment or nontreatment option.

- Finance Module. Using the results of the previous modules, the Finance Module projects all the financial information necessary to generate pro forma income statements, balance sheets, and sources and uses of funds statements. Input variables include initial values for the balance sheet accounts and income statement line items, sources for capital addition, tax rates, inflation rates, depreciation rates, and rates of return on capital. Building "from the bottom up," the module determines the required operating revenues and the corresponding consumer charges necessary to cover operating expenses and returns to capital.

- Report Generator. The Report Generator makes available the full power of PTm to the user by providing the results of the model in detailed and concise reports. The following reports are available for specified sets of years, and for system sizes, system ownerships, and regions which the user selects:

--Summary Report

--Income Statement

--Balance Sheet

--Sources and Uses of Funds Report

--Demand Report

--Capacity Report

--Treatment Report (number of systems selecting each treatment)

--Treatment Capital Expenditure Report

--Treatment Operating and Maintenance Expenses Report

An example of a Summary Report is included as Exhibit A-1 at the end of this appendix.

KEY INPUTS

An important component of the model is the set of basic inputs used in the calculations. These are the result of integrating:

- Information from the TBS Survey of Operating and Financial Characteristics of Community Water Systems (EPA-570/9-77-003, April 1977);
- Data compiled by the National Association of Water Companies in their annual publications, Financial Summary for Investor-Owned Water Utilities and Financial & Operating Data;
- Information published by Moody's Investor Service, Inc.;
- Information contained in EBASCO Business Consulting Company's Analysis of Public Utility Financing;
- Experience gained through consultation with water industry personnel;

- Information obtained in interviews with members of the banking and investment community; and

- Professional judgment.

Some of the major inputs are summarized below.

Size and Scope of the Water Utility Industry

The baseline projections forecast a specific number of water systems existing in each of the nine size categories in the year 1979. The number of systems was derived from the Federal Reporting Data System and from the Survey of Community Water Systems conducted in 1976. These numbers appear on the summary printout in Exhibit A-1, along with the average production per capita per day and the average number of people served per system.

The average population served by a water system ranges from 52 in the smallest category to 2.4 million in the largest category. Production is the second measure of system size varying from over 200 gallons per capita per day for systems serving over one million people to 110 gallons per capita per day for those serving under 100 people.

Industry Growth

It is forecast that the industry will experience modest growth over the 1979-1981 forecast period. The anticipated growth in water production, ranging from 0 to 22 percent annually for the various system sizes, is the result of two assumptions: (1) continued growth in population and the number of customers and (2) a small annual increase in per capita water consumption.

Financing

The financing of capital items has an important effect on the industry's ability to assimilate any major new requirements for capital expenditures. In projecting capital requirements, PTm calculates the internal flow of funds with any remaining fund needs to be obtained from external sources.

The projections in this analysis indicate that approximately 47 percent of the funds for normal (baseline) capital expenditures in the 1979-1981 period will come from internal sources. The model projects, however, that additional capital expenditures to meet new regulations will have to come exclusively from external sources because the internal sources will be exhausted in baseline uses.

When external financing is required, it is assumed that it will be obtained in the proportions that have prevailed for the past five years. For private systems, the proportions are as follows: a range of 90 percent long-term debt for the smaller private systems to 77 percent long-term debt for the larger private systems, with the remainder in the form of common stock or other equity capital. Public systems are assumed to use long-term debt as the sole source of external financing for treatment expenditures. Other assumptions with respect to financing include the following:

- Long-Term Debt Interest Rates. The embedded rate for existing debt is 4 percent for public systems and ranges from 4.5 percent to 6.6 percent for private systems. The interest rate on new debt is assumed to be 7 to 8 percent for publicly owned systems and 9 to 10 percent for privately owned systems. Although present rates are slightly higher, the above interest rates are those expected to prevail during the period of compliance.

- Return on Equity. The rate of return on common equity for investor-owned systems is 2 percent for the smaller size categories and 8 to 10 percent for the larger size categories. Also, the general operating surplus for publicly owned systems is expressed in the model as a return on other capital. This return on other capital averages between 2 and 3 percent.

Industry Structure

The overall structure of the industry--the proportion of publicly owned and investor-owned systems and the mix of primary water sources--has been maintained throughout the forecast period. The current projections do not assume a trend toward regionalization of water systems or any other major changes in industry structure which are potential results of compliance with the THM regulation.

