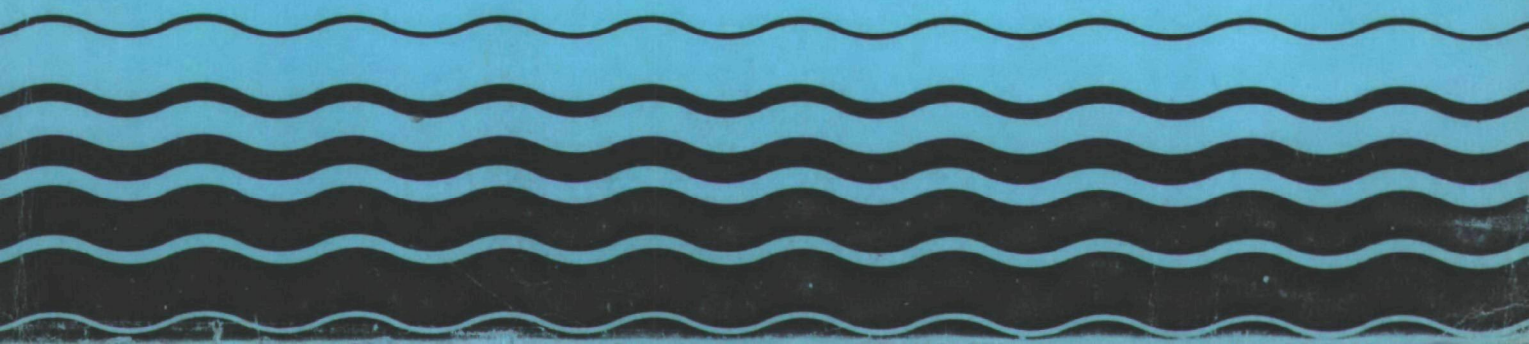


Water



Economic Impact Analysis of Proposed Regulations to Control Volatile Synthetic Organic Chemicals (VOCs) in Drinking Water



**ECONOMIC IMPACT ANALYSIS
OF
PROPOSED REGULATIONS TO CONTROL VOLATILE
SYNTHETIC ORGANIC CHEMICALS (VOCs)
IN DRINKING WATER**

OCTOBER 1985

**U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF DRINKING WATER (WH-550)
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ERRATA

Shortly before completion of this report, new information on the health effects of tetrachloroethylene (PERC) was provided to the Agency. This information requires the Agency to repropose the Recommended Maximum Contaminant Level for PERC. This economic analysis describes impacts associated with PERC as estimated before receipt of the new information. While PERC is a commonly found contaminant, it was not found to contribute significantly to the cost of the proposed regulations. Based on the new information, this finding will be reevaluated during preparation of the PERC MCL rule.

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1. SUMMARY OF RESULTS

1.1 Introduction

This document has been prepared to provide information on the economic costs and benefits associated with regulatory alternatives, as required by Executive Order 12291. It considers alternatives required to be examined by the Executive Order. However, some of the alternatives arguably may not be allowed under the Safe Drinking Water Act.

The resultant analysis is not the basis for decision-making on drinking water regulations, but it does provide useful information to assist the Administrator in understanding the impacts of the alternatives. The basis for the regulatory proposal is discussed in the preamble, and comes directly from the Safe Drinking Water Act. Specifically, the MCL is to be as close to the Recommended MCL (health goal) as is feasible. Feasibility involves determination of what technologies are available to provide for compliance with the regulation, as well as examination of the ability to routinely determine the level of contaminants in water. Costs are considered when examining feasibility. These costs were found to be reasonable for treatment technologies and analytical methods used for the volatile organic contaminants proposed for regulation.

The proposed maximum contaminant levels (MCLs) are:

Trichloroethylene	5 ug/l	Benzene	5 ug/l
Carbon Tetrachloride	5 ug/l	1,1-Dichloroethylene	7 ug/l
1,2-Dichloroethane	5 ug/l	1,1,1-Trichloroethane	200 ug/l
Vinyl Chloride	1 ug/l	p-Dichlorobenzene	750 ug/l

Of the regulatory alternatives we examined, the one which is most similar to the proposal above would control each constituent to 5 ug/l. The costs the nation would pay to meet that alternative are \$21 million/year and the benefits of the alternative are 32 cases of cancer avoided each year.

The report which follows describes the manner in which these and other estimates of regulatory impact were reached. It depends heavily on estimates of contamination occurrence, removal technology cost and health effects which are discussed each in their own background documents.

The data on contamination occurrence are contained in reports prepared by EPA in 1983 and 1984 under the general title, Occurrence of VOCs in Drinking Water, Food, and Air. There is a separate report for each contaminant. Information on removal technology is contained in EPA, Technologies and Costs for the Removal of Volatile Organic Chemicals from Potable Water Supplies. Information on health effects are contained in Drinking Water Criteria Documents prepared by EPA. There is a separate document for each contaminant.

1.2 Problem Definition

As many as 29 volatile organic chemicals (VOCs) have been evaluated through various EPA studies. Some of these have been dropped from consideration for regulation due to the inadequacy of available data on health effects. In a number of instances, the risks posed by the chemical were determined to be non-existent because the chemical was not actually found in drinking water. Nine VOCs currently are being considered for regulation. These nine chemicals are trichloroethylene, tetrachloroethylene, carbon tetrachloride, 1,1,1-trichloroethane, 1,1-dichloroethylene, 1,2-dichloroethane, benzene, vinyl chloride, and para-dichlorobenzene. One or more of these compounds occur in 12 percent of the community water systems of the United States, typically at low concentrations.

Some VOCs are thought to be carcinogenic, some are known carcinogens, and all are toxic (see Exhibit 1-1). They enter the body from drinking water through one of three routes, either by ingestion, inhalation, or dermal absorption. Ingestion and inhalation are estimated to be responsible for approximately 50 cases of cancer per year in the United States (see page IV-2). Dermal absorption might add to this, although the magnitude of cancer cases from VOCs absorbed through the skin is unknown.

Both surface and groundwater supplies are vulnerable to VOC contamination. The source of the contamination is likely to be improper disposal of industrial waste materials.

The role of government in VOC contamination problems can be viewed in terms of the inability of the market to adequately account for and respond to contamination problems in drinking water supply. These "imperfections" in the market are due to: a) a poorly developed economic demand for health risk reduction, and b) monopoly conditions in the supply of water. The demand for removing VOCs is poorly developed because knowledge of the occurrence of VOCs is far from complete. In addition, health risks are poorly understood. Although the public is intensely concerned about involuntary exposure to carcinogens, the trade-offs between costs of VOC removal and reduced health risk due to VOC removal are unclear.

Some states such as Florida and New Jersey have already moved to promulgate standards on certain VOCs. Others, such as California, New York, Pennsylvania, and Missouri have established action levels or guidelines for removal of VOCs. In the absence of federal regulations, states are approaching VOC control on a case-by-case basis. Not all states have VOC programs, however. This unevenness in state programs and the resulting unevenness to the protection of the public health highlights the need for federal standards on VOCs. Under the Safe Drinking Water Act (SDWA), EPA is mandated to develop National Primary Drinking Water Regulations.

EXHIBIT 1-1

SUMMARY OF HEALTH EFFECTS OF VOLATILE ORGANIC COMPOUNDS

HEALTH EFFECT	trichloroethylene	tetrachloroethylene	1,1,1-trichloroethane	carbon tetrachloride	benzene	p-dichlorobenzene	vinyl chloride	1,2-dichloroethane	1,1-dichloroethylene
Cancer	I	II	III	I	I	III	I	I	I
o quality of evidence	I	II	III	I	I	III	I	I	I
Toxic Effects									
o liver	o	o	o	o	o	o	o	o	o
o kidney	o	o	o	o	o	o	o	o	o
o central nervous system	o	o	o	o	o	o	o	o	o
o heart	o	o	o	o	o	o	o	o	o
o cardiovascular system	o	o	o	o	o	o	o	o	o
o gastrointestinal system	o	o	o	o	o	o	o	o	o
o adrenal system	o	o	o	o	o	o	o	o	o
o pulmonary system	o	o	o	o	o	o	o	o	o
o circulatory system/blood	o	o	o	o	o	o	o	o	o
o immunity	o	o	o	o	o	o	o	o	o
o other	o	o	o	o	o	o	o	o	o

* I=known or probably carcinogen; II=possible; III=non-carcinogen or insufficient data

o Indicates that the VOC in the column is associated with the health effect in the row

In general, the states prefer EPA to set standards for VOCs. The health advisories developed by EPA over the past five years are depended upon heavily by the states as is the guidance provided on treatment techniques. Many states believe, however, that setting standards on VOCs is something EPA is better equipped to do and is a proper role for EPA in the federal-state partnership.

At the local utility level, public pressure or the potential for public pressure has led many utilities to take immediate actions to address incidents of VOC contamination. The public is sensitized to the threat posed by chemicals in drinking water as a result of media coverage of hazardous waste disposal stories.

The treatment technologies that have been demonstrated to be effective for VOC removal are some form of activated carbon adsorption or aeration. Packed tower aeration, slat tray aeration, and other variations have been used by some systems to remove VOCs.

Many communities would opt for nontreatment alternatives if faced with VOC contamination. Nontreatment alternatives often considered by water utilities include the following:

- o Wellfield management -- shutting down of contaminated wells and increasing production from other existing wells.
- o Source protection -- monitoring of surface sources of water and identifying polluters if contamination is detected, thereby pressuring dischargers of VOCs to cease pollution of water supplies.
- o Regionalization -- interconnection with a nearby system's uncontaminated supply.
- o Alternative source -- developing a new source to replace the contaminated source.

1.3 Alternatives for EPA Actions

There are three basic alternatives that EPA can choose to limit human exposure to VOCs:

- o Take no further action (other than disseminating existing health advisories) and let states and utilities continue to deal with VOC problems.
- o Require monitoring and reporting of VOC concentrations (coupled with existing health advisories), on the premise that improved information will lead to efficient state and utility actions.

- o Set maximum contaminant levels (MCLs) on the premise that the difference in actions taken from state to state under the other alternatives will not adequately protect the public health. This will result from the fact that some communities and states will not act without EPA pressure and because some communities and states may overreact and invest excessively in VOC removal. MCLs are preceded by setting of recommended MCLs and are accompanied by monitoring and reporting requirements.

Under the Safe Drinking Water Act, EPA must establish recommended maximum contaminant levels for each contaminant which may have any adverse effect on the health of persons. These recommended MCLs must be set at a level at which no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety. EPA is required to issue maximum contaminant levels as close to the recommended maximum contaminant level as is feasible using the best technology, treatment techniques, and other means, taking costs into account. EPA published proposed recommended MCLs in the Federal Register on June 12, 1984.

1.4 Benefit Assessment

To assess the degree of health benefits from regulation of VOCs, it is necessary to estimate the number of cancer cases avoided per year at various MCLs. This analysis has estimated the number of cancer cases avoided for various alternative MCLs including MCLs that are equivalent to 10^{-5} and 10^{-6} risk levels. (Under the Safe Drinking Water Act, a risk-based approach to setting MCLs is not permitted. However, Executive Order 12291 requires consideration of regulatory alternatives that are outside of current legislative authority. Thus MCLs equivalent to 10^{-5} and 10^{-6} risk levels were studied as a part of the development of this Economic Impact Analysis.)

Results show that a total of 49 cases of cancer would be avoided per year if MCLs for all of the VOCs studied were set equal to the analytical limit of detection achievable in the best research labs (0.5 ug/l for most of the VOCs, but 1.0 ug/l for vinyl chloride). For MCLs above the analytical limit of detection, high and low estimates of cancer cases avoided were developed. MCLs of 1.0 ug/l for all VOCs produce estimates of the number of cancer cases avoided annually ranging from 38-42. MCLs of 5.0 ug/l for all VOCs produce estimates in a range of 27-32. MCLs higher than these result in progressively fewer cancer cases avoided per year.

MCLs equivalent to 10^{-5} and 10^{-6} individual lifetime risk levels also were evaluated under Executive Order 12291. The 10^{-6} MCLs are approximately equivalent to 1.0 ug/l and the 10^{-5} MCLs are roughly equivalent to 5.0 ug/l (See Exhibit 2-3). Thus, the total number of cancer cases avoided by these two alternatives are similar to those achieved by MCLs of 1.0 and 5.0 ug/l, respectively. The actual estimates of the number

of cancer cases avoided per year are 38-42 for a 10^{-6} risk level and 26-32 for a 10^{-5} risk level.

These cancer risks would not necessarily be evenly spread throughout the population. Within any population, some groups of people are more susceptible to cancer from VOCs than are others.

Although economists have tried to infer dollar values for health risk avoided, it is difficult to put a dollar value on a cancer case avoided. Economists have suggested values of life ranging from \$300,000 to \$7,000,000. Such values may facilitate policy analysis, but it should be recognized that most people do not consciously put any dollar values on their own lives.

1.5 Cost Assessment

Executive Order 12291 requires that "major rules" proposed by federal government agencies be reviewed by the Office of Management and Budget (OMB). There are three tests for a rule being considered "major": annual national cost, major cost increases, and significant adverse effects on competition and other aspects of the economy.

The "major rule" threshold for annual national cost is \$100 million per year. A substantial part of the costs of removing VOCs can be traced to the capital investment required and the operation and maintenance expense of treatment or nontreatment measures. These costs to society (in 1983 dollars) are \$157.4 million (annualized cost) if MCLs are set at 0.5 micrograms per liter for all VOCs; \$101.7 million (annualized cost) for MCLs of 1.0 ug/l; \$21.2 million (annualized cost) for MCLs of 5.0 ug/l; \$11.1 million (annualized cost) for MCLs of 10 micrograms per liter; \$7.0 million (annualized cost) for MCLs of 20 ug/l; \$6.0 million for MCLs of 25 ug/l; \$3.8 million (annualized cost) for MCLs of 50 ug/l; and \$2.4 million for MCLs of 100 ug/l. Costs also were estimated for the MCL alternatives equivalent to 10^{-5} and 10^{-6} individual lifetime risk levels. These annualized costs were estimated at \$98.7 million for the 10^{-6} risk level and \$27.0 for the 10^{-5} risk level.

A major increase in costs and prices indicates a major rule. Cost increases in water production are more or less passed along to customers. For the 5.0 ug/l MCL alternatives, the additional costs of water production for the average system in each of several size categories would be about as follows:

- o For systems serving 25-500 people, \$0.54 per thousand gallons, a nineteen percent increase over current costs.
- o For systems serving 501-3300 people, \$0.29 per thousand gallons, a sixteen percent increase over current costs.

- o For systems serving 3301-50,000 people, \$0.07 per thousand gallons, a six percent increase over current costs.
- o For systems serving more than 50,000 people, \$0.02 per thousand gallons, a two percent increase over current costs.

Thus in terms of the Executive Order 12291 cost thresholds, the 5.0 ug/l MCL alternatives would not result in annual costs over 100 million dollars and would not produce major cost increases in most water systems.

1.6 Regulatory Flexibility and Paperwork Analysis

Under the Regulatory Flexibility Act, EPA must analyze the impacts of proposed regulations on small entities. In the case of water systems, small entities are likely to be water systems serving fewer than 50,000 people. However, less than 10 percent of these small water systems would be affected by a VOC regulation (other than by any monitoring requirements applicable to all water systems). EPA guidelines on compliance with the Regulatory Flexibility Act define the threshold for a "significant impact on a substantial number of small entities" as an impact affecting 20 percent of the total population of such entities. Thus, there is unlikely to be a "significant impact on a substantial number of small entities" in this case.

Under the Paperwork Reduction Act, EPA must consider the impacts of proposed regulations on the response burden of utilities and states providing information on water quality. The monitoring of drinking water for VOCs and reporting of violations of the MCL are likely to be the largest component of reporting requirements.

Several approaches to monitoring requirements are being considered by EPA. Three specific options have been developed. The primary differences between the options relate to the extent of specific sampling requirements and the provision of state discretion. In each option, monitoring requirements are proposed to be phased in depending upon the size of the systems. Systems that are most vulnerable to VOC contamination should be sampled first. While EPA studies have not shown a clear distinction between potential source of contamination and actual VOC contamination, the ground water supply survey (GWSS) found that the best correlation was between the size of systems and VOC contamination. Therefore, proposed monitoring requirements will require that the largest systems sample first.

In addition to monitoring for VOCs, EPA is proposing to establish monitoring requirements for unregulated contaminants under Section 1445(a) of the Act. The rationale for proposing monitoring regulations is that similar analytical techniques to those used to measure the nine VOCs also can be used to measure other VOCs of concern at relatively small additional cost.

EPA has developed monitoring cost estimates for each option and these are summarized below. EPA is proposing that Option 2 be selected as the minimum enforceable monitoring requirement. All costs shown are expressed in millions of dollars annually.

<u>Initial Round</u>	<u>Option 1</u>	<u>Option 2</u>	<u>Option 3</u>
Compliance	\$25.0	\$9.3	\$3.8
Unregulated	2.7	2.3	0.5

Repeat Monitoring

Compliance	63.7	17.4	2.9
Unregulated	2.7	0	0

1.7 Summary of Costs and Benefits of VOC Removal

The total national benefits and costs of the alternative MCLs were computed by multiplying the total number of systems affected by an MCL times either the average cost of compliance or the number of cases of cancer avoided annually. This was computed separately for different size classes of water systems and the results were then summed to produce national totals.

Comparison of the total national benefits and costs of alternative MCLs reveals that the options fall into two groups or clusters; a relatively high cost group consisting of MCLs of 0.5 and 1.0 ug/l and a relatively low cost group consisting of MCLs of 5.0, 10.0, and 20.0 ug/l. The analysis shows that there is as much as a four or five fold difference in cost between the two groups compared to a difference of only a factor of two on the benefits side. The degree of difference in these results is due primarily to the fact that more stringent MCLs would affect a larger number of water systems.

Analysis of net benefits at the level of individual water systems indicates that the more stringent MCLs in the vicinity of 0.5 and 1.0 ug/l would only produce positive net benefits at the system level in the case of certain of the more highly carcinogenic VOCs. The net benefits analysis also shows that regulation of all VOCs will produce the greatest positive net benefits due to the fact that VOCs commonly occur together. Removal of the less carcinogenic compounds will often result in removal of some of the more harmful compounds as well.

2. PROBLEM DEFINITION

2.1 Introduction

This chapter provides answers to the obvious questions that are relevant and contribute to an understanding of the problem of drinking water contamination with volatile organic chemicals (VOCs). The chapter is organized into four major sections and covers the following topics: 1) health effects of VOCs; 2) nature and extent of VOC occurrence in drinking water; 3) available technologies for the removal of VOCs from drinking water; 4) the structure of the water industry; and, 5) the need and the available mechanisms for regulation of VOC contaminants.

Some of the data presented in this chapter deals with the general problem of VOC contamination, encompassing some 29 organic chemical compounds. Only nine of these are the subject of regulatory actions being proposed. The others were studied in the process of arriving at a decision to take action on the nine. NOTE: All nine were originally suspected to be either animal or human carcinogens. Two were later determined to be non-carcinogens during the course of preparation of this RIA. As a result, much of the background data presented in Chapter 2 covers nine chemicals and the analyses presented later in this document cover eight suspected carcinogens. This has no significant effect on the interpretation of the results of these analyses, however, since the last compound dropped from consideration was assumed from the start to pose much less carcinogenic risk than the others.

2.2 Health Effects

The health effects attributable to exposure to VOCs may be classified into two groups: 1) acute and chronic toxic effects (non-carcinogenic effects); and, 2) carcinogenic effects. The specific effects associated with each individual chemical are described in Appendix A.

2.2.1 Acute and Chronic Toxic Effects

Exposure at very high levels to VOCs has been shown to result in a variety of acute and chronic toxic effects. These levels are usually much higher than those found in public drinking water supplies. Damage to the liver and kidneys is a common effect demonstrated in animals from high exposure to several VOCs, as well as central nervous system effects and cardiovascular changes.

The Acceptable Daily Intake (ADI) of a contaminant is the level of intake from air, food, and water that is experimentally determined to be the "no effect" level; meaning no acute and chronic toxic effects. The ADI is expressed in mg/kg body weight

per day. For the nine VOCs, the ADIs have been converted to "Adjusted" Acceptable Daily Intakes (AADIs) to represent the equivalent no effect level divided by a safety factor specific to each chemical, where the intake is totally due to drinking water. Accordingly, AADIs are given in terms of mg/l; assuming consumption of 2 liters of water per day by a 70 kg adult.

AADIs for VOCs are presented in Exhibit 2-1. This exhibit also presents data on the estimated number of water systems believed to have concentrations of VOCs in excess of the indicated AADIs. As shown, there are believed to be very few water systems that display VOC concentrations exceeding the AADIs. Thus, acute and chronic toxic effects due to VOC contamination are probably not extensive.

2.2.2 Carcinogenic Effects

Carcinogenic effects have also been demonstrated from exposure to certain VOCs. Two compounds are demonstrated human carcinogens, while others have exhibited carcinogenic effects in animal studies. The evidence of carcinogenicity for the nine compounds ranges from sufficient evidence in humans to very limited or no evidence in animals.

In the VOC RMCL proposal, EPA raised the question of the strength of evidence on the evidentiary threshold required to conclude that a substance should be considered to be a "carcinogen" for the purposes of regulation. Subsequent to the June 12, 1984, RMCL proposal, EPA proposed an approach for classifying chemicals based upon the strength of evidence of carcinogenicity (Proposed Guidelines for Carcinogen Risk Assessment 49 FR 46294, November 1984). EPA proposed a categorization scheme based upon the International Agency for Research on Cancer (IARC) criteria. The categorization consists of a five category approach, as shown below. In contrast, the IARC classification consists of three categories with the primary difference being that IARC does not distinguish between those chemicals with inadequate animal evidence of carcinogenicity and those chemicals with no evidence for carcinogenicity, while the EPA scheme makes that distinction.