Exhibit A-1

1981
REGION 11
TOTAL OWNERSHIP
CONSTANT DOLLARS

DATA FOR ALL SYSTEMS
(MILLIONS OF DOLLARS)

FINANCIAL MODEL OF COMMUNITY WATER SYSTEMS
TEMPLE, BARKER AND SLOANE

SUMMARY REPORT

	25-99	100-499	500-999	1000-	2500-	5000-	10,000-	100,000-	> 1 MIL	TOTAL
NO. OF SYSTEMS	21585.0	17668.0	5903.0	6050.0	2809.0	2068.0	2442.0	232.0	11.0	58768.0
AVG. PRODUCTION (000 GD)	5.6	25.9	78.5	217.9	532.7	1026.5	5532.1	50557.5	514449.5	627.5
CAPITAL EXPENDITURES (CUM.)										
FOR TREATMENT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
OTHER	49.6	141.7	173.0	447.7	479.7	600.5	2510.4	1523.2	463.0	6388.9
SOURCES OF FUNDS										
TOTAL SOURCES (CUM.)	64.3	199.8	227.9	556.7	620.8	739.1	3283.7	2046.7	623.2	8362.1
EXTERNAL SOURCES (CUM.)	33.2	102.6	132.7	369.5	382.8	485.0	1658.9	965.7	344.6	4474.9
OPERATING REVENUES AND EXPENSES										
TOTAL OPERATING REVENUES	63.6	173.1	161.9	364.5	399.6	465.3	3111.2	2057.9	687.5	7484.6
O/M COSTS FOR TREATMENT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
CONSUMER CHARGES(CENTS/1000 GALS.)										
---RESIDENTIAL	64.7	100.4	144.7	93.5	81.9	72.5	85.4	75.9	48.4	79.0
---REQUIRED, ALL CUSTOMERS	166.4	119.0	110.0	91.3	82.2	72.3	73.4	54.0	36.6	63.5
CONSUMER CHARGES($/CAPITA/YEAR)										
---RESIDENTIAL	20.7	26.7	31.1	25.9	21.7	21.5	22.8	16.7	11.3	19.8
---REQUIRED, ALL CUSTOMERS	58.9	40.4	38.5	36.2	37.4	32.3	38.9	33.6	25.5	35.2

Appendix B

WATER QUALITY DATA

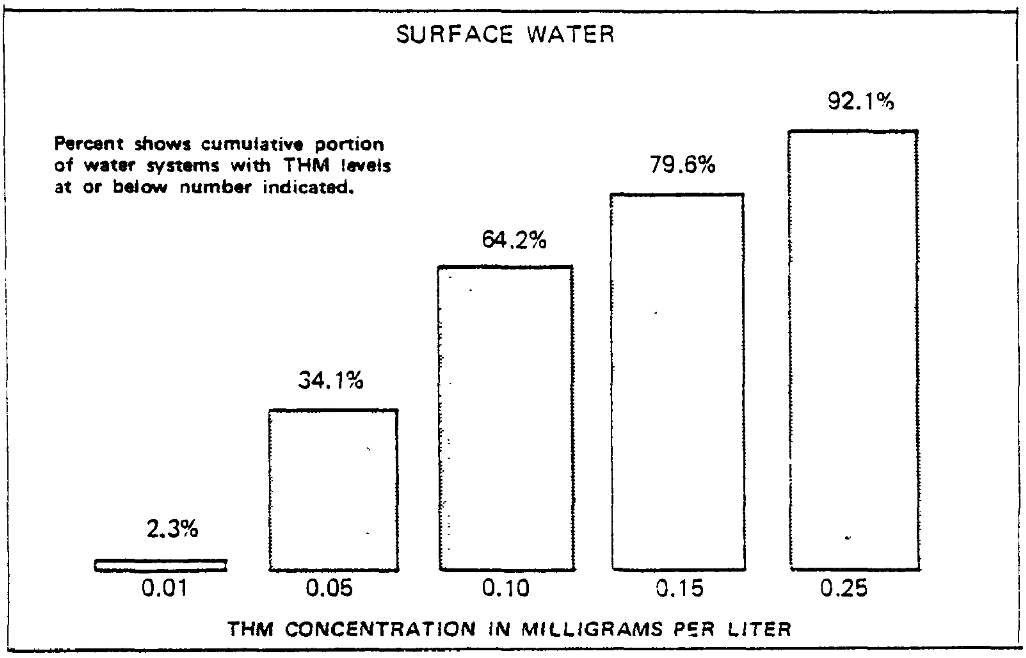
A major element in calculating the cost of a regulation is the determination of the number of water utilities which will have to add to or alter their treatment practices to comply with the regulatory standard. Data from the National Organic Monitoring Surveys (NOMS) have been used in this analysis for determining the number of and extent to which systems exceed a given MCL. These surveys were conducted by EPA's Office of Water Supply, Technical Support Division, and the Municipal Environmental Research Laboratory. The results yielded data on a broad range of known and suspected organic contaminants in drinking water, including THMs.

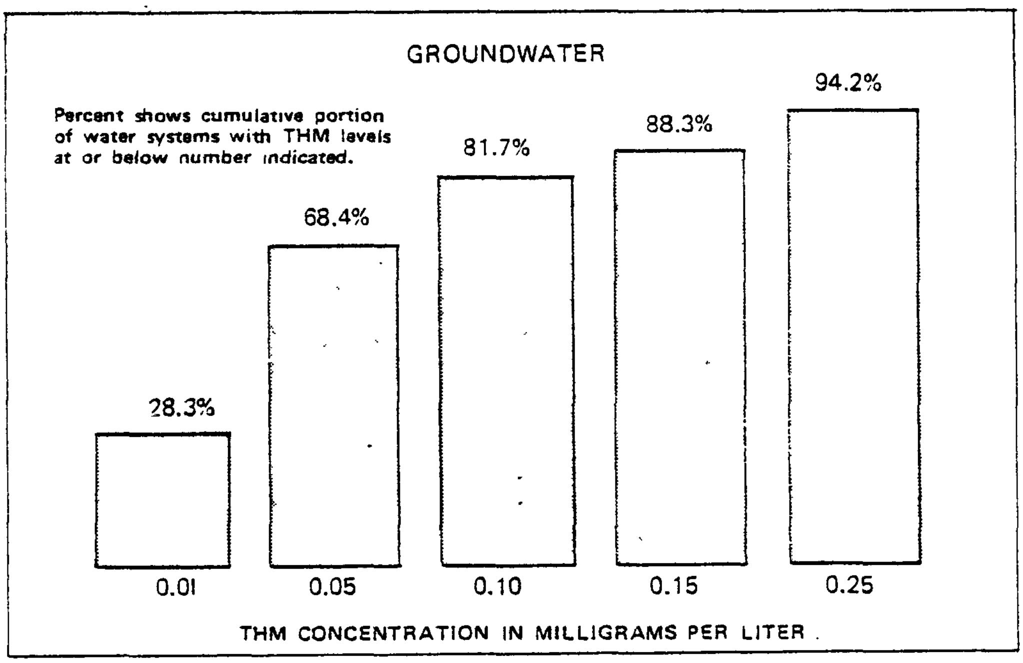
The data for the various rounds of NOMS at each site were averaged for use in this analysis. The combination provides a proxy for the annual average data likely to be found by water systems complying with the monitoring requirements of a regulation. The first exhibit shows this combined data in detail. For example, on that basis, 64.2 percent of the surface water systems and 81.7 percent of the groundwater systems showed THM levels of less than 0.10 milligrams per liter.

The combined data were analyzed to estimate the number of systems exceeding certain levels of THM contamination. The second exhibit in this chapter displays the number of systems in several system size categories which are estimated to exceed the THM level of 0.10 milligrams per liter. Of the 515 larger systems also exceeding this level, 420 are in the 10,000 to 75,000 size category and 95 serve more than 75,000 people.

Exhibit B-1

THM CONCENTRATION BASED ON NOMS DATA





SOURCE: THE NATIONAL ORGANIC MONITORING SURVEY PROVIDED BY EPA-MERL.