EPA Proposed Categorization for Carcinogens

Group A - Human carcinogen (sufficient evidence from epidemiological studies).

Group B - Probable human carcinogen.

Group B1 - At least limited evidence of carcinogenicity to humans.

Group B2 - Usually a combination of sufficient evidence in animals and inadequate data in humans.

EXHIBIT 2-1

ESTIMATED NUMBER OF WATER SYSTEMS EXCEEDING ADJUSTED
ACCEPTABLE DAILY INTAKE FOR VOCs

Compound	AADI*	System Size (Population Served)			
		25-500	3301- 501-3300	50,000	50,001+
Trichloro- ethylene	0.26 mg/l	0(a)	0(a)	0(a)	0
Tetrachloro- ethylene	0.68 mg/l	0	0	0	0
1,1,1-Tri- chloroethane	1.00 mg/l	0	0	0(b)	0
Carbon Tetra- chloride	0.025 mg/l	0	0	7(c)	2(c)
Vinyl Chloride	0.046 mg/l	0	0	3	0
Benzene	0.025 mg/l	12(d)	2(d)	0	0
1,2-Dichloro- ethane	0.26 mg/l	0	0	0	0
1,1-Dichloro- ethylene	0.35 mg/l	0	0	0	0
p-Dichloro- benzene	3.75 mg/l	0	0	0	0

* Adjusted Acceptable Daily Intake (49 FR 24338), excluding contributions from air and food.

(a) data for systems with concentrations above 0.100 mg/l: 47(24-500 persons), 14 (501-3300 people), 3(3301-50,000 people)

(b) five systems estimated over 0.1 mg/l

(c) number of systems with concentrations between 0.020 and 0.030 mg/l

(d) systems with concentrations over 0.020 mg/l

SOURCE: EPA, Occurrence of VOCs in Drinking Water, Food, and Air, 1983 and 1984. There is a separate volume for each chemical.

- Group C - Possible human carcinogen (limited evidence of carcinogenicity in animals in the absence of human data).
- Group D - Not classified (inadequate animal evidence of carcinogenicity).
- Group E - No evidence of carcinogenicity for humans (no evidence for carcinogenicity in at least two adequate animal tests in different species or in both epidemiological and animal studies).

IARC Criteria

- Group 1 - Chemical is carcinogenic to humans (sufficient evidence from epidemiological studies).
- Group 2 - Chemical is probably carcinogenic to humans.
- Group 2A - At least limited evidence of carcinogenicity to humans.
- Group 2B - Usually a combination of sufficient evidence in animals and inadequate data in humans.
- Group 3 - Chemical cannot be classified as to its carcinogenicity to humans.

Both of these classification schemes are based upon a qualitative review of all available evidence. Information considered in each assessment includes short-term tests, long-term animal studies, human studies, pharmacokinetic studies, comparative metabolism studies, structure - activity relationships and other relevant toxicological studies.

Other groups have supported the concept of assessing carcinogens by degree of evidence. The National Academy of Sciences (NAS) in Drinking Water and Health, 1977. Vol. I, classified chemicals into four groups: human carcinogens, suspected human carcinogens, animal carcinogens and suspected animal carcinogens.

The Office of Science and Technology Policy's recent review of the science and associated principles of chemical carcinogenic risk (50 FR 10372) generated a series of principles to be used to establish specific guidelines for assessing carcinogenic risk. The review discussed the type of tests (short- and long-term) used to assess potential carcinogens and the interpretation of data in light of numerous uncertainties. A classification system for carcinogens was not provided in the report; however, the assessment of chemicals based upon weight of evidence was supported.

The June 12, 1984 RMCL proposal consisted of a two-category approach to setting RMCLs; chemicals were classified as carcinogens or non-carcinogens. All chemicals with evidence of carcinogenicity

ranging from limited to sufficient were classified as "carcinogens" and their RMCLs were proposed at zero. A number of commenters pointed out that this approach did not adequately take into account the varying degrees of evidence of the chemicals classified as carcinogens. Since the proposal, the EPA guidelines for carcinogen risk assessment have been proposed which contain a classification scheme for chemicals based on strength of evidence. In response to comment and consistent with the EPA guidelines, a three-category approach has been developed which considers all of the available scientific data, as shown below:

Three Category Approach

Category I - Known or probable human carcinogens: Strong evidence of carcinogenicity.

- o EPA Group A or Group B
- o IARC Group 1, 2A or 2B

Category II - Equivocal evidence of carcinogenicity.

- o EPA Group C
- o IARC Group 3

Category III - Non-carcinogens: Inadequate or no evidence of carcinogenicity in animals.

- o EPA Group D or E
- o IARC Group 3

Category I includes those chemicals which, in the judgment of EPA, have sufficient human or animal evidence of carcinogenicity to warrant their regulation as known or probable human carcinogens. Category II includes those chemicals for which some limited but insufficient evidence of carcinogenicity exists from animal data. Category III includes those substances with inadequate or no evidence of carcinogenicity.

Exhibit 2-2 presents a summary classification of the nine VOCs in terms of all of the three different schemes for categorizing chemicals on the basis of strength of evidence.

Exhibit 2-3 presents the estimated level of carcinogenic risk (lifetime) associated with the nine VOCs based on the analysis of the Carcinogen Assessment Group (CAG).

2.3 Occurrence

Since 1975, EPA has conducted six nationwide surveys to assess the occurrence of VOCs in drinking water supplies. The most recent of these surveys are the most useful due to advances

EXHIBIT 2-2

STRENGTH OF EVIDENCE ON CARCINOGENICITY OF VOCs

<u>Compound</u>	<u>Evidence of Carcinogenicity</u>	<u>EPA Guide Lines*</u>	<u>IARC or Equivalent Classification*</u>	<u>Three Category Classification*</u>	<u>Proposed RML</u>
Trichloroethylene	Limited animal evidence Inadequate human evidence	B2	3	I	zero
Tetrachloroethylene	Limited animal evidence Inadequate human evidence	C	3	II	zero
Carbon Tetrachloride	Carcinogenic in 3 species by the oral route	B2	2B	I	zero
1,2-Dichloroethane	Carcinogenic in 2 species by the oral route	B2	2B	I	zero
Vinyl Chloride	Carcinogenic in animals by the inhalation and oral route and carcinogenic in humans by inhalation	A	1	I	zero
Benzene	Carcinogenic in animals and humans by inhalation and in animals by gavage	A	1	I	zero
1,1-Dichloroethylene	Conflicting evidence of carcinogenicity in animals, mutagenic	C	3	II	zero
p-Dichlorobenzene	No evidence	E	3	III	0.75 mg/
1,1,1-Trichloroethane	Preliminary animal evidence being audited Inadequate human evidence	D	3	III	0.2 mg/1

* Explanation in text.

EXHIBIT 2-3

CAG RISK ESTIMATES FOR VOCs AND ROUNDED VALUES DETERMINING EQUIVALENT MCLs

Chemical	CAG RISK ESTIMATES		ROUNDED VALUES ³ DETERMINING EQUIVALENT MCLs	
	10 ⁻⁶ Risk for Ingestion Only ¹	10 ⁻⁶ Risk for Ingestion and Inhalation ²	MCLs Equivalent to 10 ⁻⁶ Risk	MCLs Equivalent to 10 ⁻⁵ Risk
Trichloroethylene	1.8 ug/l	.9 ug/l	1 ug/l	9 ug/l
Tetrachloroethylene	1.0	.5	1	5
Carbon Tetrachloride	0.27	.135	1	2
1,2-Dichloroethane	0.5	.25	1	3
Vinyl Chloride	0.015	.0075	1	1
1,1-Dichloroethylene	0.24	.12	1	2
Benzene	0.67	.335	1	4
1,1,1-Trichloroethane ⁴	21.7	10.85	11	109
p-Dichlorobenzene ⁵	-	-	-	-

NOTES TO TABLE:

1. The CAG risk estimates given represent the concentration of each individual contaminant in drinking water that would be required to produce a 10⁻⁶ lifetime individual cancer risk. CAG risk estimates are based on ingestion only.
2. The risk posed by inhalation is assumed to be equivalent to that posed by ingestion. Thus, CAG risk estimates are halved to represent the combined effects of ingestion and inhalation.
3. MCLs equivalent to the CAG risk estimates are determined by rounding the CAG estimates up to the nearest integer. Rounding is necessary because the analytical limit of detection for these chemicals is in a range of 0.5 to 1.0 ug/l in the best research labs. Equivalent MCLs provide a useful point of comparison only if they are in a range that can be detected in the labs used by public water systems. A conclusion of this table is that many of the rounded values are still not in such a range.
4. Determined not to be a carcinogen during the course of this regulatory analysis; included in analysis of chapters 4 and 5.
5. Determined not to be a carcinogen; not included in analysis of chapters 4 and 5.

in the state-of-the-art of analytical chemistry that have made it possible to detect organic chemical contaminants at increasingly lower concentrations. The two most recent surveys are the Ground Water Supply Survey (GWSS) and the Community Water System Supply Survey (CWSS).

As shown in Exhibit 2-4, in the GWSS, 99 of 466 (21.2%) randomly selected groundwater supplies had at least one of the 29 VOCs identified in that survey. In the CWSS, 50 of the 330 (15.2%) groundwater supplies had at least one of 10 VOCs identified in that survey; and, 14 of 106 (13.2%) surface water supplies were found to have one or more of the 10 VOCs present.

Exhibit 2-4 also provides data on multiple occurrences of VOCs; 44 of 99 (44.4%) sites in the GWSS where VOCs were present had two or more of them, while 19 of 50 (38.0%) of the groundwater supplies in the CWSS that contained VOCs had two or more present and 5 of 14 (35.7%) of surface water supplies that contained VOCs had two or more present.

An indication of the level of contamination possible when multiple contaminants are present is illustrated by the figures shown in Exhibit 2-5. These data, taken from the GWSS, show that in 97 percent of the cases where VOCs are present, the sum of the concentrations of the VOCs present is below 10 ug/l. Concentrations of VOCs totalling more than 50 ug/l are shown to occur less than one percent of the time.

The above facts about the occurrence of VOCs are plausible in view of the suspected pattern of causation behind VOC contamination. VOCs are man-made organic compounds that are associated with industrial waste disposal practices. VOC contamination is characteristic of many hazardous waste disposal facilities that have been identified by EPA as problem sites requiring clean-up action. Thus, it is not surprising: 1) that VOCs are found to affect only a portion (13-21%) of the total number of water systems and not the entire water industry because proximity to such wastes is a prerequisite; and, 2) that the presence of multiple VOCs is fairly common (35-44%) when contamination exists since numerous chemicals are involved in industrial operations.

Because VOCs are "volatile," their presence in groundwater supplies is both more probable and more likely to occur in higher concentrations than in surface water supplies that are naturally aerated. The CWSS data cited above show the detection frequencies to be roughly the same in both ground and surface water supplies (15.2% vs. 13.2%), but there are more than four times as many community water systems using groundwater sources than surface water sources.

Evaluation of the impacts of VOC regulatory alternatives requires calculation of the total VOC exposure. Total exposure is a function of the number of people exposed and the concentrations

EXHIBIT 2-4

SUMMARY OF SINGLE AND MULTIPLE OCCURRENCE OF VOCs AS A CLASS

No. of Contaminants	GWSS ¹	CWSS ²	
	Random ³	Ground water ⁴	Surface water ⁵
0	367(78.8%)	280(84.9%)	92(86.8%)
>1	99(21.2%)	50(15.2%)	14(13.2%)
>2	44 (9.4%)	19 (5.8%)	5 (4.7%)
>3	25 (5.6%)	6 (1.8%)	1 (0.9%)
>4	14 (3.0%)	4 (1.2%)	0
>5	8 (1.7%)	2 (0.6%)	0
>6	4 (0.9%)	0	0
>7	2 (0.4%)	0	0
>8	0	0	0

¹Based on analyses for 29 VOCs. (Ground Water Supply Survey)

²466 supplies studied. (Community Water System Survey)

³Based on analyses for 10 VOCs.

⁴330 supplies studied.

⁵106 supplies studied.

EXHIBIT 2-5

CUMULATIVE OCCURRENCE FOR WATER SUPPLIES IN THE GROUND WATER SUPPLY SURVEY (GWSS) WITH TVOC CONCENTRATIONS ABOVE INDICATED LEVELS

(Total Number of Water Supplies Sampled = 466)

<u>Concentration Levels</u>	<u>Number of Supplies Above Indicated Level</u>	<u>Percent of Sample</u>
detection limit*	99	21.2
5.0 ug/l	20	4.3
10.0	12	2.6
50.0	2	0.4
100.0	0	0.0

* Detection limits varied by chemical from 0.5 to 1.0 ug/l.

to which they are exposed over time. EPA has prepared estimates to serve this purpose, drawing on the best information from all recent survey work. Exhibits 2-6 and 2-7 present estimates of the number of water systems by size and source which have VOC contamination above the analytical limit of detection of 0.5 ug/l for each of the individual VOCs. Confidence intervals associated with these estimates are presented in Exhibit 2-8.

Exhibits 2-9 and 2-10 present estimates of the proportion of ground and surface water systems that are above various levels of influent concentration for each of the individual VOCs.

2.4 Control Technologies

The range of technologies for controlling VOCs in drinking water includes five treatments. The following list includes the treatments considered and the basic assumptions used in this economic impact assessment. The complete basis for defining the available treatments is given in Technologies and Costs for Removal of Volatile Organic Chemicals from Potable Water Supplies. A more detailed summary of this document is also included in the Federal Register notice proposing these regulations. Treatments are assumed to be designed for various influent concentrations, ranging from 5 ug/l to 100 ug/l and various effluent concentrations ranging from 0.5 ug/l to 50 ug/l.

- o Granular Activated Carbon (GAC): a new installation if selected.
 - it is assumed that 100 percent of the water is contaminated and therefore treated.
 - systems with flows less than 2 mgd use factory-assembled steel pressure vessels.
 - carbon usage rates depend on the VOCs present and their influent concentration.
- o Packed Tower Aeration: new installation if selected.
 - it is assumed that 100 percent of the water is contaminated and therefore treated.
 - a maximum column diameter of 10 feet, a maximum liquid loading rate of 34 gpm/ft², and maximum blower size of 6400 standard cubic feet per minute were assumed.
 - in some states, granular activated carbon may also have to be used to prevent air pollution from air stripped VOCs; these costs are not considered here.
- o Diffused Air Aeration: retrofit of existing treatment equipment if selected.

EXHIBIT 2-6

**ESTIMATED NUMBER OF GROUND WATER SYSTEMS HAVING CONCENTRATIONS
GREATER THAN OR EQUAL TO 0.5 ug/l FOR THE INDICATED VOCs**

<u>Contaminant</u>	<u>System Size (Population Served)</u>			
	<u>25-500</u>	<u>501-3300</u>	<u>3301-50,000</u>	<u>50,001+</u>
Trichloro-ethylene	1128	330	153	20
Tetrachloro-ethylene	996	290	259	7
1,1,1-Tri-chloroethane	961	283	138	8
Carbon Tetra-chloride	82	196	53	5
Benzene	453	132	42	2
p-Dichloro-benzene	367	106	35	2
Vinyl Chloride*	0	0	27	4
1,2-Dichloro-ethane	94	27	37	3
1,1-Dichloro-ethylene**	593	173	86	6
1 or more VOCs	3640	1160	528	31
Number of Sys-tems in U.S.	34799	10168	3358	133

* Number of Systems with concentrations greater than or equal to 1 ug/l.

** Number of Systems with concentrations greater than 0.2 ug/l.

SOURCE: EPA, Occurrence of VOCs in Drinking Water, Food, and Air, 1983 and 1984. There is a separate volume for each chemical.

EXHIBIT 2-7

ESTIMATED NUMBER OF SURFACE WATER SYSTEMS HAVING CONCENTRATIONS
GREATER THAN OR EQUAL TO 0.5 ug/l FOR THE INDICATED VOCs

<u>Contaminant</u>	<u>System Size (Population Served)</u>			
	<u>25-500</u>	<u>501-3300</u>	<u>3301-50,000</u>	<u>50,001+</u>
Trichloro-ethylene	101	98	234	65
Tetrachloro-ethylene	34	33	87	26
1,1,1-Tri-chloroethane	0	0	62	21
Carbon Tetra-chloride	96	94	298	89
Benzene	106	102	81	12
Para-Dichloro-benzene	0	0	9	3
Vinyl Chloride*	0	0	9	3
1,2-Dichloro-ethane	68	66	143	39
1,1-Dichloro-ethylene**	0	0	26	9
1 or more VOCs	427	414	616	150
Number of Sys-tems in U.S.	3937	3817	2994	454

* Number of systems with concentrations greater than or equal to 1 ug/l.

** Number of systems with concentrations greater than 0.2 ug/l.

SOURCE: EPA, Occurrence of VOCs in Drinking Water, Food, and Air, 1983 and 1984. There is a separate volume for each chemical.

EXHIBIT 2-8

CONFIDENCE INTERVALS FOR NUMBER OF WATER SYSTEMS HAVING VOC CONTAMINATION

95% Confidence Interval for Number of Systems Having VOCs*

<u>VOC</u>	<u>Groundwater Systems</u>	<u>Surface Water Systems</u>
trichloroethylene	1031-2228	216-783
tetrachloroethylene	1047-2066	13-346
1,1,1-trichloroethane	799-1984	29-136
carbon tetrachloride	124-545	299-850
benzene	330-939	64-537
p-dichlorobenzene	197-822	0-34
vinyl chloride**	13-48	0-34
1,2-dichloroethane	0-337	82-551
1,1-dichloroethylene***	336-1349	0-81

* Number of systems with VOC concentration greater than or equal to 0.5 micrograms per liter.

** Number of systems with concentration greater than or equal to 1 ug/l.

*** Number of systems with concentration greater than or equal to 0.2 ug/l.

SOURCE: EPA, Occurrence of VOCs in Drinking Water, Food, and Air, 1983 and 1984. There is a separate volume for each chemical.

EXHIBIT 2-9

INFLUENT CONCENTRATIONS OF VOCs IN GROUNDWATER SYSTEMS

Percentage of Systems With Influent Concentration
Greater than Concentration Indicated

<u>Contaminant</u>	<u>0.5 ug/l</u>	<u>5.0 ug/l</u>	<u>20.0 ug/l</u>	<u>50.0 ug/l</u>
trichloroethylene	3.37	0.87	0.43	0.27
tetrachloroethylene	3.20	0.66	0.14	0.01
1,1,1-trichloroethane	2.87	0.76	0.16	0.01
carbon tetrachloride	0.69	0.23	0.00	0.00
benzene	1.30	0.28	0.03	0.00
p-dichlorobenzene	1.05	0.00	0.00	0.00
vinyl chloride*	0.06	0.04	0.01	0.01
1,2-dichloroethane	0.33	0.00	0.00	0.00
1,1-dichloroethylene**	1.77	0.17	0.00	0.00

* Lowest influent concentration is 1 ug/l

** Lowest influent concentration is 0.2 ug/l

Source: EPA, Occurrence of VOCs in Drinking Water, Food, and Air, 1983 and 1984. There is a separate volume for each chemical.

EXHIBIT 2-10

INFLUENT CONCENTRATIONS OF VOCs IN SURFACE WATER SYSTEMS

Percentage of Systems With Influent Concentration
Greater than Concentration Indicated

<u>Contaminant</u>	<u>0.5 ug/l</u>	<u>5.0 ug/l</u>	<u>20.0 ug/l</u>	<u>50.0 ug/l</u>
trichloroethylene	4.45	0.08	0.08	0.00
tetrachloroethylene	1.61	0.00	0.00	0.00
1,1,1-trichloroethane	0.74	0.00	0.00	0.00
carbon tetrachloride	5.15	0.25	0.08	0.00
benzene	2.69	0.00	0.00	0.00
p-dichlorobenzene	0.11	0.00	0.00	0.00
vinyl chloride*	0.11	0.00	0.00	0.00
1,2-dichloroethane	2.82	0.73	0.00	0.00
1,1-dichloroethylene**	0.31	0.00	0.00	0.00

* Lowest influent concentration is 1 ug/l

** Lowest influent concentration is 0.2 ug/l

Source: EPA, Occurrence of VOCs in Drinking Water, Food, and Air, 1983 and 1984. There is a separate volume for each chemical.

- all water is treated.
 - an existing basin with a detention time of 20 minutes is assumed to be available for retrofitting with diffusers.
 - fine bubble diffusers are assumed.
 - blowers are assumed to provide an air-to-water ratio of 8:1.
 - in general, a removal efficiency of 90 percent or less is achieved.
- o Tray Tower Aeration
 - it is assumed that 100 percent of the water is contaminated and therefore treated.
 - aerators are assumed to be 16 feet in height.
 - aerator area is based on a hydraulic loading of 50 gpm/ft²; maximum surface area of a single aerator is 200 square feet.
 - in general, a removal efficiency of 90% or less is achieved.
 - o Powdered Activated Carbon (PAC): additional PAC used by systems already using PAC.
 - all water is treated.
 - PAC use is increased by conventionally designed water plants which treat surface water and which already add PAC for taste and odor control.
 - no capital costs are required.
 - an additional 20 mg/l above that normally used at the plant for taste and odor control is assumed.
 - on average 25 to 50 percent of VOCs are removed with this method.

A number of alternatives to central treatment solutions were evaluated. These techniques are listed below with the respective assumptions used in this analysis. Bottled water and point-of-use treatments were not included in the list, however. Point-of-use devices were considered, but they were not included in the cost analysis because they were judged to be too expensive; most water systems would probably select another alternative. Bottled water does not address the problems of inhalation and dermal absorption.