Exhibit B-2

DISTRIBUTION OF WATER SYSTEMS BY WATER SOURCE, DISINFECTION PRACTICE, AND THM LEVEL[1]

System Size by Population Served	All Systems				Systems Which Use a Disinfectant			Systems Which Disinfect and Have THM Levels > 0.10 Milligrams Per Liter		
	S	G	P[2]	Total	S	G	Total	S	G	Total
Over 1 million	10	1	0	11	10	1	11	4	0	4
100,000-1 million	135	66	31	232	134	60	194	48	11	59
75,000-100,000	59	59	29	147	59	59	118	21	11	32
10,000-75,000	666	1,273	356	2,295	612	1,045	1,657	219	201	420
1,000-10,000	2,181	7,313	1,433	10,927	2,138	4,865	7,003	765	934	1,699
Total Over 10,000	870	1,399	416	2,685	815	1,165	1,980	292	223	515

[1]Figures include anticipated treatment changes due to the Interim Primary Drinking Water Regulations and growth in the number of systems which serve fewer than 10,000 people.

[2]Water sold wholesale is assumed to have been treated by its seller. Hence systems which purchase the majority of their water would not require additional treatment. P = more than 50 percent of the water distributed by the system is purchased. Similarly, S = > 50 percent is surface water, and G = > 50 percent groundwater.

Source: Estimates based on inputs from EPA-MERL, EPA-ODW, and TBS.

Appendix C

INDIVIDUAL SYSTEM TREATMENT COSTS

The unit treatment costs used in this analysis were derived from a computer model containing the data presented in an EPA publication entitled "Estimating Costs for Water Treatment as a Function of Size and Treatment Plant Efficiency" (EPA-600/2-78-182). This document, written by the consulting firm of Culp/Wesner/Culp, provides detailed cost data for most major drinking water treatment processes. The costs for five treatments are shown in Exhibit C-1.

The model itself requires the specification of plant design and operating flows, treatment design and operating flows, factor costs, fees, and cost indices. The model outputs yield total capital costs before and after fees are added, total operation and maintenance costs, and costs per thousand gallons for both capital and O & M. A sample output is presented in Exhibit C-2 for the chlorine/ammoniation treatment for a system serving 100,000 to 1 million people.

To determine the necessary model inputs, meetings were held with staff members from EPA-MERL, EPA-ODW, C/W/C, and TBS. Based on these discussions, the individual system costs presented in Table C-1 were derived for the nine system sizes serving populations greater than 1,000 and five treatments (only the six sizes representing systems serving more than 10,000 people are presented).

The following represent the primary technical assumptions used in deriving these costs: (a) chlorine/ammoniation dose at 4 milligrams per liter; (b) chlorine dioxide doses at 1.5 milligrams per liter; (c) ozone dose at 2 milligrams per liter with a five-minute detention time; (d) GAC with a nine-minute empty bed contact time, conversion of existing filter beds, 360-day regeneration cycle, and multiple hearth regeneration furnaces with some of the smaller systems using regional regeneration facilities; and (e) GAC plus ozone which combines the assumptions for GAC and ozone with the exception that a 720-day regeneration cycle is used.

Exhibit C-1

COSTS FOR A TYPICAL WATER SYSTEM
FOR SELECTED TREATMENTS

(1980 dollars)

	10,000-25,000	25,000-50,000	50,000-75,000	75,000-100,000	100,000-1 Million	Over 1 Million
Average Population Served Per System	17,000	37,000	63,000	93,000	264,000	1,223,000
Ozone						
Capital Expenditures	$341,000	$ 625,000	$1,080,000	$1,471,000	$2,729,000	$ 7,161,000
Annual O & M Expense	17,000	27,000	44,000	60,000	148,000	943,000
Annual Per Capita Cost	3.00	2.40	2.40	2.30	1.60	1.40
Chlorine Dioxide						
Capital Expenditures	$ 30,000	$ 31,000	$ 34,000	$ 38,000	$ 76,000	$ 362,000
Annual O & M Expense	17,000	26,000	41,000	56,000	148,000	680,000
Annual Per Capita Cost	1.20	0.80	0.70	0.70	0.60	0.60
Chlorination/Ammoniation						
Capital Expenditures	$ 12,000	$ 15,000	$ 19,000	$ 22,000	$ 31,000	$ 61,000
Annual O & M Expense	4,000	8,000	13,000	18,000	51,000	253,000
Annual Per Capita Cost	0.30	0.20	0.20	0.20	0.20	0.20
GAC						
Capital Expenditures	$435,000	$ 760,000	$1,264,000	$1,733,000	$5,240,000	$21,063,000
Annual O & M Expense	20,000	36,000	63,000	90,000	269,000	756,000
Annual Per Capita Cost	3.70	3.10	3.00	2.90	3.00	2.40
GAC and Ozone (BAC)						
Capital Expenditures	$760,000	$1,357,000	$2,299,000	$3,141,000	$7,753,000	$27,259,000
Annual O & M Expense	29,000	48,000	79,000	104,000	307,000	1,107,000
Annual Per Capita Cost	6.20	5.00	5.00	4.50	4.20	3.20

Source: Derived using EPA's computer model of unit treatment costs (described in EPA's Unit Treatment Cost Report) with inputs from EPA-MERL, EPA-ODW, C/W/C, and TBS.

Exhibit C-2

COST SUMMARY FOR 1 WATER TREATMENT PROCESS

PROCESS	FLOW MGD DESIGN	FLOW MGD ACTUAL	PROCESS PARAMETER DESIGN	PROCESS PARAMETER OPERATING	COSTS DOLLARS CONSTR	COSTS DOLLARS CAPITAL	COSTS CTS/1000 GAL O&M	COSTS CTS/1000 GAL DEBT	COSTS CTS/1000 GAL TOTAL
1 AQUA AMMONIA FEED FACILITY $ 236.00/TON FOR AMMONIA	75.600	50.350	504.4 LB/DAY	335.9 LB/DAY	18737.	30940.	0.278	0.017	0.295
				TOTAL	18737.	30940.	0.278	0.017	0.295

SITEWORK,SUBSURFACE,STNDY POWER	4684.
GEN CON OH & P, 12.0%	2811.
ENGINEERING	3148.
LAND, 0.00 ACRES	0.
LEGAL,FISCAL,ADMIN	1319.
INT DURING CONSTR	242.
TOTAL CAPITAL	30940.

TOTAL O&M:	KWH	MATERIALS,$	LABOR,HR	DIESEL,GAL	NAT GAS,CU FT	CHEMICALS,$
	570.	140.	152.	0.	0.	49109.

COSTS PRESENTED ARE CURRENT AS OF 1980

CAPITAL COST FACTORS

ENGINEERING(%)	12.00
SITEWORK,INTERFACE PIPING(%)	15.00
SUBSURFACE CONSIDERATIONS(%)	10.00
STANDBY POWER(%)	0.00
INTEREST RATE(%)	8.00
NUMBER OF YEARS	20.00
LAND AREA, ACRES	0.00
LAND COST, $/ACRE	2000.00

UNIT COST FACTORS

ELECTRICITY, $/KWH	0.04
LABOR, $/HR	11.75
DIESEL FUEL, $/GAL	0.840
NATURAL GAS, $/CU FT	0.0038
BLDNG ENERGY USE,KWH/SQ FT/YR	102.6

COST INDEXES

EXCAVATION (ENR SKILLED LABOR)	290.2
MANUFACTURED EQUIP (BLS #114)	257.1
CONCRETE (BLS #132)	267.1
STEEL (BLS #101.3)	324.2
LABOR(ENR SKILLED LABOR)	290.2
PIPES & VALVES (BLS #114.901)	292.4
ELECTRICAL & INSTR (BLS #117)	194.6
HOUSING (ENR BUILDING COST)	301.1
PRODUCER PRICE INDEX	235.3

Appendix D

REFERENCES

Further documentation of previous efforts related to this economic analysis of the THM regulation can be found in the references listed below.

1. "Economic Impact Analysis of a Trihalomethane Regulation for Drinking Water," August 1977, U.S. EPA Office of Water Supply.

2. "Estimating Costs for Water Treatment as a Function of Size and Treatment Plant Efficiency," August 1978, EPA-600/2-78-182.

3. "Policy Testing Model for Water Utilities--Final Report" (submitted to U.S. EPA Office of Water Supply), August 1976, Temple, Barker & Sloane, Inc.

4. "Survey of Operating and Financial Characteristics of Community Water Systems," April 1977, U.S. EPA Office of Water Supply, EPA-570/9-77-003.

5. "Interim Treatment Guide for the Control of Chloroform and Other Trihalomethanes," June 1976, EPA-MERL, Water Supply Research Division.

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