- o Source Protection: Source protection consists of surface water systems monitoring their water supply to identify VOCs. This has a short-term effect of diminishing discharges of contaminants into the water source, since producers of the contaminants (typically industries) know that they are being monitored. Small systems are often "free riders," since larger utilities drawing upon the same source will engage in monitoring and then report results to smaller systems at no cost to the smaller systems.
- o Regionalization: Regionalization consists of inter-connection with an existing system with sufficient capacity to supply all of the affected community's water. This technique could be used by small water systems. It is assumed that the host utility has an adequate supply of water and could meet any VOC standard. Costs include new pumping stations and transmission pipelines. Costs exclude the procurement and treatment of water because the net cost of this water depends on the characteristics of the host system and the contaminated systems; net costs (the difference between the host system and discontinued and contaminated system) may be very small. A weighted average of pipeline lengths of 3, 7.5, and 10 miles is assumed.
- o Wellfield Management: Wellfield Management consists of pumping to waste of contaminated wells and increasing production from remaining wells. Twenty percent of the wells in a wellfield are assumed to be contaminated. This alternative would be selected only by groundwater systems with sufficient well capacity remaining to supply their needs without drilling new wells. Thus, only larger groundwater systems would adopt wellfield management (greater than 1 mgd).
- o Alternative Source: Alternative source consists of drilling of new wells and installation of appropriate transmission pipelines to replace a contaminated ground or surface source. For larger systems not all the water is assumed to be contaminated. The distance to the new wells is a function of system size, but new wells are assumed to be less than five miles away except for systems serving over 500,000 people. These new wells would supply all or some of the contaminated utility's water, depending on system size. It is assumed that alternative groundwater sources are of such quality that existing treatment is adequate. The existing distribution system is utilized.

2.5 Market Characteristics, Imperfections, and the Need for Regulation

2.5.1 Structure of the Water Industry

The American public is served by approximately 216,800 water systems. These are the water systems defined by the Safe Drinking Water Act as public water systems and which are under federal jurisdiction in terms of regulation. These systems are divided into two categories: community water systems (CWS), and non-community water systems (NCWS). CWS constitute 27 percent of the systems and serve primarily residential areas, while NCWS make up the other 73 percent of the water systems and serve mainly transient or non-residential areas. There is a total of 158,100 non-community water systems which serve approximately 36 million persons.

Community water systems are defined as those serving 25 or more persons, or, having at least 15 service connections. There are approximately 58,718 community water systems in the country. Of these, approximately 37,813 (64.4%) can be categorized as "very small" -- serving 25-500 people; 13,915 (23.7%) can be categorized as "small" -- serving 500-3300 people; 3,943 (6.7%) are "medium" -- serving 3,301-10,000 people; 2,770 (4.7%) are "large" -- serving 10,001-100,000 people; and only 277 (0.5%) are classified as "very large" -- serving more than 100,000 persons. More than 64 percent of the systems serve less than 2.6 percent of the population, whereas about 0.5 percent of the systems serve more than 44 percent of the population.

Urban water systems (a subset of CWS) are defined as those systems which serve 50,000 or more persons. There are approximately 750 urban water systems in the U.S.; these large systems serve 56 percent of the community water system population.

Surface water is the primary source for 18.8 percent of community water systems and is the primary source for 65.6 percent of the population served by community systems. Ground water is the source for 81.2 percent of the systems, serving 34.4 percent of the CWS population. In general, the CWS falling into the very small, small, and medium population categories use ground water 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 ground water sources. EPA data show an increase in the use of ground water sources between 1975 and 1980 in the smaller categories, and a decrease in the larger population categories.

2.5.2 Ownership

Public systems are predominantly owned by municipal governments, although a sizeable number of systems also are owned by the federal government. Large wholesalers of water, such as the Metropolitan Water District of Southern California, are one

of the major owners of very large systems. Publicly owned systems serve approximately 85 percent of the total population which use community water supplies. Approximately 73 percent (553) of the urban water systems are publicly owned.

According to the Survey of Operating and Financial Characteristics of Community Water Systems (U.S. EPA Office of Drinking Water, 1982), there are about 15,740 private water systems serving some 31,000,000 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. In addition, there are about 16,907 "ancillary" systems serving another 1.7 million people who live in trailer parks and other small developments. As evident 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 largest number of investor owned systems are in Pennsylvania, Florida, Texas, and California. In addition, two states, Connecticut and New Jersey, have the majority of their populations served by private water companies.

The total number of investor owned systems is increasing. This is primarily the result of growth in rural, underdeveloped areas in Florida, Texas, Arizona, California, and other Sunbelt states. In suburban or rural areas, housing developers have little choice but to "go into the water business."

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 rate increases (from the state public service commission) large enough to yield sufficient profits.

2.5.3 Characteristics of the Municipal Water Supply 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 includes chemical mixing, coagulation and flocculation, sedimentation (or clarification), filtration (usually through sand or a dual media), and disinfection (usually chlorination). Special treatment processes often are needed to remove iron and manganese, color, hardness, or organic contaminants such as THMs or VOCs.

Innovative treatment techniques are periodically introduced by U.S. equipment manufacturers, but acceptance of either new technologies or those proven to be effective in Europe (e.g., ozone or granular activated carbon) has been slow.

Water supply is a highly capital intensive, yet not highly profitable business. Water has the second highest asset/revenue ratio of any utility. Water utilities exhibit tremendous economies of scale and can be considered natural monopolies since no two water utilities serve the same geographic area.

2.5.4 Regulation of the Water Supply Industry

Primary responsibility for the provision of water has traditionally been with the local governments. The role of the federal government has been to support local and state governments in meeting water supply needs (primarily through construction of large water resource development projects) and to address problems beyond the scope of lower levels of government. The other federal role has been regulatory in nature. In 1974, Congress enacted the Safe Drinking Water Act which required EPA to set national drinking water standards and also provided support to state programs in the form of grants. Under the provisions of this act, EPA promulgated National Interim Primary Drinking Water Regulations (NIPDWR) which went into effect on June 24, 1977.

Both public and private systems are regulated by state health departments. Fifty-three of 57 states and territories have accepted primary enforcement responsibility under the Safe Drinking Water Act. All 57 must approve plans and specifications for either new water facilities or additions to water facilities.

Investor owned systems also are regulated by state public utility commissions (PUC's). State PUC's have the authority to approve rate increases, regulate quality and quantity of service, approve areas in which a utility can operate, and approve methods and levels of financing. In reality, however, most PUC's regulate only rate increases.

2.5.5 Rate Levels

The price charged for water is a function of the average cost of producing the commodity. The average cost is then marked up in order to attain a profit level. Pricing is also affected by "unaccounted-for" water -- total production of water minus total deliveries of water. If water is "lost," rates are set higher, so in fact metered customers pay for more water than they actually receive. This occurs when utilities cover the total cost of production. Cost includes operating and maintenance costs, depreciation, taxes or payments in lieu of taxes (however, publicly-owned systems do not generally pay taxes, and as a rule, record no depreciation expense), and interest expense.

Operating and maintenance costs are the direct costs of producing water and maintaining the water system - labor, fuel, electricity, chemicals, repairs, and the like. Treatment costs can affect operating and maintenance costs. Treatment costs vary depending on the source of the water, contaminants in the

water, and compliance with drinking water standards. The proportion of deliveries (only in the larger systems) going to residential versus industrial users also has an impact on cost.

Water rates vary throughout the country. In many small systems, the consumer may pay as little as \$2-5/month flat rate for water. In some larger investor owned systems and in arid areas of the west and southwest, water rates can be as high as \$2-3 or more per 1000 gallons. The trend in water rates is toward more frequent increases. Also, because water utilities exhibit tremendous economies of scale, declining block structures typically have been the rate structure preferred by utilities. This too is changing as the public perception of the value of water, which always has been low, increases.

2.5.6 Market Imperfections and the Need for Regulation

Some economists believe that market forces by themselves are an efficient mechanism for allocating resources. Economic theory holds that in a perfect market, the natural market forces allocate resources efficiently and that the common good is represented by economic efficiency, a state in which society has maximized its net benefits. Under the conditions of perfect competition with no externalities, efficiency can be reached through the process of individual actions in the marketplace. In such a perfect market, there would be no need for government intervention.

The marketplace is characterized by "imperfections," however, and experience has shown that government intervention often is justified. The question to be examined in this section is whether the market can determine the best course of action for limiting human exposure to VOCs from drinking water.

There are several reasons why the market, acting alone, cannot produce the most efficient set of actions with regard to VOC control:

- 1) the general public is generally uninformed about the presence of VOCs in drinking water;
- 2) the public is generally unaware of the health risks posed by exposure to VOCs;
- 3) consumers typically cannot place a dollar value on health risks avoided; and
- 4) water is supplied to the public by regulated monopolies, not by competing utilities.

Because these conditions exist, it is difficult to register the demand for drinking water quality as a function of the amount consumers are willing to pay. The same conditions make it difficult to represent competitive costs of supply in the marketplace.

A brief illustration of conditions on both the demand and supply sides of the market for drinking water quality shows that imperfections exist and that government intervention is needed. On the demand side, several conditions must be met before a perfectly operating market can exist. These conditions deal with the preferences of water consumers. One of the demand side conditions says that money and drinking water quality must be comparable; that is, each individual must be able to state preferences between money and drinking water quality. In the absence of a centralized, authoritative source of market information on the subject (such as the EPA), this condition clearly cannot be met.

On the supply side of the market, it is clear that water utilities do not represent a competitive market. Each community served by a water utility is served by only one water supplier. Therefore, monopoly conditions exist. Water utilities are natural monopolies in that they exhibit large economies of scale and competitive services from other suppliers would not be cost-effective.

In conclusion, neither the demand nor supply sides of the market for drinking water meets the conditions for a perfectly competitive market. As a result, economic efficiency cannot necessarily be realized from interacting market forces alone. Market imperfections are so strong that government intervention is required to achieve efficiency.

In the specific case of VOC regulations, the following reasons for imperfection apply:

- 1) the economic demand for VOC removal is not quantifiable;
- 2) the public is not generally knowledgeable about health risks;
- 3) information about VOC occurrence is incomplete;
- 4) suppliers of drinking water are natural monopolies; and
- 5) drinking water cannot be provided at different quality levels in the same service area.

Thus, the market does not provide a mechanism for registering the costs and benefits of VOC removal and for maximizing the net benefits of VOC removal.

2.6 State Actions to Control VOCs in the Absence of Federal Regulations

In 1984, EPA conducted an informal survey of 13 state water supply directors to determine what actions states were taking to control VOCs in the absence of federal regulations. These

states were distributed across all ten federal regions. The matrix shown in Exhibit 2-11 summarizes the results of the survey.

There is substantial variation among state programs, as could be expected. There are many commonalities in approaches, however. The principal characteristics of state VOC programs are as follows:

- o Virtually all states react to incidents of VOC contamination on a case-by-case basis. The level of clean-up required is decided on a judgmental basis after the water supply professionals consult with state toxicologists and epidemiologists.
- o All states interviewed depend heavily upon health advisories, reports, and other toxicological and health data developed by EPA.
- o Six of 13 states contacted had conducted extensive statewide surveys of VOC contamination in water systems. Some of the others cited lack of resources, few occurrences, or dependency on EPA as reasons for not having conducted monitoring surveys.
- o Several states have established guideline or "action levels" for certain VOCs. The action level is the concentration at which a utility must notify the state; substantial exceedence of an action level requires mitigative action by the utility. California has set action levels for the same nine VOCs being considered for regulation by EPA; Pennsylvania, New York, and Missouri have established guideline levels for certain VOCs.
- o The State of Florida has established maximum contaminant levels for eight VOCs; these MCLs went into effect in May, 1984. Several other states have indicated that they will move to establish regulations if EPA does not do so. These states include Wisconsin, Washington, Maryland, and California. New Jersey, although not interviewed, is moving quickly to establish their own regulations. These standards are not uniform from state to state.
- o Some states indicate that they will not establish MCLs for VOCs even in the absence of EPA regulations. Some states, such as Colorado, are prohibited from establishing MCLs unless EPA first promulgates regulations.
- o Some states would prefer that EPA not promulgate regulations for VOCs. This is a minority opinion and is based on the concern that federal standards will be established at too high a level. However, most existing state standards or action levels are well below the proposed MCLs.

EXHIBIT 2-11

SUMMARY OF VOC PROGRAM ACTIONS IN THIRTEEN STATES

1. Type of State Regulation or Action

• MCL

- Total VOCs
- One or more of the nine VOCs in RIA
- Other VOC

• Action Level

- Total VOCs
- One or more of the nine VOCs in RIA
- Other VOC

• Health Advisory

- Total VOCs
- One or more of the nine VOCs in RIA
- Other VOC

• Case by Case Consideration

2. Monitoring Requirements

• Total VOCs

- One or more of the nine VOCs in RIA
- Other VOC

3. Survey for VOC Contamination

• Total VOCs

- One or more of the nine VOCs in RIA
- Other VOC

4. Provision of Technical Assistance

- Information concerning removal measures
- Conduct toxicological studies
- Review and evaluate public health data
- Conduct epidemiological studies
- Uses U.S. EPA Health Assessment Data

CA	CO	FL	LA	ME	MD	MA	MI	MO	NY	PA	WA	WI
		X										
		X										
							X		X			
X				X					X	X		
										X		
						X		X		X		
X	X		X	X	X	X	X	X	X	X	X	X
											X	
		X		X								
		X		X								
X						X	X		X			X
			X									X
									X			
X			X	X	X	X			X	X		X
X		X		X		X			X	X		
X	X	X	X		X			X		X	X	

- o The state water supply directors feel that the amount of scientific evidence on the health effects of these chemicals is sketchy. Therefore, any concentration of VOCs in drinking water is a matter of public concern. As a result, most state directors feel that national standards based on good health data are needed.
- o States would like EPA to adopt flexible monitoring and reporting requirements. The state directors believe they are better positioned to decide which systems to monitor than is the EPA.

As noted above, all states approach occurrences of organic contamination on a case-by-case basis. After confirming the levels of contamination by specific chemicals, state public health personnel review EPA's Health Advisories and other available public health information and develop recommendations for action. For carcinogenic (actual or suspected) contaminants, recommended target action levels have, in some cases, been based on a 10^{-6} risk level.

Predominant actions taken in response to occurrences of VOC contamination appear to be closing down the contaminated wells and drilling new wells in the same well field.

Although most states want EPA to set MCLs for VOCs, and quickly, five state water supply directors contacted would prefer to see no EPA regulation of VOCs or other contaminants. As they view proposed regulations, the primary problem centers on lack of sufficient credible scientific data upon which to fix specific maximum exposure levels.

In the absence of EPA MCLs, these state officials are able to convince affected water utilities that "less contamination is better than more," and these affected systems are taking actions appropriate to the contaminants and their concentrations. In the absence of regulations, a water system having a 10 ppb level of TCE, for example, will most likely take action to minimize this level of contamination. On the other hand, if EPA sets a TCE MCL at a higher level, the supplier with 10 ppb may be able to justify not taking any action to reduce contamination levels.

2.7 Actions Taken by Water Utilities in Response to VOC Contamination

Informal interviews were conducted with nine individual water supply managers to determine the actions taken by local water utilities in response to VOC contamination of water supplies. Pertinent information also was obtained from informal interviews with the state water supply directors.

Questions specifically asked managers of water supply systems were directed at the nature of their VOC problems, how they

learned of the problem, what actions were taken or are planned, and how action decisions were made. In those cases involving shutdown of a contaminated water supply, information was solicited as to how the utility proceeded to find alternate sources of supply.

2.7.1 Nature Of The VOC Problems Encountered

All VOC incidents cited occurred in groundwaters, and nearly all are caused by chlorinated organics. A few cases involve benzene, toluene, and xylenes, which are thought to be present as a result of leaking underground gasoline storage tanks. Many instances of VOC contamination stem from leakage of waste disposal sites; others from discharges of contaminating chemicals into rivers which feed underground wellfields.

In instances for which the contaminating source has been found, levels of contamination have been reduced significantly after cessation of discharge or cleanup of the polluting site. However, in many other instances, the sources of contamination have not yet been located, and interim measures, including treatment, have been instituted.

In many instances of VOC contamination, other organic chemicals also are present which are not listed by EPA as VOCs. These include pesticides, PAHs, and similar organics.

2.7.2 Actions Taken To Date

The types of actions taken in response to VOC occurrences vary widely and are always site-specific. As a result, no clearcut trends could be established to predict specific actions based upon the small sample of systems contacted.

It was hypothesized that large, medium and small water systems would respond differently to VOC contamination problems. as a result of differences in availability of resources, analytical equipment, and trained personnel.

Similarly, it had been anticipated that the smaller systems would not be capable of taking much responsive action, nor would they have the resources to take action. The larger utilities were expected to be able to take fast action, and the medium sized utilities were expected to respond in an intermediate fashion, depending upon the extent of their resources.

In fact, all small public water systems contacted which have VOC contamination have taken significant actions on their own initiatives. It can be argued that such actions were taken in response to public pressure, or to avoid public pressure, or through lack of balanced information of the risks that are associated with the contamination found.

The most common response to VOC contamination problems is to close the contaminated well. If other wells are available in the field, these are used to replace the contaminated source. If another well is not available, the typical action is to drill a new well.

When the source of contamination is an uncontrolled hazardous waste site on the CERCLA National Priority List, this has caused mixed reactions. When a Superfund site is involved, indications are that more testing and surveying of the extent of contamination is conducted, and more extensive treatment is likely to be installed to correct the problem, not only at the hazardous waste site itself, but also to treat the contaminated water supply.

2.7.3 Factors Which Influenced How Action Decisions Were Made

The overriding factor affecting actions taken was public response to notification of VOC contamination. One state official advised that the public can cause faster responses from local utilities than can state agencies. However, several local water supply managers have found the key to harnessing the power of public pressure to work to their benefit.

In several cases local water officials have approached the public with presentation of all data available, a discussion of what is known about the health risks, alternative action plans, costs, and timing. Unanimously, these officials have found that when they have been forthright with the public, the first benefit is lack of pressure to move too rapidly without proper planning.

Most local water supply utilities take direction and seek guidance from the state water supply agency and from local health departments. They are not generally concerned about EPA actions, although they do appreciate that state water agencies respond to EPA regulations, and adjust and adapt state actions accordingly.

2.8 Control of VOCs Via Other Federal Legislation

There are eight major pieces of legislation that control exposure to toxic substances such as the nine VOCs. All eight Acts control one or more of the VOCs in this analysis to some extent. Each Act uses a variety of control measures to form a complex pattern of regulation. For example, while the Food and Drug Administration (FDA) has authority to control levels of contaminants in a wide range of foods, the Department of Agriculture's Food Safety and Quality Service (FSQS) controls the levels of contaminants in meats through the Federal Meat Inspection Act and the Poultry Products Inspection Act. However, the FSQS usually incorporates FDA's tolerances for food additives. In addition to overlapping authorities, each Act usually empowers a number of regulatory programs. These regulatory programs do not control all of the nine VOCs in the same manner or to

the same degree. Under the Clean Air Act's new source performance standards (NSPS), for example, only a few of the VOCs are regulated.

The following discussion provides a brief summary of the regulatory programs authorized by the above-mentioned legislation concerning control of exposure to one or more of nine VOCs as well as to other toxic substances.

- o Clean Water Act: This act provides protection to surface waters, i.e., water bodies including those not specifically designated as drinking water supplies through regulatory programs such as Toxic Pollutant Effluent Standards, Water Quality Criteria, Effluent Limitations, New Source Performance Standards, Pretreatment Standards for New and Existing Sources, and Designation of Hazardous Substances and Reportable Quantities. It indirectly controls human exposure through limiting emission of toxic substances into surface waters.
- o Clean Air Act: This act protects air quality. Programs include the National Ambient Air Quality Standards, Emission Standards for Hazardous Air Pollutants, Prevention of Significant Deterioration, and New Source Performance Standards. It controls exposure through limiting emission of toxic substances into the ambient air.
- o Occupational Safety and Health Act: The Occupational Safety and Health Administration develops recommended practices and prescribes permissible exposure limits in the workplace. This Act has jurisdiction over all workplace settings. It includes all routes of exposure including inhalation, ingestion, and dermal absorption. Controls range from prescriptive correction measures to allowable limits of exposure.
- o Food, Drug and Cosmetic Act: This legislation controls contamination of food through treatment, packaging and preparation processes applied to food. VOCs are controlled mainly as contaminants and packaging ingredients.
- o Consumer Product Safety Act: This Act controls consumer products and consumer formulation, but not production. Its jurisdiction includes physical as well as chemical safety of consumer products.
- o Resource Conservation and Recovery Act, Comprehensive Environmental Response Compensation and Liability Act and the Toxic Substances Control Act: All three of these Acts primarily concern the prevention of human exposure through control of disposal, spills, and production. RCRA's mandate is to control hazardous wastes from their generation through ultimate disposal. CERCLA's mission is to clean up abandoned hazardous waste sites that pose acute and chronic health risks. TSCA can

be used to control toxic substances in any context; TSCA's primary focus, however, is to prevent toxic substances from entering the marketplace.

Of these eight pieces of legislation, the two most important ones from the standpoint of controlling VOCs in drinking water are RCRA and CERCLA. Drinking water standards and health advisories may serve as the basis for clean-up goals under RCRA and CERCLA. As noted in an earlier section, some communities are pursuing Superfund monies as a funding source for cleaning up contaminated drinking water sources.

3. REGULATORY AND NON-REGULATORY ALTERNATIVES

OVERVIEW

The major alternatives to be considered for limiting human exposure to VOCs in drinking water were discussed briefly in the Proposed Rulemaking notice of June 12, 1984 (49 FR 24344). These alternatives are listed below:

1. No Federal Regulations. Provision of health advisories for State action as appropriate.
2. Set federal monitoring regulations and provide health advisories for State action as appropriate.
3. Set Primary Drinking Water Regulations for certain of the VOCs.

There are several variations that can be incorporated into each of these alternatives. In establishing primary drinking water regulations for instance, EPA could choose to set a technology based standard or develop MCLs based on feasibility and costs.

The authority for establishment of recommended maximum contaminant levels (RMCLs) and maximum contaminant levels (MCLs) is the Safe Drinking Water Act (SDWA). The SDWA (42 U.S.C. 300f et seq.) requires the EPA to establish RMCLs for "each contaminant which, in [the Administrator's] judgment may have any adverse effect on the health of persons." Section 1412(b)(2) requires the establishment of an MCL for each contaminant for which an RMCL is established. Further, the MCLs must be as close to the RMCLs as feasible, taking cost into consideration.

In addition to the regulatory mandates, the SDWA provides authorities for ensuring the safety of the nation's drinking water in a non-regulatory context. Section 1442(a)(2)(B) authorizes EPA to provide technical assistance to states and publicly owned water systems in response to and alleviation of any emergency situation which the Administrator determines to be a substantial danger to public health. In the absence of appropriate State or local action, Section 1431 authorizes EPA to take such actions as the administrator deems necessary to protect public health from a contaminant that may present an imminent and substantial endangerment to the health of persons.

Each of the three major alternatives for controlling VOCs in drinking water is discussed in the following sections.

3.1 Alternative No. 1: No Federal Regulations

States and local utilities have been addressing site-specific VOC contamination problems since the late 1970s in the absence of federal regulations. EPA has assisted the states in addressing

this problem by issuing health advisories and providing advice on treatment techniques and analytical methods.

EPA has issued health advisories* on 20 different chemical contaminants to date. Anecdotal evidence indicates that state officials value the health advisories and depend heavily on them when making decisions regarding VOC control. When the first health advisories on certain VOCs were issued in the form of SNARLS (Suggested No Adverse Response Levels), states interpreted and applied them in different ways. Some states applied the health advisories as if they were standards while some considered adopting them as state standards.

More recent experience has shown that several states are moving to establish their own standards in the absence of EPA regulations. Florida already has standards in effect while New Jersey, California, Washington, and Wisconsin are taking actions to set standards. Maine has a monitoring regulation.

In the absence of federal regulations, states will either design control strategies to address incidents of contamination on a case-by-case basis or establish statewide standards for VOCs that occur frequently. Either of these approaches is likely to be inefficient for four reasons. First, state drinking water programs tend to be uneven in quality; therefore, some states may tend to overregulate while others may not regulate at all. Second, many state programs are faced with increasing constraints on resources; this lack of resources could lead to no action in some states. Third, if each state moves to adopt regulations, it will be a lengthy process. State agencies will have to be educated and convinced, a process that could take years. Fourth, some states cannot establish drinking water regulations for contaminants not regulated by the federal government (e.g., Colorado).

* Health advisories are developed for substances not regulated under the SDWA to provide scientific guidance to federal, state, and local officials concerning the health effects of substances that are detected in drinking water supplies. These advisories may be used to assist in determining appropriate "immediate actions." Immediate actions can be defined as actions in the interim between discovery of contamination and a complete regulatory decision (48 FR 45507). Health advisories for noncarcinogens suggest levels of contamination at which no adverse health effects would occur, including a safety margin for sensitive populations, such as pregnant women. Health advisories for carcinogens provide risk estimates but do not recommend levels. Since most of the nine VOCs considered here are suspected carcinogens, health advisories have reported each substance's cancer risk.

These factors, all of which contribute inefficiency to the process of limiting human exposure to VOCs, provide strong justification for federal standards for these chemicals.

3.2 Alternative No. 2: Set Federal Monitoring Regulations and Provide Health Advisories as Appropriate

This alternative would result in all public water systems determining if they have VOCs in their drinking water. Section 1445 of the Safe Drinking Water Act (SDWA) authorizes EPA to require recordkeeping, reporting, monitoring, and any other information to 1) assist in compliance with the SDWA, 2) evaluate health risks of unregulated contaminants, and 3) advise the public of such health risks. This alternative is based on the premise that states and utilities could more efficiently deal with VOC contamination incidents if better information on occurrence and concentrations of contaminants were available to them and to the public. Since health advisories have been issued, the information generated by monitoring would enhance public knowledge.

The results of no EPA action other than health advisories would thus be modified by more systematic monitoring for VOCs and possibly by greater public concern in response to VOC contamination. States would still be free to set their own standards, but theoretically they would be working with better information. There is evidence, gained from EPA studies, which indicates that several states already have completed, or are in the process of completing, monitoring surveys of their community water systems.

There are several disadvantages to the "monitoring only" alternative:

1. It provides no guidance regarding safe levels of contamination. The states would have to depend upon the EPA health advisories and apply their own judgment on a case-by-case basis.
2. A monitoring requirement would not have the impact of an MCL; utilities would not be forced to remove a contaminant once it was determined to exist.
3. Some states may elect to take no action to establish regulations.
4. Better information, the major benefit of a monitoring only alternative, is only one of several "market imperfections" that exist. Government intervention still would be justified by other imperfections.

Under this alternative, the public would be better informed, thus placing them in a position to exert pressure on utilities to remove VOCs from drinking water supplies. Anecdotal evidence acquired by EPA indicates that public action has indeed resulted in utility actions to remove VOCs in a number of communities.

3.3 Alternative No. 3: Set Primary Drinking Water Regulations for Certain of the VOCs

This alternative would involve establishment of RMCLs, MCLs, and monitoring and reporting requirements for a selected number of VOCs. Section 1412 of the SDWA authorizes EPA to set maximum contaminant levels (MCLs) for those contaminants in drinking water that may have "any adverse effect on the health of persons." Recommended Maximum Contaminant Levels (RMCLs) are set at a level at which "no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety." MCLs are to be set as close to RMCLs as is feasible, taking costs into consideration [Section 1412 (b) (3) of the SDWA].

RMCLs are health goals and are non-enforceable; MCLs, by contrast, are enforceable standards that also require regular monitoring and reporting by affected utilities. Under the statute, the RMCLs and MCLs are to be established in separate and consecutive rulemaking actions (i.e., RMCLs are proposed; RMCLs are then promulgated at the same time the MCLs are proposed; MCLs are then promulgated). If an RMCL is promulgated for a particular contaminant, an MCL also must be established.

If "it is not economically or technologically feasible to ascertain the level of a contaminant in drinking water," a treatment technique requirement is to be established (in lieu of MCLs) (Section 1401). The nine VOCs being considered for regulation are detectable using conventional analytical techniques. Thus, EPA is not considering a treatment-based requirement for these chemicals.

Proposed RMCLs were published in the Federal Register on June 12, 1984 (49 FR 24348). RMCLs of zero were proposed for seven chemicals: trichloroethylene, tetrachloroethylene, carbon tetrachloride, 1,2-dichloroethane, vinyl chloride, benzene, and 1,1-dichloroethylene. RMCLs also were established for 1,1,1-trichloroethylene (0.2 mg/l) and p-dichlorobenzene (0.75 mg/l). The approach used by EPA to establish these proposed RMCLs was to select zero levels for potential or known carcinogens. Proposed RMCLs for the two non-carcinogens were derived by calculating an AADI (Adjusted Acceptable Daily Intake) level and assuming a proportional exposure contribution from drinking water.

The basis for proposing and setting MCLs for drinking water contaminants traditionally has been feasibility of removal, taking costs into consideration. Application of certain treatment technologies (such as GAC), without consideration of costs, can generally remove chemicals to or below the limit of detection. Such low levels may result in extremely low risks to the general population and high cost per theoretical benefit. These risks may be lower than those on which EPA has acted in the past. Thus, a generally acceptable risk approach and the traditional feasibility and cost approaches represent alternative regulatory

mechanisms. Adoption of a generally acceptable risk approach would require changes in the Safe Drinking Water Act and is not within the limits of current authority. Such an approach is nonetheless considered in various sections of this economic impact analysis because Executive Order 12291 instructs that options outside the limits of current authority should not be excluded from analysis.

Benefits and costs for MCLs equivalent to 10^{-5} and 10^{-6} individual lifetime risk levels have been calculated. Benefit calculations and results are presented in Chapter 4 and costs are discussed in detail in Chapter 5. Results indicate that these MCL alternatives are essentially equivalent to MCL alternatives that were being considered by EPA on the basis of feasibility and cost.

A primary advantage of setting MCLs for VOCs is that it would provide consistent, national controls for these contaminants. In the absence of federal regulations, the control of volatile organic chemicals will provide uneven protection of the public health due to the inefficiency of the state-by-state, case-by-case approach.

Another direct benefit of federal regulations of VOCs is that these MCLs can be used as guidance by state and federal officials grappling with the question of "how clean is clean." Officials responsible for cleanup of waste sites under CERCLA (i.e., Superfund) commonly rely on drinking water standards as the basis for aquifer restoration and protection.

The majority of state officials want federal standards for VOCs. The kinds of activities undertaken by the EPA in setting standards -- extensive evaluation of analytical methods, exposure assessments, research and demonstration of feasibility of treatment technologies, and cost assessments -- is clearly beyond the capabilities possessed by many states.

State officials view this set of activities as the proper role for the EPA in the federal-state partnership.

3.4 Other Authorities to Protect Drinking Water

Section 1442 of SDWA authorizes EPA to provide technical assistance to states and publicly owned water systems in response to and alleviation of any emergency situation which the Administrator determines to be a substantial danger to public health. In the absence of appropriate state or local action, Section 1431 authorizes EPA to take such actions as the Administrator deems necessary to protect public health from a contaminant that may present an imminent and substantial endangerment to the health of persons.

The court system also provides an institutionalized means to achieve removal of VOCs from drinking water. Some water

systems, such as the one serving Acton, Massachusetts, have filed lawsuits against firms believed to be responsible for contamination of drinking water supplies as a result of improper disposal of waste materials. Citizen suits against polluters and public water systems appear to be a developing trend as public concern about chemicals in drinking water increases.

4. ASSESSMENT OF BENEFITS

4.1 Introduction

Assessment of the benefits of regulating exposure to potentially carcinogenic substances may be undertaken via a straightforward calculation of the number of cases of cancer that are likely to be produced in the U.S. population at varying levels of exposure. This calculation requires knowledge of the following: 1) the extent of exposure to the substance in the absence of regulation; 2) the degree of reduction in exposure that will be produced by different regulatory strategies; and 3) the probability, or risk, of getting cancer from a given amount of exposure. This chapter presents such an analysis for proposed primary drinking water standards for volatile organic chemicals (VOCs).

4.2 Baseline Exposure and Cancer Risk

As discussed in Chapter 2, the Office of Drinking Water has conducted a number of nationwide studies to determine the nature and extent of drinking water contamination with VOCs. Various summaries of this data are presented in Chapter 2.

As mentioned in the NOTE on page 2-1, there were originally nine chemicals that were the subject of this document. The background data in chapter 2 covers nine chemicals. Two were subsequently determined to be non-carcinogens. One of these determinations was made too late for the chemical to be deleted from the analysis supporting chapters 4 and 5. Eight chemicals are therefore covered in these chapters. This does not have a major effect on the results (see Exhibit 4-3).

The exposure data for all of the chemicals under examination display a similar pattern. Generally speaking, there are many water systems having low concentrations of these contaminants and relatively few water systems having high concentrations. Accordingly, the cumulative distribution of the number of contaminated water systems with respect to concentration, takes the form of a log-log curve. The data were fit to log-log equations to facilitate analysis of regulatory options across the entire range of concentrations. Equations were developed for each of twelve size classes of both ground and surface water systems.

These equations were used to estimate the total number of people exposed above a given concentration. If, for example, a maximum contaminant level (MCL) is set at 20 ug/l, the number of water systems in each size/source category having concentrations equal to or greater than 20 ug/l can be determined from the family of equations. Then, using the average population of the water systems within each category it is possible to convert from the number of water systems having VOC contamination above a given level to the number of people exposed to VOC concentrations above a given level. This produces a cumulative distri-

bution of the number of people exposed, as illustrated in Exhibit 4-1. These people are currently incurring a certain risk of cancer as a result of this exposure. An MCL established at this level would remove or reduce this exposure, thus avoiding an associated number of cancer cases per year. This is the appropriate measure of the benefit of the regulatory alternatives.

The exposure data may be used to develop an estimate of the baseline number of cases of cancer occurring annually from exposure to VOC's by multiplying the number of people exposed times the average concentration at which they are exposed times the annual risk of cancer per person per ug/l of exposure to each chemical. The formula is given in equation 1.

$$\text{Eq1: } \# \text{CASES} = \sum_i \sum_j \sum_k \# \text{EXPOSED}(i,j,k) \times \text{AVECONC}(k) \times \text{RISK}(i)$$

Where:

#EXPOSED(i,j,k) = number of people in size/source category (j) exposed to chemical (i) in concentration range (k)
 AVECONC(k) = the average concentration at which those people are exposed to [the mid-point of concentration range k]
 RISK(i) = the annual risk of cancer per person per ug/l of exposure to chemical (i)

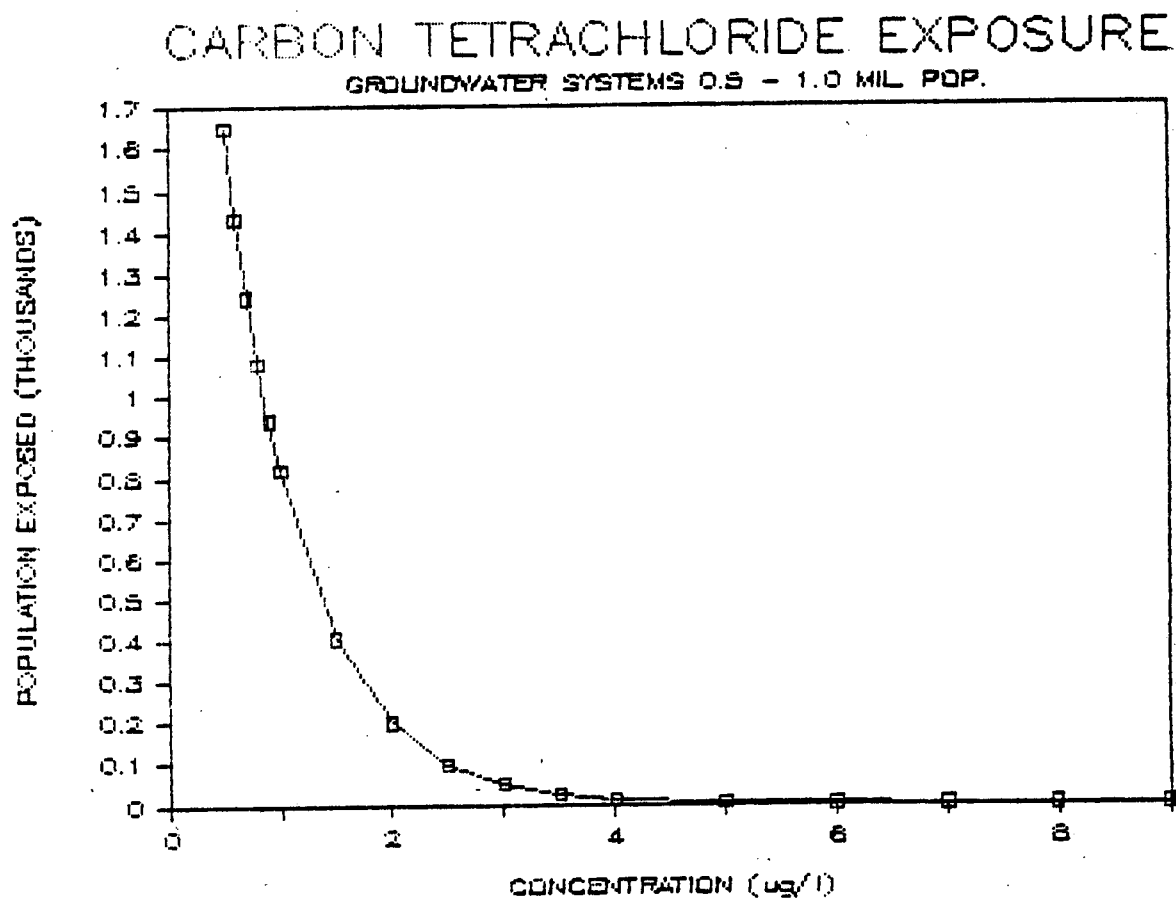
The risk factors, represented as RISK(i) in the above expression, are those developed by the Carcinogen Assessment Group (CAG). The CAG risk numbers for all of the chemicals are presented in Exhibit 2-3. The numbers given show the risks from both ingestion and inhalation exposure routes. As these risk numbers indicate, vinyl chloride is by far the most potent of the VOCs.

Using the above equation, it is estimated that there are a total of approximately fifty cancer cases induced annually by the combined effects of the eight VOCs. Of these fifty cases, thirty-seven are attributable to vinyl chloride.

The baseline estimate of fifty cases per year may represent the low end of the range due to analytical limitations in the measurement of VOCs. The analytical limit of detection in the surveys performed by the Office of Drinking Water was generally 0.5 ug/l. Given the shape of the cumulative distribution of occurrence for VOCs, exemplified by the curve for carbon tetrachloride in Exhibit 4-1, it is conceivable that there could be a significant amount of occurrence at concentrations below the analytical limit of detection (0.5 ug/l for most VOCs, but 1.0 ug/l for vinyl chloride). The estimate of fifty cases per year is based only on the occurrence above the analytical limit of detection.

EXHIBIT 4-1

EXAMPLE CUMULATIVE DISTRIBUTION OF
THE NUMBER OF PEOPLE EXPOSED TO VOCs



4.3 Methodology for Evaluation of Multiple Occurrence

Calculation of the baseline number of cancer cases by the procedure described in the preceding section is dependent upon the underlying assumption that the risks posed when two or more chemicals are present are additive. As indicated in the equation shown above, the number of cases is calculated separately for each chemical (i) and then the totals are added. This assumes that there are no synergistic or antagonistic effects. As explained in the preamble to the final RMCL regulation, EPA is unable to set a total or multiple contaminant RMCL. These contaminants may be synergistic, antagonistic, or additive in their effects and data on multiple VOC effects are not available. However, EPA believes that absent conclusive scientific data, it is necessary and protective to apply the individual MCLs to multiple exposure situations.

Given the assumption of additive risk, the above-described procedure provides a good estimate of the baseline number of cases of cancer produced in the aggregate. The procedure must be modified for purposes of estimating the benefits of alternative regulatory strategies, however, because it cannot provide information about the benefits of alternatives such as regulating the eight chemicals individually or of regulating on the basis of risk (not permitted under SDWA, but evaluated under E.O. 12291). For example, 87 percent of the time, trichloroethylene (TCE) is found in the presence of other VOCs. Because the treatment technologies are the same for all VOCs, a regulation affecting TCE will produce benefits greater than those indicated by the removal of TCE; some amount of the other VOCs present in the multiple occurrence cases also will be removed.

The multiple occurrence case is important since almost 50 percent of all VOC occurrence is joint occurrence. Moreover, vinyl chloride, the most potent VOC, appears to occur only in the presence of other VOCs. To permit analysis of the benefits of regulating individual VOCs and of the effect of regulatory alternatives on the multiple occurrence case, it is necessary to evaluate the benefits of single and multiple occurrences separately from one another.

Data on the occurrence of VOCs is inadequate to fully specify the joint probability distributions of the eight chemicals. It is not possible to know with certainty which chemicals are most likely to occur together and in what concentrations they are likely to be present. All that is known from the available data is the percent of the time that a given chemical is likely to occur singly and the percent of the time it is likely to occur jointly with others. Given this fundamental piece of information, it is possible to restructure the formula presented earlier as follows:

Eq2: #CASES =

$$\sum_i \sum_j \sum_k \#EXPOSED(i,j,k) \times \%SINGLE(i) \times AVECONC(k) \times RISK(i) \\ + \sum_i \sum_j \sum_k \#EXPOSED(m,j,k) \times AVECONC(k) \times RISK(m)$$

Where:

$\%SINGLE(i)$ = the percentage of the time that chemical (i) occurs by itself, with no other VOCs present
 $\#EXPOSED(m,j,k)$ = the number of people in size/source category (j) exposed to "typical mixture" (m) in concentration range (k)
 $RISK(m)$ = the annual risk of cancer per person per ug/l of "typical mixture" (m)

The above formula is based on the concept of defining a number of "typical mixtures," denoted by the index (m), to represent the multiple occurrence case. This approach requires two sets of assumptions:

- (1) The extent of the occurrence of these "typical mixtures" must be defined in terms of the number of people exposed and the concentrations to which they are exposed. This is reflected in the variable, $\#EXPOSED(m,j,k)$.
- (2) The degree of cancer risk represented by the constituents of each of the "typical mixtures" must be defined, reflected by the variable $RISK(m)$.

As noted earlier, trichloroethylene (TCE) occurs 87 percent of the time in the presence of other VOCs. As shown in the table in Exhibit 4-2, this is the largest proportion of multiple occurrence of all the VOCs. In addition, TCE is the most commonly occurring VOC. Thus it is appropriate to use the occurrence distribution of TCE as a stand-in for the occurrence of the multiple contaminant case. More formally, this assumption is as follows:

$$0.87 \times \#EXPOSED(TCE,j,k) = \#EXPOSED(m,j,k)$$

This yields an occurrence distribution which is given in terms of ug/l of TCE instead of ug/l of Total VOCs (TVOC). This discrepancy is compensated for by defining the $RISK(m)$ variable as the cancer risk of the "typical mixture" per ug/l of TCE instead of per ug/l of TVOC, simply a change in units.

There are two conceivable methods for assigning a value to the variable $RISK(m)$:

EXHIBIT 4-2

PROPORTIONS OF SINGLE (VS. MULTIPLE) OCCURRENCE
FOR INDIVIDUAL VOCs

Chemical -----	Percent Single -----
Trichloroethylene	13
Tetrachloroethylene	34
Carbon Tetrachloride	57
1,1,1-Trichloroethane	24
1,2-Dichloroethane	20
Benzene	60
1,1-Dichloroethylene	0
Vinyl Chloride	0

- (1) Bottom-up Approach -- Using the available occurrence data, "typical mixtures" can be constructed on the basis of judgment; specifying the constituents and concentrations which appear typical.
- (2) Top-down Approach -- Using the total number of cancer cases per year estimated by the aggregate approach in Equation 1 (50 cases) as a control total, an amount of risk can be assigned to RISK(m) which will be just sufficient to cause Equation 2 to produce the same result; this is the implied amount of risk that should characterize the "average typical mixture."

The top-down approach is clearly the preferred choice of the two because it is possible to "calibrate" to the result produced by the aggregate method. The results of this calibration step are summarized in Exhibit 4-3 which compares the risk factors for the individual VOCs to the risk factor derived for the "average" "typical mixture" by this procedure.

The data presented in Exhibit 4-3 allows a check on the realism of the top-down results. The "typical mixture" displays more risk than many of the individual constituents. The calibration result might be interpreted as representing the mid-point between two extremes; low risk mixtures featuring chemicals such as trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane; and, high risk mixtures featuring chemicals such as vinyl chloride and carbon tetrachloride. On the other hand, there is growing evidence that vinyl chloride may be a by-product of biological degradation of the other VOCs. If this hypothesis is correct, small concentrations of vinyl chloride may be expected in many cases of VOC occurrence (when likely parent compounds are present), which would also account for the calibration result.

By contrast, a bottom-up approach to assessing the multiple occurrence case was selected as a basis for treatment cost estimates used in Chapter 5. On the cost side, however, the problem is somewhat different since it is assumed that the same treatment techniques provide some level of removal for all VOCs. Thus, all that was necessary was a set of assumptions representative of the type of equipment that would have to be installed. Cost estimates for the multiple contaminant case were based on the assumption that carbon usage rates are additive for granular activated carbon and on the most difficult constituent to remove for aeration treatments.

4.4 Analysis of Regulatory Alternatives

Regulation of contaminants by the Office of Drinking Water takes the form of Maximum Contaminant Levels (MCLs) which stipulate the level to which contaminants must be removed. The methodology described in the preceding two sections applies to calculation of the baseline number of cases of cancer that will result in the absence of regulation. This methodology must be modified

EXHIBIT 4-3

ANNUAL RISK OF CANCER FACTORS FOR INDIVIDUAL VOCs AND THE MULTIPLE CONTAMINANT CASE

Chemical -----	Risk Factor* -----
Trichloroethylene	1.6 * 10 ⁻⁸
Tetrachloroethylene	2.9 * 10 ⁻⁸
Carbon Tetrachloride	1.1 * 10 ⁻⁷
1,1,1-Trichloroethane**	1.3 * 10 ⁻⁹
1,2-Dichloroethane	5.7 * 10 ⁻⁸
Benzene	4.3 * 10 ⁻⁸
1,1-Dichloroethylene	1.2 * 10 ⁻⁷
Vinyl Chloride	1.9 * 10 ⁻⁶
Multiple Contaminant Case	7.7 * 10 ⁻⁷

* Annual risk of cancer per person per ug/l
(All figures are rounded.)

** Determined to be a non-carcinogen during the course of preparation of this document. It was included in the analysis of the total number of cases of cancer avoided. As evident from the risk factor, it does not have a major effect on the results.

to calculate the number of cases that will be avoided as a result of alternative regulatory actions. This is accomplished by replacing the variable AVECONC(k) with the expression:

$$\{AVECONC(k)-MCL(i)\}$$

This substitution causes Equation 2 to produce an estimate of the cases avoided per year as a result of alternative MCLs. The result produced by this procedure reflects a strict interpretation of the effect an MCL will have on the water industry; that is, it assumes that water systems will only install the minimum amount of treatment that is required of them. In reality, many water systems may opt to treat to levels below the MCL in an attempt to completely remove organic contaminants. This pattern has been followed in a number of cases of VOC contamination. (It is noted however that MCLs could not be effectively monitored and enforced at these levels due to the limitations of analytical methods of detection.) Non-treatment alternatives such as development of alternative water sources also are popular solutions. Public attitudes regarding this form of contamination can influence the treatment decision in the direction of more thorough removal.

To accommodate this uncertainty in treatment selection, the results of the analysis are presented as the high and low ends of a range. The high estimate is the result produced when the above-described substitution in Equation 2 is not made, reflecting the assumption that all water systems affected by the MCLs would attempt to treat to levels below the limit of detection in the best available research labs. The low estimate is the result produced when the above-described substitution is made in Equation 2, implying an assumption of minimum compliance where all water systems treat only to the level of the MCL.

Exhibit 4-4 presents estimates of the total number of cancer cases that would be avoided at a national level as a result of alternative MCLs. MCLs evaluated range from 0.5 ug/l (the limit of detection) to 100 ug/l. For simplicity, the totals represent the case in which the MCLs are set at the same level for all eight VOCs. This need not always be the case, however, and results also are presented for "risk-based" MCLs where the MCLs differ for each contaminant but each is controlled to the same level of risk. "Risk-based" MCLs are evaluated to represent regulatory strategies designed to obtain uniform 10^{-5} and 10^{-6} risk levels for all contaminants. (It is noted that, under the Safe Drinking Water Act, a risk-based approach to setting MCLs is not permitted. However, Executive Order 12291 requires consideration of regulatory alternatives that are outside current legislative authority. Thus, MCLs equivalent to 10^{-5} and 10^{-6} risk levels were studied as part of the development of this Economic Impact Analysis.)

The results in Exhibit 4-4 show a total of 49 cases of cancer per year that would be avoided under an MCL of 0.5 ug/l. This differs slightly from the control total of 50 cases obtained with Equation 1 due to rounding errors inherent in the calibration procedures described above.

EXHIBIT 4-4

TOTAL NUMBER OF CANCER CASES AVOIDED PER YEAR
UNDER ALTERNATIVE MCLs

MCL	No. Cancer Cases Avoided Per Year	
	High Estimate	Low Estimate
10 ⁻⁶	42	38
10 ⁻⁵	32	26
0.5 ug/l	49	49
1.0	42	38
5.0	32	27
10.0	31	23
20.0	29	16
25.0	29	13
50.0	10	4
100.0	1	0

Since 0.5 ug/l is the analytical limit of detection (for most VOCs), the answer of 49 cases is the same for both the high and low estimates. This results from the engineering reality that designing for the limit of detection is the technical equivalent of designing for zero. The practical effect of detection limits will carry over to other very low MCLs as well. At an MCL of 1.0 ug/l, for example, it is likely that many treatment systems would be designed the same way if the MCL were zero. Hence, the low estimate of cancer cases avoided at an MCL of 1.0 ug/l should probably be ignored in favor of the high estimate. For MCLs of 5.0 ug/l and below, there will be a tendency to design for zero to compensate for variability in influent concentration. As a result, the high estimates of the number of cancer cases avoided are closer to the correct figure.

Exhibit 4-4 also presents results for "risk-based" MCLs intended to achieve 10^{-5} and 10^{-6} risk levels. The 10^{-6} MCLs are in the vicinity of 1.0 ug/l and the 10^{-5} MCLs are in the vicinity of 5.0 ug/l. It is therefore no surprise that the total number of cancer cases avoided by these two alternatives are very similar to those achieved by MCLs of 1.0 and 5.0 ug/l. It may be concluded from this analysis that MCLs of 1.0 and 5.0 ug/l imply roughly the same benefits as "risk-based" MCLs of 10^{-6} and 10^{-5} , respectively.

Exhibit 4-5 presents a breakdown of the results by four different system size categories. The table shows that most of the benefits reside in the larger system size categories. This is a product of the simple fact that there are many more people exposed to cancer risk as a result of VOC contamination in larger size systems.

Similar analysis of costs by system size categories presented in Chapter 5 shows that the smaller system size categories bear a disproportionately larger share of the total costs. Therefore, an alternative regulatory strategy that would provide a variance to systems under 10,000 population also was studied. (Such variances are not permitted on the basis of cost or system size under the SDWA. However, the alternative was studied in complying with Executive Order 12291.) The results show that the effect of such a variance would be to reduce the total national benefit from 49 to 42 cancer cases avoided per year at an MCL of 0.5 ug/l. The corresponding reduction in total annual costs would be approximately one-third.

A final alternative approach considered was that of having a separate TVOC (Total VOCs) MCL to assure adequate treatment in the multiple contaminant cases. It is conceivable that a mixture of VOCs could be treated to the point where the MCLs of the individual constituents are satisfied but the additive effect of the residuals still amounts to a significant exposure. A separate MCL for TVOC concentration would be one approach to dealing with this problem (assuming the implied monitoring requirement would be manageable).

EXHIBIT 4-5

TOTAL NUMBER OF CANCER CASES
 AVOIDED PER YEAR BY SYSTEM SIZE

MCL	25-100		501-3301		3301-50K		50K+	
	High Est.	Low Est.	High Est.	Low Est.	High Est.	Low Est.	High Est.	Low Est.
10 ⁻⁶	1	1	3	2	20	18	18	16
10 ⁻⁵	1	0	2	1	14	11	16	13
0.5 ug/l	1	1	3	3	23	23	22	22
1.0	1	1	3	2	20	18	18	16
5.0	1	1	2	1	14	12	16	13
10.0	1	0	2	1	13	10	15	12
20.0	1	0	1	1	12	7	15	8
25.0	0	0	1	1	12	6	15	7
50.0	0	0	1	0	7	3	1	1
100.0	0	0	0	0	0	0	0	0

This concept was analyzed; it was found to not have a significant effect on the total benefits. The reason stems from the technical nature of the treatment technologies employed to remove VOCs. For the most part, both aeration and activated carbon approaches will remove all VOCs present in a mixture to low enough levels that the residual does not represent a significant exposure level.

4.5 Uncertainties in Benefits Assessment

There are many sources of uncertainty in judging the health effects of specific chemicals and in estimating the risks due to these chemicals' presence in environmental media. Ideally, one would like to separate the various sources of uncertainty and then estimate the magnitude of each using statistical methods. Typically, however, this requires knowledge of the frequency distribution of the relevant variables, and this knowledge is usually sparse. It is generally easier to estimate uncertainties in risk using results based on experimental experience, or obtained by consulting experts -- the so-called "Delphi" method. While each of these approaches has its drawbacks, the lack of statistical data often gives scientists and policy-makers few other alternatives. The discussion below attempts to identify the factors that contribute to the overall uncertainty and to describe what is known about the likely magnitude of each factor.

A widely used technique for estimating the risk corresponding to a particular dose level involves the formulation of a dose-response model. Models such as the probit, one-hit and multistage models have been investigated in detail over the past decade, and these and other models have been commonly postulated as useful approximations for estimating risk due to a particular dose level. A problem arises, however, in using these models to extrapolate from the results obtained with laboratory animals to the low doses typical of human exposures (i.e., those producing lifetime risks in the range of 10^{-4} to 10^{-6} per person). Statistical procedures such as those described above are only valid within the range of the original experimental data; when the procedures are used outside this range, extrapolation errors result. Furthermore, the size and direction of these errors vary with the choice of model used; therefore, the estimation of human risk can vary widely with the choice of extrapolation model. At low doses, the differences among predictions range over as much as five orders of magnitude (100,000 times).

In addition to the problems posed by the choice of extrapolation model, other factors introduce uncertainty into the estimation of risk and health impacts. These include:

- Experimental error. Risk factors for animals are obtained from bioassay experiments. Inappropriate choices of test species or protocols, or improper laboratory procedures, can lead to inaccurate estimates of risk factors. Even where these problems are absent, the application of

statistical analysis to a sample of animals yields finite confidence intervals around the point-estimate result.

- Unit exposure. Calculations of human exposure generally assume that 2 liters of water are consumed per day. In the case of VOCs, it has been further assumed that an amount of the contaminant equivalent to that found in two liters of water is inhaled daily by each person, as a result of aeration from shower water, etc. The bases for these assumptions have not been documented as fully as possible, and it is to be expected that they are another source of possible error.
- o Numbers of people exposed. The distribution of population by concentration of VOC is derived from surveys of limited samples of water systems. The 95 percent confidence interval in the number of people exposed to a given concentration level typically ranges from ± 25 percent of the mean at low concentrations (where sample sizes are relatively large) to greater than ± 100 percent of the mean at high contaminant levels (for which only small sample sizes are available; see EPA, "Occurrence [of VOCs] in Drinking Water, Food, and Air," 1983). In addition, the estimates of the proportion of people exposed to a given VOC alone versus those exposed to the same VOC in conjunction with other VOCs is known only from limited surveys of groundwater systems.

Exhibit 4-6 lists some of the major contributors to uncertainty in estimating risks and health impacts, and gives estimates of the magnitude of the resulting uncertainty to the extent it is possible to do so.

Overall, it has been estimated that, excluding the five-order-of-magnitude uncertainty in the extrapolation model, the remaining uncertainty in any particular risk estimate may be as high as two or three orders of magnitude (see Uncertainty in the Regulatory Decision-Making Process, U.S. EPA Office of Drinking Water, September 28, 1984).

In order to account for these sources of uncertainty in the estimates of benefits accruing to VOC regulations, the following assumptions were made:

- o Uncertainty due to the choice of a risk extrapolation model were ignored. The Agency has standardized on a linealized multi-stage model. Therefore, the risk estimates for VOCs will at least be consistent with those for other substances and other media.
- o The remaining uncertainty in the unit risk estimates derived by the Carcinogen Assessment Group was assumed to have a standard error of either 20 percent, 50 percent, or 80 percent of the value given. (The CAG figures

EXHIBIT 4-6

SELECTED FACTORS CONTRIBUTING TO UNCERTAINTY IN RISK ESTIMATION

(Adapted from Uncertainty in the Regulatory Decision-Making Process, U.S. EPA Office of Drinking Water September 28, 1984)

<u>Factor</u>	<u>Possible Contribution to Uncertainty</u>
1. Diet of test animals	\pm factor of 2
2. Laboratory procedure	- 2 orders of magnitude
3. Decision criteria re carcinogenicity	+ 2 orders of magnitude
4. Synergism/antagonism among substances	Unknown
5. Number of animals used and distribution by dosage	\pm 2 orders of magnitude
6. Selection of experimental dose levels	\pm 2 orders of magnitude
7. Choice of extrapolation model	Possibly \pm 5 orders of magnitude; see text
8. Statistical noise	\pm factor of 2
9. Other:	
Ability of experimental personnel	
Choice of species, sex, age and strain of test animals	
Diseases in test animals	
Lack of corresponding human tissues	
Inappropriate statistical methodology	
Choice of significance level	
	Errors in any of these factors can cause a given experiment to be invalid in whole or in part

A more detailed breakdown is given in Techniques for the Assessment of Carcinogenic Risk to the U.S. Population Due to Exposure from Selected Volatile Organic Compounds from Drinking Water Via the Ingestion, Inhalation and Dermal Routes; Cothorn, Coniglio, and Marcus; EPA 570/9-85-001.

themselves are conservative, representing the upper 95 percent confidence limit of the experimental results extrapolated to humans. The size of the confidence limit itself was not available.)

- o The standard errors in the occurrence data were derived by fitting log-log regression curves to the distributions of population by concentration, as obtained from the reference cited above. Separate regressions were estimated for each VOC and for each water source (surface and ground). The standard errors of the regressions were a few percent of the point estimates at low concentrations, ranging up to one or two hundred percent at high concentrations.
- o For each VOC, the standard error in the proportion of exposures represented by single occurrences was estimated directly from the Ground Water System Survey data. The standard error was always less than one percent of the proportion.

For any VOC occurring singly, the expected number of cancer cases in the population within a given concentration interval is derived by multiplying the exposed population by the unit risk factor and again by the mean concentration in the interval and the proportion of single occurrences. (For the multiple occurrence case, the last term is replaced by one minus the single-occurrence proportion for TCE.) Because the terms are multiplicative, the standard errors described above can be combined using the following expression:

$$S_i^2 = (S_p^2 + \bar{P}^2) * (S_r^2 + \bar{R}^2) * (S_c^2 + \bar{C}^2) * (S_f^2 + \bar{F}^2) - \bar{P}^2 * \bar{S}^2 * \bar{C}^2 * \bar{F}^2$$

where:

S_i = standard error of the estimate of cancer cases in the exposure interval i

\bar{P} = mean population exposed in the interval

\bar{R} = mean point estimate of the unit risk

\bar{C} = average concentration in the interval

\bar{F} = proportion of all exposures that are single exposures.

The resulting standard errors were combined (by taking the square root of the sum of their squares) over all exposure intervals and VOCs to obtain the standard error in the total number of cancer cases estimated to occur from exposure to the VOCs in

question. This total standard error was approximately 40 percent of the point estimate of the number of cancer cases. This is equivalent to the standard error in the number of cases avoided if the MCL were to be set to zero for all VOCs.

The standard errors in cases avoided for specific MCLs other than zero were not explicitly computed. For any MCL below 20 ug/l, however, these standard errors would be about the same proportion of the mean as in the case of a zero MCL. This is because the vast majority of the total uncertainty is attributable to exposures higher than 20 ug/l, which would be eliminated in either case. Total uncertainty was found to be dominated by the errors in the exposure data. The standard errors in the various estimates of unit cancer risk, which were allowed to vary between 20 percent and 80 percent of the mean, contributed negligibly to the standard error in the total number of cases avoided.

<u>Influent Levels</u> (ug/l)	<u>Effluent Levels</u> (ug/l)
0.5	0.5
5.0	5.0
20.0	20.0
50.0	50.0
100.0	

The model was run separately for each VOC and effluent level, generating, for each VOC-MCL combination, capital and O&M costs of compliance for each of the 24 industry segments. Each pair of capital and O&M costs was reduced to an equivalent annualized cost, using an appropriate rate of interest (interest rates are discussed further below). The annualization expression used was:

$$A_1 = F_1 \times [(1-(1+i)^{-n})/i]^{-1} + V_1$$

where:

A_1 = the annualized cost
 i = an appropriate interest rate, and
 n = the useful life of the capital equipment.

These annualized costs were then summed for surface and groundwater systems within each size category. Finally, a regression curve was fitted to the annualized PTM results for each VOC, with annualized cost as the dependent variable and MCL as the independent variable. The resulting expressions enabled the analyst to obtain an annualized cost of compliance for any arbitrary MCL. For each VOC, separate regressions were run for each of the 12 system size categories.

In all, 84 cost regressions were estimated (six individual VOCs plus one multiple occurrence case, times 12 system size categories). For half of these, a log-log curve was fitted by the method of ordinary least squares. For the remainder, a semi-log curve was used because it provided a better fit to the PTM results. The algebraic forms of the two equations are as follows:

$$\text{Log-log: } \ln(Y) = a + b \times \ln(\text{MCL})$$

$$\text{Semi-Log: } Y = a + b \times \ln(\text{MCL}).$$

In the vast majority of cases, the value of R^2 is in excess of 0.98.

Note that this interpolation procedure lumps capital and O&M costs together into an annualized cost. Although PTM itself produces separate estimates for capital and O&M costs, it was not possible to obtain statistically valid regression results

for O&M costs alone from the PTm output. Therefore, the method described above was chosen as the best way of incorporating information about both types of costs in the national cost estimates.

In addition to compliance costs, PTm generates estimates of the numbers of systems requiring treatment to achieve a given MCL for a particular VOC. Like the cost calculations, these estimates are computed for a discrete set of influent and effluent levels. Therefore, to generalize the results to any arbitrary MCL, regression curves were fitted to the PTm number-of-systems outputs in a fashion similar to that described above, with number of systems as the dependent variable and MCL as the independent variable. In order to obtain a good fit, however, it was necessary to aggregate the PTm outputs from 12 size categories down to four.

5.2.2 Inputs and Assumptions

The PTm model was run for seven contaminant conditions. Six of these represent specific VOCs as single occurrences; the last represents all multiple occurrences. Single and multiple occurrences had to be treated separately to avoid double-counting the costs of removing VOCs that occur in association with others that are also being removed. The single-occurrence cases were as follows:

- Trichloroethylene
- Tetrachloroethylene
- Carbon Tetrachloride
- 1,1,1-Trichloroethane
- Benzene
- 1,2-Dichloroethane.

Vinyl chloride and 1,1-dichloroethylene, two of the VOCs being regulated by this action, do not occur singly. Therefore, their costs of removal were not specifically computed by PTm; instead, they were subsumed into the "multiple occurrence" case. The relative frequencies of occurrence of the eight VOCs of interest as single and multiple occurrences were obtained for groundwater systems from EPA's Ground Water Supply Survey; the same proportions were used to extrapolate these occurrences to surface water systems. The frequencies of occurrence have been summarized in Exhibit 4-2 above.

For each of the single-occurrence VOCs, a distribution of drinking water systems by raw water concentration was obtained from the series of EPA reports entitled, Occurrence [of VOCs] in Drinking Water, Food, and Air. Separate distributions were obtained for each water source (surface and ground) and system size category; they are summarized in Chapter 2. No data exist, however, on the composition of multiple occurrences or their frequency distribution by size category and influent level. Therefore, for the multiple occurrence case, the distribution

of contaminated systems was assumed to have the same shape as the distribution of (single-occurrence) trichloroethylene (TCE). TCE is one of the two most prevalent VOCs in drinking water, and is found in association with other VOCs 87 percent of the time. (The other substances in the multiple occurrence case were assumed, on the basis of engineering judgment to be 1,1,1-trichloroethane and tetrachloroethylene.) The distributions thus derived were used to generate the frequency-of-occurrence portion of the decision tree matrix, one of the inputs to PTM (see Section 5.2.1 above).

The probabilities that systems of a given size and water source would choose a particular treatment, given a specified influent level and MCL, were generated by convening a panel of water supply engineers, water chemists, and economists familiar with the decision making processes of the water supply industry. The panel considered, for each VOC, system size, influent level and MCL, the relative unit cost and effectiveness of each available control measure. The panel participants also applied their practical experience in estimating the frequency with which each treatment would be chosen. Their probability estimates were entered in the remaining portion of the PTM decision tree matrix.

The costs of treatment per unit of water treated were estimated for each treatment method. Treatment methods considered included the following:

- Granular activated carbon
- Packed tower aeration
- Diffused air aeration
- Slat tray aeration
- Powdered activated carbon
- Wellfield management (for groundwater systems only)
- Source protection (for surface water systems only)
- Regionalization
- Use of an alternative source
- Point of use treatment devices

These methods of treatment are discussed further in Chapter 2. Also, complete technical analyses of these options may be found in Technologies and Costs for the Removal of Volatile Organic Chemicals for Potable Water Supplies, U.S. EPA, Office of Drinking Water, December 13, 1984.

Capital costs per unit of capacity and O&M costs per unit of production were generated separately for each combination of VOC, treatment method, influent level, and effluent level. For the multiple occurrence case, the following contaminant levels were assumed for the purpose of generating unit costs:

Influent Concentration

Trichloroethylene	Tetrachloroethylene	1,1,1-Trichloroethane
100 ug/l	50 ug/l	50 ug/l
50	20	20
20	5	5
5	5	5

The results of the unit cost calculations were entered into the treatment cost matrix of the PTm model. In that matrix, "No Treatment" was also an allowable option, for those systems not contaminated by VOCs or for those that the panel of experts judged to be physically incapable of complying.

In addition to the cost and probability inputs just described, PTm requires the user to specify detailed operating and financial information on the water supply industry. These inputs, however, do not change from run to run and are independent of the VOCs, treatments, or costs being considered. The required data were obtained from EPA's Survey of Operating and Financial Characteristics of Community Water Systems (U.S. EPA, Office of Drinking Water, 1982).

To annualize the PTm outputs for purposes of generating regression equations, it was necessary to select an appropriate interest rate. Two options existed. The first was the social interest rate, reflecting the opportunity cost of resources assuming no risk for alternative investments. The second was the market rate, reflecting the actual cost of capital to drinking water systems, and therefore incorporating considerations of risk and imperfect access to capital markets. The social rate was chosen for purposes of annualization, and the final annualized costs of compliance were then adjusted appropriately to obtain annualized market costs. The social interest rate was determined from a one-year average rate for three-month treasury bills (8.64 percent) adjusted for the same year's inflation rate (4.2 percent) to yield a (rounded) value of 4.4 percent. The market rate of interest was obtained from current yields on municipal bonds and corporate bonds; adjusted for inflation, it was found to be 7.5 percent for small systems (those serving fewer than 50,000 people) and 6.2 percent for large systems.

Also, for the annualization procedure, a useful lifetime of 20 years was selected. This was believed to be appropriate for the equipment used by drinking water systems.

5.2.3 Results

Exhibit 5-1 shows the national cost of meeting VOC maximum contaminant levels using market-based interest rates. The estimates

TOTAL ANNUAL MARKET COSTS OF VOC REMOVAL
 (Figures in millions of 1983 dollars)

Small system interest rate (inflation free) = 7.5%

Large system interest rate (inflation free) = 6.2%

n = 20 yrs.

System Size (Pop.):	25-500	501-3300	3301-50K	50K+	Total
<hr/>					
10-5 Risk					
Annualized Costs	3.2	5.5	10.3	10.9	29.9
Present Value	32.8	56.2	116.3	123.0	328.3
10-6 Risk					
Annualized Costs	10.9	20.5	34.7	42.6	108.8
Present Value	111.3	209.5	391.4	481.2	1193.4
MCL = 0.5 ug/l					
Annualized Costs	18.0	35.0	57.4	64.1	174.5
Present Value	183.1	356.5	647.9	723.6	1911.1
MCL = 1 ug/l					
Annualized Costs	11.5	21.3	35.6	43.7	112.1
Present Value	116.8	217.6	402.1	493.2	1229.5
MCL = 5 ug/l					
Annualized Costs	4.1	6.2	9.9	3.5	23.7
Present Value	42.0	63.1	111.3	39.6	256.0
MCL = 10 ug/l					
Annualized Costs	2.6	3.3	5.5	0.7	12.6
Present Value	26.5	38.5	62.6	7.8	135.3
MCL = 20 ug/l					
Annualized Costs	1.7	2.6	3.4	0.4	8.1
Present Value	17.3	26.9	38.6	4.3	87.1
MCL = 25 ug/l					
Annualized Costs	1.5	2.3	2.9	0.3	7.0
Present Value	15.2	23.3	33.0	3.5	75.1
MCL = 50 ug/l					
Annualized Costs	1.0	1.5	1.8	0.2	4.5
Present Value	10.0	15.1	20.5	2.0	47.6
MCL = 100 ug/l					
Annualized Costs	0.7	0.9	1.1	0.1	2.8
Present Value	6.7	9.7	12.8	1.1	30.2

are expressed in terms of annualized cost (i.e., the annual payment that would cover operating costs and a 20 year mortgage on the capital facilities at the stated interest rate) and present value (i.e., capital cost plus the discounted stream of annual O&M costs). The equivalent costs using a social interest rate are presented in Exhibit 5-2. These costs (and those presented in the remainder of this chapter) represent totals over all of the regulated VOCs.

The number of systems in the nation requiring treatment to attain a given MCL was computed by PTM for four specific MCLs (0.5, 5, 20, and 50 ug/l) and interpolated to other MCLs using the regression technique described above. The results are presented in Exhibit 5-3, rounded off to the nearest whole system.

Exhibit 5-4 shows the annual cost of removal (computed using the market interest rates) per system requiring treatment. Within each of the three smallest size categories, the average cost per system is fairly stable over all MCLs. This is because, as the MCL decreases, the cost of treating any given system increases, while new systems that are relatively inexpensive to treat are "captured" by the regulation at a roughly compensating rate. The largest size category is an exception, however. Here, the addition of new systems to the population of those that must treat does not compensate for the increased cost of treating an individual system as the MCL decreases. Therefore, the average per system cost rises with decreasing MCL in this size category.

Using statistics on water production per system and per household from the Survey of Operating and Financial Characteristics of Community Water Systems (U.S. EPA, Office of Drinking Water, 1982), the costs per system were transformed into annual costs per 1000 gallons and per household. These are shown in Exhibits 5-5 and 5-6 respectively. The first of these exhibits shows the annual treatment related increase in the cost of water production to the utility, assuming that the average utility pays the market interest rates used in the annualization computation. The second exhibit gives the equivalent average increase in the yearly water bill for homes within each size category, assuming that all of the treatment related costs are passed on to the customer without any markup by the utility. The impacts on both the utility and the consumer increase markedly with decreasing system size.

The costs of an alternative regulatory strategy also were analyzed. This alternative maintained the same MCLs as the basic strategy, but allowed variances for all systems serving fewer than 10,000 people. (Such a strategy is not permitted under SDWA but was evaluated under Executive Order 12291.) The estimated national costs for this strategy were approximately 60 percent of the costs for the basic strategy at MCLs of 0.5 and 1 ug/l. At 5 ug/l, the ratio dropped to 44 percent. At

TOTAL ANNUAL SOCIAL COSTS OF VOC REMOVAL

(Figures in millions of 1983 dollars)

interest rate (inflation free) = 4.4%
n = 20 yrs.

System Size (Pop.):	25-500	501-3300	3301-50K	50K+	Total
<hr/>					
10-5 Risk					
Annualized Costs	2.6	4.9	9.3	10.1	27.0
Present Value	34.3	64.4	122.6	132.7	354.0
10-6 Risk					
Annualized Costs	8.9	17.1	31.9	40.8	98.7
Present Value	116.8	224.0	419.1	535.5	1295.4
MCL = 0.5 ug/l					
Annualized Costs	14.7	28.3	53.0	61.5	157.4
Present Value	192.4	371.6	694.8	806.7	2065.5
MCL = 1 ug/l					
Annualized Costs	9.3	17.7	32.8	41.8	101.7
Present Value	122.6	232.6	430.4	548.8	1334.4
MCL = 5 ug/l					
Annualized Costs	3.3	5.6	8.9	3.3	21.2
Present Value	43.8	73.9	117.3	43.0	278.0
MCL = 10 ug/l					
Annualized Costs	2.1	3.4	5.0	0.6	11.1
Present Value	27.7	44.1	65.9	8.4	146.1
MCL = 20 ug/l					
Annualized Costs	1.4	2.1	3.1	0.3	7.0
Present Value	18.3	28.0	40.6	4.5	91.4
MCL = 25 ug/l					
Annualized Costs	1.2	1.8	2.7	0.3	6.0
Present Value	16.0	24.2	34.8	3.7	78.7
MCL = 50 ug/l					
Annualized Costs	0.8	1.2	1.6	0.2	3.8
Present Value	10.6	15.5	21.6	2.0	49.6
MCL = 100 ug/l					
Annualized Costs	0.5	0.8	1.0	0.1	2.4
Present Value	7.1	9.9	13.4	1.1	31.5

EXHIBIT 5-3

NUMBER OF SYSTEMS REQUIRED TO REMOVE VOCs

RISK or MCL (ug/l)	System Size (Pop.):				Total
	25- 500	501- 3300	3301- 50K	50K+	
10-5	653	279	146	17	1095
10-6	2127	863	555	66	3610
.5 ug/l	3483	1406	989	126	6004
1 ug/l	2246	906	575	68	3794
5 ug/l	862	303	168	15	1347
10 ug/l	506	182	100	7	795
20 ug/l	332	119	61	4	516
25 ug/l	290	104	52	3	450
50 ug/l	192	68	32	2	294
100 ug/l	127	45	20	1	193

EXHIBIT 5-4

ANNUAL MARKET COSTS PER AFFECTED WATER SYSTEM

(Figures in thousands of 1983 dollars)

RISK or MCL (ug/l)	System Size (Pop):				Average
	25- 500	501- 3300	3301- 50K	50K+	
10-5	4.9	19.8	70.5	655.4	27.3
10-6	5.1	23.8	62.5	646.9	30.1
.5 ug/l	5.2	24.9	58.1	507.8	29.1
1 ug/l	5.1	23.6	62.0	645.8	29.5
5 ug/l	4.8	20.4	58.7	239.9	17.6
10 ug/l	5.1	20.7	55.6	93.0	15.8
20 ug/l	5.1	22.1	56.1	96.7	15.8
25 ug/l	5.1	22.0	56.2	98.0	15.6
50 ug/l	5.1	21.6	56.5	105.7	15.2
100 ug/l	5.2	21.0	56.6	108.5	14.7

EXHIBIT 5-5

ANNUAL MARKET COSTS PER UNIT OF PRODUCTION

(Only water systems requiring VOC removal are included.)
(Figures are in \$'s/1000 gal)

RISK or MCL (ug/l)	System Size (Pop):				Average
	25- 500	501- 3300	3301- 50K	50K+	
10-5	0.56	0.28	0.09	0.04	0.08
10-6	0.58	0.33	0.08	0.04	0.07
.5 ug/l	0.59	0.35	0.07	0.03	0.06
1 ug/l	0.58	0.33	0.08	0.04	0.07
5 ug/l	0.54	0.29	0.07	0.02	0.06
10 ug/l	0.58	0.29	0.07	0.01	0.06
20 ug/l	0.58	0.31	0.07	0.01	0.07
25 ug/l	0.58	0.31	0.07	0.01	0.07
50 ug/l	0.58	0.30	0.07	0.01	0.08
100 ug/l	0.59	0.29	0.07	0.01	0.08
1983 Ave. Cost of Production	2.84	1.83	1.23	0.89	

EXHIBIT 5-6

ANNUAL MARKET COST OF VOC REMOVAL PER HOUSEHOLD

(Only affected water systems are included.)
(Figures are in \$'s/household/yr.)

RISK or MCL (ug/l)	System Size (Pop):				Average
	25- 500	501- 3300	3301- 50K	50K+	
10-5	93.46	39.74	13.88	8.45	13.57
10-6	97.36	47.87	12.31	8.34	12.84
.5 ug/l	97.79	50.00	11.43	6.54	11.11
1 ug/l	96.69	47.36	12.20	8.32	12.83
5 ug/l	90.74	41.07	11.55	3.09	10.84
10 ug/l	97.40	41.56	10.94	1.20	10.51
20 ug/l	97.16	44.51	11.03	1.25	11.78
25 ug/l	97.21	44.20	11.06	1.26	12.10
50 ug/l	97.25	43.48	11.12	1.36	13.15
100 ug/l	97.75	42.19	11.14	1.40	14.11

all higher MCLs, the ratio of alternate strategy costs to those of the basic strategy was close to 30 percent.

Another alternative regulatory strategy is that of having an additional TVOC MCL applicable to the multiple contaminant case. Analysis of this concept showed that a nearly threefold increase in total social cost would be produced at the 10^{-5} level while costs at the 10^{-6} level are unaffected because 10^{-6} is stringent enough to provide an equivalent level of VOC removal.

5.3 Uncertainties in Cost Assessment

There is a degree of uncertainty inherent in any estimate of compliance costs. This uncertainty arises from two general sources.

- o Only a small number of observations are available for many of the factors that contribute to overall costs. These factors include the following:

- the frequency and degree of contamination from any given VOC;
- the unit costs of available treatment technologies;
- the likelihood that a system will select a particular treatment technology;

and others:

- o Some of the factors that contribute to costs, such as system growth rates, cannot be observed more than once.

The errors in the estimates of these input variables contribute to the overall uncertainty in the computed total compliance cost.

In order to estimate the magnitude of the uncertainty in the final result, it is normally necessary to take account explicitly of the errors in the independent variables used in the model. This has been done elsewhere for a hypothetical, but realistic, application of PTm (see Uncertainty in the Regulatory Decision-making Process, U.S. EPA, Office of Drinking Water, September 28, 1984). In the present case, however, the computation of total cost is based on a regression equation that itself incorporates the errors inherent in the PTm model results. Therefore, one can compute the uncertainty in the predicted value of national cost directly from the standard error of the prediction equation. This is accomplished using the formula:

$$s_n^2 = s^2 \left[1 + 1/T + (x - \bar{x})^2 / \sum_t^T (x_t - \bar{x})^2 \right]$$

where:

s_n = standard error in the national cost

s = standard error in the regression equation

x = MCL for which a cost prediction is desired

\bar{x} = average value of all MCLs

x_t = MCLs at which the observed MCLs were computed

T = total number of observations.

This expression gives the following values of the standard errors in the estimates of annualized social costs of compliance:

<u>MCL (ug/l)</u>	<u>Total Annual Cost*</u> <u>(\$millions, 1983)</u>	<u>Standard Error**</u> <u>(\$millions, 1983)</u>
0.5	157.4	14.7
1	101.7	13.4
5	21.2	12.1
10	11.1	11.8
20	7.0	12.2
25	6.0	10.2
50	3.8	10.2
100	2.4	10.9

* From Exhibit 5.2

** The probability that the true value lies within plus or minus one standard error of the estimate is 68 percent. The probability that the true value lies within plus or minus two standard errors is 95 percent. These probabilities assume that the error is normally distributed.

The standard errors shown are conservative, in that they assume that all errors in the PTM model (on which the regressions are based) are independent and uncorrelated. These conditions will not hold if, for example, unit treatment costs are consistently under estimated or over estimated, or if the occurrence data are subject to bias. The figures do show, however, that the relative magnitude of the uncertainty increases rapidly as MCL increases. This is presumably because these MCLs affect only those systems that have high influent concentrations to start with, and the estimates of the numbers of such systems are subject to large errors because they are rare.

5.4 Cost to State Governments of Federal VOC Regulations

5.4.1 Purpose

The purpose of this analysis was to determine the start-up and on-going costs to water supply departments in state governments should EPA develop MCLs for volatile organic compounds in drinking water. Start-up costs are defined as those costs, including labor and capital, incurred to initiate a state program. On-going costs are those costs which states incur each year to implement the program. Specific elements of both start-up and on-going costs are discussed below.

5.4.2 Data Sources

To determine the costs of an EPA MCL, informal telephone interviews were conducted with representatives of state drinking water programs in 12 states. Each respondent was asked to estimate:

- o the costs of their state's current program (if any) for regulating VOCs in drinking water; and
- o the likely additional costs their state would incur should EPA institute MCLs to regulate VOCs in their drinking water.

The twelve states were chosen to represent the range of severity of VOC contamination problems. In addition, the states were selected to represent all regions of the country. The states are listed below:

- | | |
|---------------|----------------|
| o California | o New Jersey |
| o Florida | o New York |
| o Maine | o Pennsylvania |
| o Michigan | o South Dakota |
| o Mississippi | o Tennessee |
| o Missouri | o Washington |

5.4.3 Cost Categories

Respondents were asked to estimate the costs of the current state program and the additional costs of an EPA program in terms of labor (expressed in work years) and capital (expressed in dollars). The cost categories are as follows:

Start-Up Costs

Review of Legislation or Guidelines
Preparation of Guidelines
Training of Staff
Conducting Baseline Surveys
Setting up Laboratory
Initiation of Technical Outreach

Review of Monitoring Data
Review of Treatment Options
Review of Health Risks
Enforcement of State Actions

Ongoing Costs

Review of Utility Monitoring
Conducting of State Monitoring (if any)
Provision of Technical Assistance
Preparation of EPA Reports
Provision of Laboratory Analytical Services
Enforcement of State Actions
General Administration

State representatives also were asked to report the number of water systems sampled for VOCs, the number of contaminated systems discovered, and the schedule for testing of VOCs (if any).

5.4.4 Findings

Cost estimates for the 12 states are shown in Exhibits 5-7 through 5-9. Costs are presented for the current state program, if one exists, and for additional activities if EPA were to set MCLs for certain VOCs. Exhibit 5-7 presents the start-up and ongoing costs for each state. The costs are specified in work years of labor and dollars of capital. The data show a range in current program and anticipated additional expenditures. The wide variation in costs estimated by the states illustrates two phenomena: 1) the substantial unevenness in state programs; and 2) the fact that states both measure and account for costs differently. The cost data obtained from states were "best estimates" from the person interviewed and do not reflect actual accounting data.

Total dollar figures for all 12 states are shown in Exhibit 5-8. A loaded labor rate of \$40,000 was used as the value of an average work year.

Using these cost estimates, the state costs of additional EPA regulations for the entire nation were calculated. Several factors were analyzed to relate current and additional costs to state characteristics. The factors considered were as follows:

- o current level of state program (measured in dollars)
- o state population
- o state population density
- o region of the country
- o severity of VOC contamination problem

These factors in combination can adequately explain why a particular state incurs its current costs or estimates a certain additional cost. However, none of the factors was statistically correlated with the costs of current or additional VOC programs.

EXHIBIT 5-7

SUMMARY OF CURRENT AND ADDITIONAL COSTS
OF VOC REGULATION BY STATE GOVERNMENTS

	STARTUP COSTS				ONGOING COSTS			
	For Current Program		For Additional EPA Regulations		For Current Program		For Additional EPA Regulations	
	Labor*	Capital	Labor*	Capital	Labor**	Capital	Labor**	Capital
California	18.75	0	4	0	15	0	1.	0
Florida	.16	\$ 3,000	0	0	.7	0	0	0
Maine	.75	\$34,500	1.23	\$134,500	1.26	0	.1	0
Michigan	3.55	0	0	0	4	0.	0	0
Mississippi	.6	\$215,000	2.25	0	.6	0	1	0
Missouri	1.1	0	4.8	\$340,000	2.5	0	5	0
New Jersey	6.5	\$2 Mil.	0	0	6.11	900,000	6	0
New York	25.92	\$750,000	1.17	0	4.25	0	2.	0
Pennsylvania	2.1	0	0.05	0	1.5	0	0	0
South Dakota	0	0	1.9	0	0	0	.25	0
Tennessee	.5	0	2.3	0	1.2	0	4.5	0
Washington	2.5	0	2	\$500,000	1	0	1	0

NOTE: The data shown are based on informal telephone interviews. The costs state officials reported show their best estimate for costs they may not record and may not yet have incurred.

* Work years

** Work years per year

EXHIBIT 5-8

ESTIMATED COSTS FOR VOC REGULATION FOR SAMPLE STATES*

	<u>For Current State Programs</u>	<u>For Additional EPA Regulations</u>
Start-Up Costs	\$5.5 million	\$1.8
Ongoing Costs	\$2.4	\$0.8

EXHIBIT 5-9

ESTIMATED NATIONAL COSTS OF STATE GOVERNMENT
IMPLEMENTATION OF EPA REGULATIONS FOR VOCs*

	<u>For Current State Program</u>	<u>For Additional EPA Regulation</u>
Start-Up Costs	\$12.8 million	\$4.1
Ongoing Costs	\$ 5.6	\$1.9

*A loaded rate of \$40,000/work year was used to determine labor costs.

That is, it is not possible to predict additional costs due to EPA regulations as a function of state characteristics since there is no statistically significant relationship between additional costs and state characteristics. Thus, it was not possible to project costs to non-sample states on the basis of state characteristics.

Instead, to estimate the costs of all 50 state governments of additional VOC programs resulting from EPA regulations, an assumption was made that the states contacted represent a random sample of states (weighted by population). The group of sample states represents 43 percent of the U.S. population, therefore the costs of the sample states were assumed to represent 43 percent of the costs to all states for administering VOC programs. Using this assumption, cost estimates were extrapolated to the entire nation. Exhibit 5-9 shows that the predicted start-up costs to the country for an additional EPA program would be approximately \$4.1 million and on-going costs would be approximately \$1.9 million per year. The on-going costs are roughly equivalent to one person year/state. States with a greater number of VOC problems such as California, New Jersey, and Florida can be expected to expend considerably more.

6. SYSTEM LEVEL NET BENEFITS ANALYSIS

6.1 Introduction

Chapters 4 and 5 deal with total national benefits and total national costs. This aggregate level of analysis serves a fundamental and necessary purpose in evaluating national policy alternatives for drinking water regulation. It is essential to develop estimates of the total impact at a national level and such estimates are required to comply with Executive Order 12291. However, these aggregate analyses are not, by themselves, adequate to reveal all the subtleties of a proposed regulatory strategy.

Some of those subtleties are quite important and are "subtle" only in the sense that they are not readily apparent in an aggregate level analysis. To evaluate these aspects of regulatory alternatives, Executive Order 12291 also requires analysis of "net benefits" which entails a more refined comparison of benefits and costs. This chapter presents an analysis of the "net benefits" of alternative regulations evaluated at the individual water system level. It is emphasized that regulatory decisions under SDWA cannot be based on benefit/cost analysis. This analysis is prepared therefore only to comply with Executive Order 12291.

Net benefits analysis may be viewed simplistically as a mere reformulation of the familiar concept of benefit/cost analysis where net benefits are defined as the difference of benefits less costs. Where in benefit/cost analysis it is desirable to have a ratio exceeding 1.0, in net benefits analysis it is desirable to have a difference that is positive. In both of these formulations, the argument being made is no more complicated than the common sense notion that in order for a regulatory action to be worthwhile, the benefits should exceed the costs.

This is not an adequate distinction of the type of methodology employed in this chapter, however. Net benefits analysis as defined in the above paragraph could be carried out at the aggregate level using the results of Chapters 4 and 5. The distinction being made here is that of evaluating net benefits at the system level.

The need for a system level analysis stems from the fact that while the net benefits of a given regulatory action may be positive in the aggregate, the aggregate figures may disguise an unknown number of negatives that are "netted-out" and therefore never seen in the aggregate results. The analysis of individual systems of varying sizes can reveal such circumstances.

Sensitivity to system size is perhaps the most immediately obvious, but not the only distinguishing characteristic of the analysis presented in this chapter. The other important feature is that it is a "marginal" analysis of net benefits. The meaning

of this term is often obscure to non-economists because it is often deeply embedded in the nature of the problem and therefore difficult to define in abstract. For example, the need to pay attention to the effect of system size is made explicit in terms of: 1) the risk of setting an MCL that is too stringent; and, 2) the risk of setting an MCL that is not stringent enough. These are the essential elements of a problem that lends itself to "marginal" analysis -- a situation in which it is best to evaluate a gradient of alternative actions searching for the one that goes just far enough without going too far.

Specifically, "marginal" analysis in public policy problems involves the study of society's "willingness-to-pay" for social benefits. If society behaved in perfect accord with the prescriptions of economic theory, the upper limit of our willingness-to-pay would be defined by the equivalence of marginal social benefit and marginal social cost. In terms of the above mentioned gradient of regulatory action, this means that as long as a dollar's worth of expenditure brings more than a dollar's worth of benefit, the buyer (the public, via EPA) should be willing to continue making such bargains up to the break-even point. Beyond such a point, the buyer should, of course, have no further interest in the transaction.

It is not easy to place a monetary value on benefits when valuing human life. One approach to coping with this discomforting situation is to cast the problem in the context of society's implied willingness-to-pay. On the basis of past regulatory actions, it is possible to define the range of what society has been willing to pay per death avoided in other similar instances. An inspection of EPA's recent regulatory actions reveals that values of life in the range of \$300,000 to \$7,000,000 have been considered. The approach suggested by this finding is simply to check regulatory alternatives to see if they fall somewhere within the range of this implied willingness-to-pay. It is important to note, however, that this should be a "marginal" comparison.

The importance of performing this comparison on a marginal basis is made clear by consideration of the implications of sole reliance on the results of aggregate analysis such as presented in Chapters 4 and 5. The aggregate national totals presented in the two chapters can be combined to produce estimates of the "average" cost per case of cancer avoided. It may be misleading to use these average cost figures to evaluate society's willingness to pay. The problem is that noted above; the "aggregate average cost" provides no guidance on whether the associated regulatory action will err on the side of going too far or of not going far enough.

It is easy to conceive of circumstances in which a regulatory action may impose compliance requirements on a small segment of the target group whose marginal cost of compliance happens to be far in excess of the range society is normally willing

to pay. Because they are a minority, their costs are averaged in with all other systems at the aggregate level and the regulation appears to be within acceptable bounds. This is the situation where marginal cost exceeds average cost. That fact, in itself, is not bad, but average cost as an indicator gives no hint as to how fast the marginal cost is continuing to rise with more stringent increments of regulation or where the marginal benefit stands with respect to society's implied willingness-to-pay. In other words, the average cost indicator does not provide guidance on when to stop adding increments of stringency in the regulatory action.

On the other hand, it is equally conceivable that the average cost could conceal the fact that a regulatory action does not go far enough. This is the circumstance where marginal cost is less than average cost. This can easily come about in situations where a large fixed capital investment is required for control equipment capable of meeting a wide range of treatment standards. In such cases, the average cost may be relatively stable over a wide range of alternative treatment standards, indicating no significant advantage in adding further increments of stringency in the regulation. While the average cost is relatively stable, however, the difference between marginal cost and marginal benefit may offer attractive bargains over this same range. The danger, therefore, is that of stopping short with the choice of regulatory action because the average cost indicator provides no guidance on how far to proceed.

Ultimately, true willingness-to-pay can only be determined at the level of individual water systems. It cannot be accurately analyzed as a decision criterion on the basis of aggregate or average cost data. The net benefits analysis presented in this chapter provides the type of system level marginal indicator that is needed to evaluate regulatory alternatives in terms of willingness-to-pay. It makes possible an assessment of whether a given regulatory action has gone too far or is not stringent enough.

6.2 Methodology

The total net benefits of alternative MCLs are evaluated on a present value basis, computed via the following formula:

$$PVNB = \{PVF \times [(ARC \times INF \times EFC \times POP \times V) - OMC]\} - CAPC$$

Where:

PVNB = the present value of total net benefits

PVF = the present value factor: 14.877, based on a 3 percent discount rate and a 20 year period.

ARC = the annual risk of cancer, using the same assumptions as in Chapter 4.

INF = the concentration of the VOC in the influent raw water before treatment.

EFC = the efficiency of removal of the VOC present, figured as the percent removed.

POP = the average population of a water system in a given size category.

V = the value of life assumed; expressed in terms of dollars per cancer case avoided.

OMC = the annual operation and maintenance cost of the treatment technology; based on data supporting the analysis of Chapter 5.

CAPC = the capital cost of the treatment technology; based on data supporting the analysis of Chapter 5.

The treatment technology assumed for purposes of the cost estimates used in this analysis was packed tower aeration. It was chosen because it may be used for either partial or total removal of VOCs. This permits evaluation of the widest possible range of alternatives. Some other treatment options such as granular activated carbon (GAC) are restricted to total removal. Cost curves reflecting the effects of various levels of removal were used as the input data based on the same analysis that supports the aggregate cost estimates of Chapter 5.

The cost curves and the risk factors in the above equation are the only variables that are held constant in the evaluation of net benefits. All of the other variables are jointly varied across their entire ranges to determine the effects on net benefits produced by the different combinations of circumstances. The dimensions of variation are outlined as follows:

INF -- from high to low levels of influent concentration

EFC -- from high to low levels of removal, reflecting more or less stringent MCLs

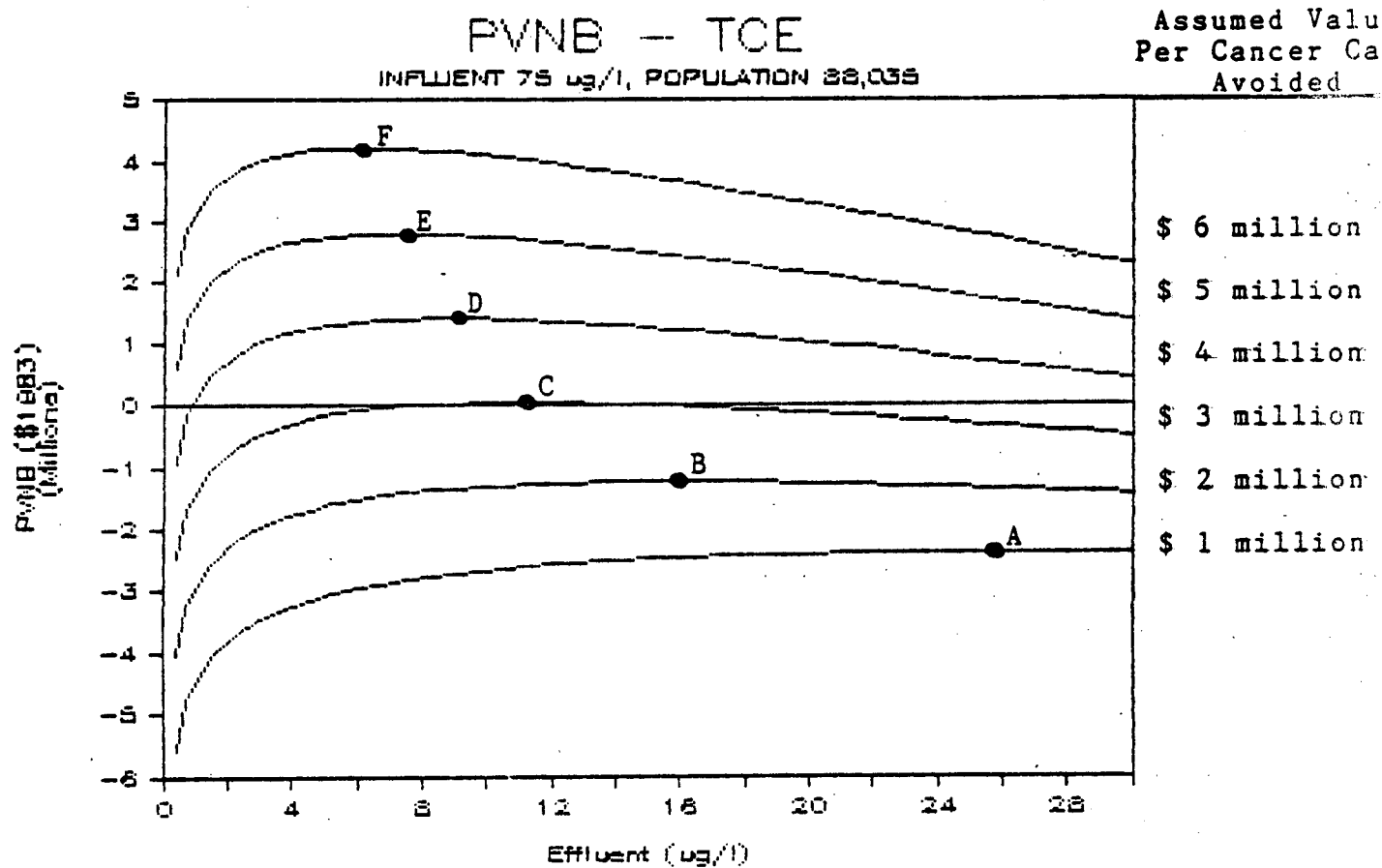
POP -- from large to small water system sizes

V -- from high to low values per case of cancer avoided

The framework for evaluating these dimensions of variation is illustrated in Exhibit 6-1. The graph shows how PVNB changes at MCLs of varying stringency (EFC) given varying assumptions about the value per cancer case avoided (V). Separate analyses were prepared for each combination of high and low values of

EXHIBIT 6-1

PRESENT VALUE NET BENEFITS AS A FUNCTION OF MCL AND THE ASSUMED VALUE PER CANCER CASE AVOIDED



the influent concentration (INF) and large and small water system-sizes (POP).

The graph in Exhibit 6-1 illustrates the finding that there is a maximum value of PVNB for any given value of V; this is indicated by the fact that each of the PVNB curves has a maximum point. The maximum point on each PVNB curve (e.g., point E) represents the point at which the marginal addition to cost for an additional increment of stringency is exactly equal to the marginal addition to benefits. In other words, marginal net benefits are zero. When marginal net benefits are zero, total net benefits are maximized. Thus, the maximum point defines the optimal MCL for the value of V assumed and the other conditions assumed for population and influent concentration.

It also is apparent from the graph that PVNB is not positive for all values of V, not even at the maximum point. There is a threshold level, V', associated with the "break-even" point -- the point where the maximum value of total net benefits is exactly equal to zero (point C in Exhibit 6-1). Levels of V equal to or greater than V' must be assumed in order to justify regulatory action. This break-even point also defines the minimum level of stringency required in an MCL in order to achieve positive (or non-negative) total net benefits for the threshold value of V. Furthermore, all successive maximum points (D, E, F, etc.) are to the left of the break-even point, implying that more stringent MCLs than that associated with the break-even point are required to maximize total net benefits for values of V above V'.

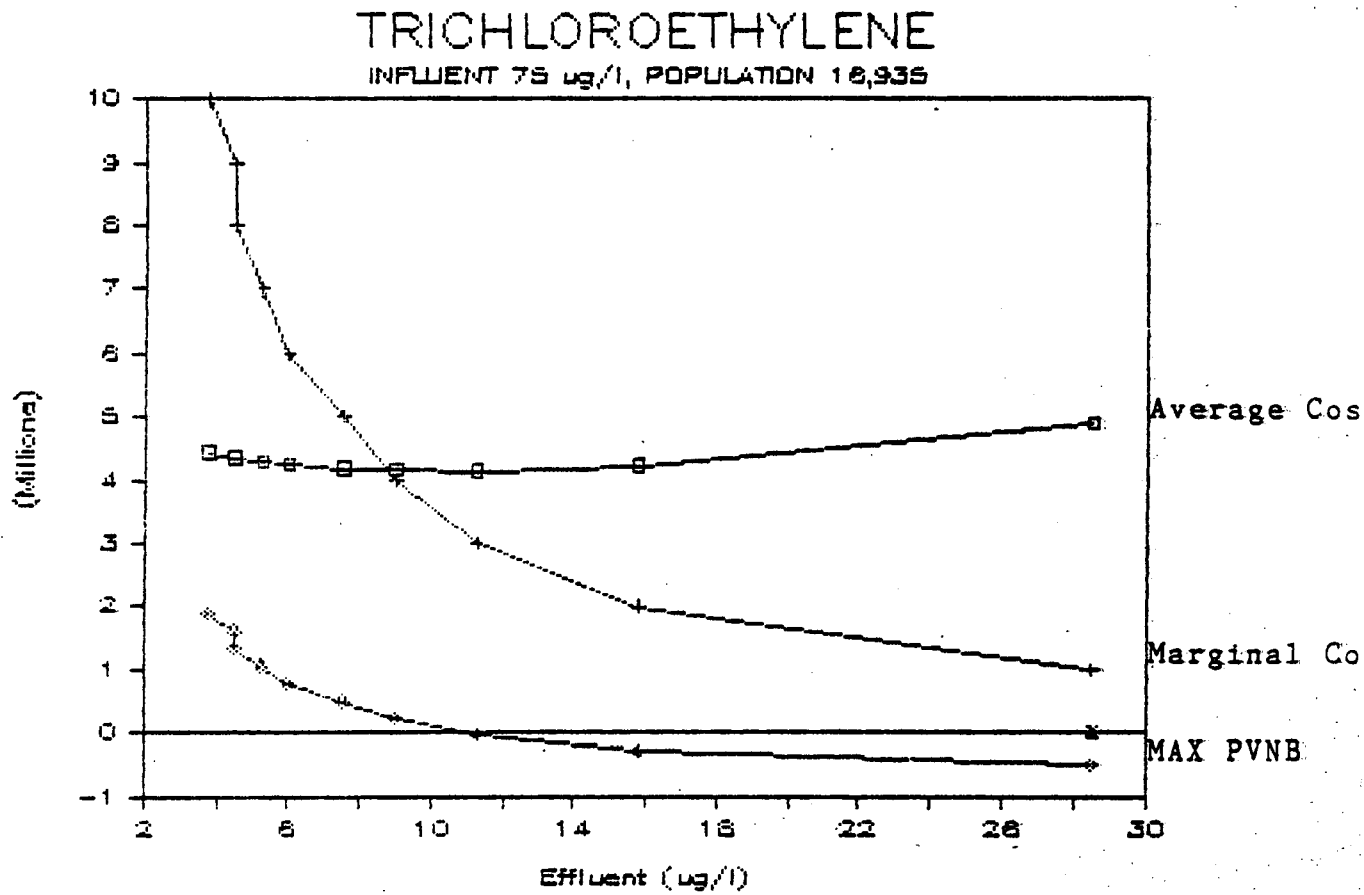
This family of PVNB curves can be collapsed into a more compact form by sketching the single curve which connects the maximum points of the individual curves. This produces a MAX PVNB curve as shown in Exhibit 6-2. The point at which this curve crosses from the negative to the positive zone is the break-even point. It defines the minimum value of life required to produce positive total net benefits (V') and the associated minimum level of stringency in MCL selection required to attain maximum net benefits for any value of V above V'.

One might be inclined to ask how there can be a minimum level of stringency required to justify regulatory action. Would not some measurable benefit result from any level of action? The answer is yes, but below this minimum level of stringency, the net benefits will be either negative or, if positive, less than the maximum attainable for the given value of V.

Plotted above the MAX PVNB curve in Exhibit 6-2 are the marginal and average cost curves associated with it. The relationship between these two curves is familiar in light of the earlier discussion of marginal and average cost. The diagram confirms that the average cost curve is fairly flat over most of the relevant policy range (i.e., the range of MCLs being considered). Thus one cannot be certain on the basis of average cost alone whether a given MCL is above or below the break-even point.

EXHIBIT 6-2

MAXIMUM PRESENT VALUE NET BENEFITS AS A FUNCTION
OF MCL AND RELATION TO MARGINAL AND AVERAGE COST



There is no direct theoretical link between the average cost curve and the MAX PVNB curve. A somewhat indirect link is provided by the intersection of the marginal and average cost curves. Principles of differential calculus mandate that the marginal curve will always intersect the average curve at the minimum point of the average curve. In this particular problem, the location of this intersection will always be somewhere to the left of the break-even point on the MAX PVNB curve.

The intuitive reason for this is embedded in the definition of the break-even point; it is the point at which enough benefit is being realized to offset the initial fixed cost of the treatment technology. It stands to reason that the average cost will steadily decrease as one adds successive increments of benefit against the same fixed cost. Minimum average cost is not required to achieve the break-even point, but it is not surprising to find it nearby.

This might suggest that analysis of regulatory options using average cost per case estimates developed in Chapters 4 and 5 may lead to choices having positive net benefits when a "least-cost-per-unit-of-benefit" or "minimum average cost" criterion is applied. If, however, the average cost curve is very flat (or if there are large uncertainties that affect the perceived shape of the curve) in the vicinity of the minimum point, the potential for error may be great and options having negative net benefits or excessive costs at the margin could be selected by this procedure. It is further important to note that the average cost per case implied by the analyses of Chapters 4 and 5 is an aggregate of the average costs of all system size categories whereas the average cost curve shown in Exhibit 6-2 is based on the system level average cost. While the minimum average cost may be easy to spot on a diagram at the level of an individual water system, there is no straightforward method of defining a point of minimum average cost in the aggregate.

By contrast, the marginal cost curve in Exhibit 6-2 is continuously upward sloping. Because the points on the MAX PVNB curve represent the points at which marginal cost and marginal benefit are equal, the marginal cost curve also may be regarded as a marginal benefit curve. So defined, it may be directly interpreted in terms of the willingness-to-pay decision criterion mentioned earlier. The marginal cost/marginal benefit curve and the MAX PVNB curve may be used together to define the solution space; the boundaries within which all MCL choices are associated with a maximum level of positive net benefits for values of V above V' but below the upper limit of society's implied willingness-to-pay.

The minimum acceptable MCL or break-even level of stringency is defined by the point at which the MAX PVNB curve crosses into the positive zone. Extending a vertical line up from this point to intersect the marginal cost/marginal benefit curve defines the value per cancer case avoided (V') which must be

assumed in order to make positive net benefits achievable. In some cases, this value may be outside the affordable range, thus dictating no viable regulatory action.

The maximum level of stringency is defined by extending a horizontal line from the \$7,000,000 mark on the vertical axis across to its intersection with the marginal cost/marginal benefit curve. The MCL corresponding to this point (directly below it) represents the maximum level of stringency that is within the affordable range.

Summarizing, the analysis developed in this chapter may be used to answer three essential questions for any given set of population and influent conditions:

- o What is the minimum value per case of cancer avoided (V') that must be assumed in order to obtain positive net benefits? And, is this within the affordable range based on society's implied willingness-to-pay?
- o Assuming V' is within the affordable range, what is the minimum level of stringency required for an MCL in order to maximize net benefits?
- o What is the most stringent MCL that is within the affordable range based on society's implied willingness to pay?

6.3 Results and Discussion

The analysis described above was performed for a sampling of the VOC contaminants being considered for regulation to provide a check on the validity of conclusions inferred from the results of the aggregate analyses of Chapters 4 and 5. The following cases were studied across twelve population size categories:

- o Trichloroethylene (TCE)
 - influent 10 ug/l
 - influent 75 ug/l
- o Benzene
 - influent 10 ug/l
 - influent 75 ug/l
- o Carbon Tetrachloride
 - influent 10 ug/l
 - influent 75 ug/l
- o Multiple Contaminants -- "Average" Mixture
 - influent 10 ug/l
 - influent 75 ug/l
- o Multiple Contaminants -- "Weak" Mixture
 - influent 10 ug/l
 - influent 75 ug/l

Exhibit 6-3 presents the results of these analyses, providing answers to the three questions listed above. The table presented in this exhibit requires some explanation prior to interpretation.

First, results are presented in terms of risk levels achieved instead of the equivalent MCLs concentrations. This lends more meaning to the interpretation by facilitating equal comparisons between contaminants and by stating the result in terms of what it is that society is willing-to-pay for; the attainment of a lower level of cancer risk. Risk levels are presented in terms of 10^{-5} and 10^{-6} individual lifetime cancer risks. (It is noted that under SDWA, MCLs cannot be set on the basis of a risk-based approach. This analysis merely evaluates MCLs in terms of risk out of analytical convenience and to comply with Executive Order 12291.)

Two risk levels are presented for each case studied. The first represents the risk associated with the least stringent MCL that will produce positive net benefits for the break-even value of V. Sometimes this is 10^{-5} and other times it is 10^{-6} . The second risk level listed for each case represents the risk associated with the most stringent MCL that is within the affordable range. In many cases the break-even MCL and the most stringent MCL are both 10^{-6} . An MCL more stringent than 10^{-6} would be outside the affordable range in most instances.

The adjacent column of the table presents a summary of the results on what society would have to be willing to pay in order to achieve the associated risk levels. These values are presented as a range which represents the variation across different water system sizes. In general, the low end of the range is representative of the marginal cost per case avoided to the largest systems and the high end of the range is representative of the marginal cost per case avoided to smaller systems.

Incorporation of the very smallest size categories would require a much broader range in the cost column of the table. For this reason they are not included in the ranges given. Instead, the footnotes to the table indicate places where the cost ranges applicable to the large and mid-size systems are insufficient for the smallest size categories.

Interpretation of these results must be prefaced with a brief classification scheme; all VOCs were not evaluated but those that were are intended to represent the others, as follows:

- trichloroethylene -- relatively low risk group
- benzene -- moderate risk group
- carbon tetrachloride -- relatively high risk group
- multiple contaminants -- a special case

This classification is purely relative and reflects broadly the variation in risk indicated in Exhibit 4-3.

EXHIBIT 6-3

SUMMARY OF RESULTS OF PRESENT VALUE NET BENEFITS ANALYSIS

Contaminant & Influent Condition	Effluent Risk Levels Associated With Break-Even MCL And With Most Stringent MCL Affordable	Value Per Case Of Cancer Avoided (V) That Must Be Assumed To Obtain Break-Even MCLs And Most Stringent MCLs (\$ Millions)
Trichloroethylene 10 ug/l	Break-Even MCL: 10^{-6} Most Stringent MCL: 10^{-6}	30 - 40 * 30 - 40 *
75 ug/l	Break-Even MCL: 10^{-5} Most Stringent MCL: 10^{-6}	4 - 7 ** 15 - 25 ***
Benzene 10 ug/l	Break-Even MCL: 10^{-6} Most Stringent MCL: 10^{-6}	10 - 30 *** 10 - 30 ***
75 ug/l	Break-Even MCL: 10^{-5} Most Stringent MCL: 10^{-6}	4 - 8 ** 14 - 18 ***
Carbon Tetrachloride 10 ug/l	Break-Even MCL: 10^{-6} Most Stringent MCL: 10^{-6}	4 - 8 ** 4 - 8 **
75 ug/l	Break-Even MCL: 10^{-5} Most Stringent MCL: 10^{-6}	2 - 5 ** 5 - 9 **
Multiple Case "Average" Mixture 10 ug/l	Break-Even MCL: 10^{-6} Most Stringent MCL: 10^{-6}	1 - 3 **** 1 - 3 ****
75 ug/l	Break-Even MCL: 10^{-6} Most Stringent MCL: 10^{-6}	1 - 3 **** 1 - 3 ****
Multiple Case "Weak" Mixture 10 ug/l	Break-Even MCL: 10^{-6} Most Stringent MCL: 10^{-6}	10 - 15 * 10 - 15 *
75 ug/l	Break-Even MCL: 10^{-5} Most Stringent MCL: 10^{-6}	4 - 7 ** 10 - 14 ***

- * The four smallest system size classes would require values of V even further outside the affordable range to achieve this MCL.
- ** The two smallest system size classes would require values of V outside the affordable range to achieve this MCL.
- *** The two smallest system size classes would require values of V even further outside the affordable range to achieve this MCL.
- **** The smallest system size category would require values of V in the neighborhood of \$7 to \$10 million to achieve this MCL.

The most obvious conclusion to be drawn from the data in Exhibit 6-3 is the fact that it does not appear to be possible to produce positive net benefits in the two smallest of the twelve system size categories for any of the cases studied. These categories consist of systems having 25-100 people and 101-500 people. The populations at risk are simply not large enough to produce a level of benefits equal to the cost of control measures.

The results for carbon tetrachloride, representing the relatively high cancer risk category of VOCs, indicate that a 10^{-6} risk level can be achieved for both the high and low influent concentration ranges at costs per case ranging from \$4-9 million. A 10^{-5} risk level could also be achieved with positive net benefits for the high influent concentration case, but 10^{-6} is the minimum level required to produce positive net benefits in the low influent concentration case.

The results for trichloroethylene (TCE) and benzene, representing low and medium cancer risk categories of VOCs, indicate that positive net benefits are available only when influent concentrations are high. With influent concentrations of 75 ug/l, a 10^{-5} level of removal is within the "affordable" range, requiring a cost per case of \$4-7 million for TCE and \$4-8 million for benzene. However, removal to the 10^{-6} level is not within the affordable range, costing \$15-25 million per case for TCE and \$14-18 million per case for benzene.

For the more important case of low influent concentrations positive net benefits cannot be attained for TCE and benzene except at the 10^{-6} level of removal. The cost per case would be beyond the affordable range, however, costing \$30-40 million for TCE and \$10-30 million for benzene. This finding is significant because most occurrence of these VOCs is characterized by low influent concentrations. The implication is that it is not worth it to regulate them. This conclusion will be reversed, however, upon consideration of the multiple contaminant case, discussed below.

The multiple contaminant case is evaluated in terms of two different mixtures. One reflects the total risk in terms of a weighted "average" of all possible constituents including two very high risk VOCs -- vinyl chloride and 1,1-dichloroethylene -- which occur only in the presence of other VOCs. The other "weak" mixture represents a mix of TCE, tetrachloroethylene, and 1,1,1-trichloroethane which are very low risk, but very ubiquitous VOCs.

Results for the "average" mixture indicate that there is no question but that a 10^{-6} level of removal is in the "affordable" range, at both high and low influent levels, costing only \$1-3 million per cancer case avoided. This result, however, is really nothing but a reflection of the fact that there are high cancer risk VOCs assumed to be present in this mixture. When the difference

in risk between the high and low risk chemicals is in terms of one or two orders of magnitude, as is the case here, the presence of only a small amount of a high risk chemical is sufficient to drive the analysis to the same conclusion as when the high risk chemicals are considered individually. In other words, there is a negligible dilution effect.

Results for the "weak" mixture are similar to the results obtained for TCE and benzene except that the cost ranges for the 10^{-6} level of treatment are somewhat closer to the affordable range. The cost per case for high influent concentrations is estimated to be \$10-14 million while the cost for low influent concentrations is estimated to be \$10-15 million. A 10^{-5} level of treatment produces positive net benefits in the high influent concentration case at a cost per case of \$4-7 million. In the low influent concentration range, positive net benefits cannot be achieved except at the 10^{-6} level.

As discussed in Chapters 4 and 5, the option of establishing an MCL for Total VOC concentration (TVOC) has been considered as a means of dealing with the multiple contaminant problem. The above analysis suggests that the choice of an optimal level for such an MCL would be complicated by uncertainty over which contaminants are present. To err on the side of safety and specify a 10^{-6} requirement would produce negative net benefits in cases where high risk VOCs are not found.

It appears that the approach of setting individual MCLs for each of the contaminants is more efficient for several reasons. The comparative volatility of the different VOCs favors an approach in which the low and moderate risk VOCs are removed to some degree to assure removal of the high risk VOCs as well. For example, removal of TCE to a 10^{-5} level by packed tower aeration also will remove vinyl chloride to a 10^{-6} level during the same treatment process.

This feature of the treatment technologies takes on special significance in consideration of some evidence which suggests that certain VOCs, including the very potent vinyl chloride, may be found primarily in the multiple contaminant case because they may be produced as biological degradation products of the other VOCs. If this is indeed the case, then the above results for low and moderate risk VOCs would be incorrect. A corrected analysis would have to impart a portion of the risk posed by compounds such as vinyl chloride to the parent compounds. A result more like that obtained for the "average" multiple contaminant case would then be expected.

7: REGULATORY FLEXIBILITY ANALYSIS AND PAPERWORK ANALYSIS

7.1 Regulatory Flexibility Analysis

The Regulatory Flexibility Act (RFA) was enacted on September 19, 1980 and requires all executive agencies to explicitly consider small entities in their regulatory design and implementation process. The purpose of RFA is to encourage regulatory agencies to try and minimize the disproportionate burden that falls on small entities. The three specific objectives of the RFA are listed below:

1. To increase agencies' awareness of their regulatory impact on small entities;
2. To compel agencies to explicitly analyze, explain, and publish regulatory impacts on small entities; and
3. To encourage agencies to provide regulatory relief to small entities while still accomplishing their statutory mandates.

These objectives are accomplished through the requirements of regulatory flexibility analyses for all existing and proposed regulations. If a regulation does not have a "significant" impact on a substantial number of small entities, then the regulatory flexibility analysis will consist of a certification to that effect.

Prior to conducting a regulatory flexibility analysis, a regulatory agency such as EPA must define a small entity. (It should be noted that, under the Safe Drinking Water Act, EPA's Office of Drinking Water employs a different definition of small water systems from that used here. The analyses presented in this section are prepared only for compliance with the RFA.) The RFA defines small entities as including small businesses, organizations, and governments [PL 96-354, Section 601(6)]. Small businesses are defined as any business which is independently owned and operated and not dominant in its field (15 USC, Section 632). Small organizations are defined as any non-profit enterprise which is independently owned and operated and is not dominant in its field. Finally, small government entities are defined as those city, county, town, township, village, school district, or special district governments serving a population of less than 50,000 persons [Regulatory Flexibility Act, PL 96-354, Sections 601(4) and 601(5)].

Community water systems can be divided into three ownership categories for purpose of RFA analysis: 1) publicly owned, 2) investor owned, and 3) ancillary systems. Publicly owned systems are those owned by governmental entities; investor owned systems are privately owned; and ancillary systems are those small systems that are ancillary to other enterprises such as

mobile home parks or hospitals. According to EPA's 1980 Survey of Operating and Financial Characteristics of Community Water Systems, there are 26,424 publicly owned community water systems. Of this total, 98 percent serve fewer than 50,000 persons (see Exhibit 7-1).

Investor owned water systems are firms primarily engaged in production and distribution of water to consumers (SIC 4941). These companies are considered to be small businesses if their annual receipts are less than \$3.5 million (Federal Register, Vol. 49, No. 28, p. 5035). Applying the Consumer Price Index for water and sewage maintenance for the period February 1980 to February 1984 to this figure, the upper limit for a small water utility would be \$2.4 million in 1980 dollars. EPA's Survey of Operating and Financial Characteristics of Community Water Systems indicates that a population of 50,000 persons is roughly the cut-off for systems generating revenues of \$2.4 million. Revenues for investor owned water systems serving 25,000-50,000 persons averaged \$1.97 million in 1980. For investor owned systems serving 50,000-75,000 persons, revenues in 1980 averaged about \$3.16 million.

There is some question as to whether investor owned water utilities serving fewer than 50,000 persons qualify as small businesses. Many of these utilities are not individually owned, but are owned and controlled by large holding companies such as American Water Works Service Co. and General Water Works. In addition, every investor owned utility operates in a franchised area and thus constitutes a natural monopoly. This raises the question of whether domination in a limited geographic area is the same as dominance in a field of enterprise. The Small Business Administration considers dominance to mean on a national basis; therefore, no individual water utility can be dominant in the marketplace.

All ancillary community water systems serve fewer than 500 persons according to EPA's 1980 survey. These could be considered small entities; however, the main activity of the enterprise may be sufficiently large to disqualify the organization as a small entity. It is not possible to determine how many of these systems constitute small entities because of the lack of data.

7.1.1 Purpose of Regulation

Under the Safe Drinking Water Act, EPA is authorized to set maximum contaminant levels (MCLs) for those contaminants in drinking water which may have any adverse effect on the health of persons. The purpose of regulations for VOCs is to limit human exposure to these chemicals via drinking water (i.e., both from inhalation and ingestion) and thereby reduce the health risk posed by this class of chemicals. Regulations to control VOCs in drinking water are likely to affect a number of small water systems. It is estimated that one or more VOCs will be

EXHIBIT 7-1

NUMBER OF COMMUNITY WATER SYSTEMS BY POPULATION SERVED

	<u>Population Served</u>				<u>TOTAL</u>
	<u>25-500</u>	<u>501-3300</u>	<u>3301- 50,000</u>	<u>50,000+</u>	
Publicly Owned	8,932	11,544	5,455	493	26,424
Privately Owned	12,591	2,239	802	108	15,740
Ancillary	<u>16,907</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>16,907</u>
Total	38,430	13,783	6,257	601	59,071

Source: EPA, Survey of Operating and Financial Characteristics of Community Water Systems, 1982.

detected in over 6700 systems serving fewer than 50,000 persons (See Exhibits 2-6 and 2-7).

7.1.2 Number of Systems Affected

Exhibit 7-2 shows the number of water systems that would be affected if EPA sets MCLs at eight different levels. The exhibit also shows a distribution by size category.

EPA guidelines on compliance with the Regulatory Flexibility Act (April 12, 1983) indicate that, in general, a substantial number of small entities is more than 20 percent of the total. Exhibit 7-2 shows that a total of 6004 systems serving 50,000 or fewer persons would be affected by a 5.0 ug/l MCL. The total population of systems in this size range is approximately 59,000. Therefore, the maximum proportion of systems likely to be affected is about 10 percent.

Even this number is overstated since the 6004 number includes those systems in which there is multiple occurrence of VOCs; thus some double counting probably has occurred. A less stringent MCL would affect even a smaller proportion of total systems. Therefore, by the 20 percent rule, VOC regulations would not affect "a substantial number" of small water utilities.

7.1.3 Economic Impacts of VOC Regulations on Small Water Systems

Exhibit 5-4 shows annual cost of VOC removal on a per system basis (costs are for treatment only; see also section 7.2.4 regarding monitoring costs). These data indicate that at an MCL of 5.0 ug/l, very small systems (serving 25-500 people) would incur an annual cost of about \$4800 per year. For those systems serving 501-3300 persons, annual costs would amount to about \$20,400 annually. Systems serving 3301-50,000 persons would incur average annual costs of about \$58,700. Annual costs at less stringent MCLs would be about the same or marginally less.

Exhibit 5-5 shows that for an MCL of 5.0 ug/l, average water production costs would increase by \$0.54 per 1000 gallons for affected systems in the 25-500 population served range. For those systems in the range of 501-3300 population served, average production costs would increase by about \$0.29/1000 gallons. Systems serving 3301-50,000 persons would experience average production costs of about \$0.07/1000 gallons. These costs would represent increases in production costs of about nineteen percent in systems serving 25 to 500 persons, about sixteen percent in systems serving 501-3300 persons, and six percent in systems serving 3301-50,000 persons.

EXHIBIT 7-2

SYSTEMS REQUIRED TO TREAT AS A FUNCTION OF MCL

MCL (ug/l)	<u>System Size Category (Population Served)</u>				<u>TOTAL</u>
	<u>25-500</u>	<u>501-3300</u>	<u>3301- 50,000</u>	<u>50,000+</u>	
0.5	3483	1406	989	126	6004
1	2246	906	575	68	3794
5	862	303	168	15	1347
10	506	182	100	7	795
20	332	119	61	4	516
25	290	104	52	3	450
50	192	68	32	2	294
100	127	45	20	1	193

7.2 Paperwork Analysis

7.2.1 Paperwork Reduction Act

Among the purposes of the Paperwork Reduction Act (Public Law 96-511; 94 STAT 2812) are as follows:

- o minimization of the federal paperwork burden for individuals, small businesses, state and local governments, and other persons; and
- o minimization of the costs to the federal government of collecting, maintaining, using, and disseminating information.

Water utilities and state water supply agencies will be required to maintain records on monitoring of VOCs and report results to the EPA; this is likely to be the largest component of paperwork associated with establishment of federal VOC regulations. The Paperwork Reduction Act is intended to minimize the burden imposed on utilities and states as they strive to protect the public health by implementing the provisions of the SDWA.

7.2.2 Requirements of the Paperwork Reduction Act

EPA is required to submit to the Office of Management and Budget (OMB) proposed information collection requests. EPA also must submit a copy of proposed rules containing an information collection requirement. These proposed rules must be submitted no later than publication of a notice of proposed rulemaking in the Federal Register. When a final rule is published in the Federal Register, EPA must explain how any information collection requirements have been designed to be responsive to public comments. OMB determines the necessity, practicality, and utility of the information being requested, and if approval of the request is made, OMB will issue a control order.

Under the Safe Drinking Water Act, EPA is authorized to regulate contaminants in drinking water to protect the public health. VOCs are known to constitute a health risk. To determine whether a specific water system exceeds an MCL for VOCs, or to determine whether VOCs are present in drinking water supplies, EPA must require water systems to collect and analyze samples and report results to the relevant primacy agent (i.e., either EPA or the states). In the case of VOCs, EPA, the states, water utilities, and the public would use monitoring information to determine whether VOCs are present. More importantly, this monitoring data would allow appropriate action plans and removal decisions to be made by affected utilities.

7.2.3 Number of Systems Affected

Exhibit 7-3 shows the number of water systems having one or more VOCs present. There are about 4070 very small systems

EXHIBIT 7-3

WATER SYSTEMS WITH VOLATILE ORGANIC COMPOUNDS

	<u>System Size (Population Served)</u>			
	<u>25-500</u>	<u>501-3300</u>	<u>3301- 50,000</u>	<u>50,000+</u>
Number of Systems with VOCs*	4067	1574	1144	181
Percentage of Systems with VOCs	10.5	11.3	18.0	30.8
Total Systems in U.S.**	38,736	13,985	6,352	587

* One or more VOCs with at least one having a concentration greater than or equal to 0.5 micrograms per liter. In the case of vinyl chloride the minimum concentration is 1.0 microgram per liter, and in the case of 1,1-dichloroethylene the minimum concentration is 0.2 micrograms per liter.

** totals are different than those shown in Exhibit 7-1; the difference is due to fluctuating inventory numbers.

having VOC occurrence, amounting to 10.5 percent of all systems in this size category. The number of systems with VOC occurrence decreases with system size, but the proportion increases due to the smaller number of systems in larger size categories.

All systems probably would be required to monitor at least once to determine whether VOCs are present. Those systems contaminated with VOCs, or which are thought to be vulnerable to VOC contamination, would in all likelihood be required to monitor on a regular basis.

7.2.4 Respondent Burden (Monitoring Requirements)

Respondent burden will largely be a function of monitoring and reporting requirements. Compliance monitoring requirements will be proposed by EPA for the purpose of determining if public water systems are distributing drinking water that meets the MCL. As a class of chemicals, VOCs are included in the second tier of the three tiered approach presented in the Phase II ANPRM published on October 5, 1983 (48 FR 45502). The tiers are as follows:

Tier I those which occur with sufficient frequency and which are of sufficient concern to warrant national regulation (MCLs) and consistent monitoring and reporting.

Tier II those which are of sufficient concern to warrant national regulation (MCLs) but which occur at limited frequency, justifying flexible national minimum monitoring requirements to be applied by state authorities.

Tier III those which would not warrant development of a regulation but for which non-regulatory health guidance could be provided to States or water systems.

EPA considered the following factors in the development of VOC compliance monitoring alternatives for community water systems:

- o differences between ground and surface water systems;
- o the collection of samples which are representative of consumer exposure;
- o the economic burden associated with the sampling and analytical costs; and
- o the limited occurrence of VOCs and the need for states to take an active role in requiring increased monitoring over the federal minimums.

EPA has determined that the sampling and analytical costs are reasonable and that there are sufficient analytical laboratories capable of handling sample analyses provided the initial monitoring

requirements are phased-in over a period of several years. Surface and ground waters have been considered separately because: (1) the sources and mechanisms of contamination for these systems are different, (2) the quality of ground waters tends to change more slowly with time than does the quality of surface waters, and (3) ground water contamination is usually a localized problem confined to one or several wells within a system.

For groundwater systems, sampling will be performed at entry points to the distribution system since VOC contamination of the water reaching the consumer is not expected to increase within the distribution system. However, source monitoring results may be used to decrease the number of samples taken at entry points to the distribution system or to reduce the frequency of monitoring for the determination of compliance with the MCL. Determination of a reduction in the number of samples or frequency of monitoring will be allowed at the option of the primacy agency.

Compliance Monitoring Requirements

The fundamental questions considered by EPA in developing proposed compliance monitoring requirements are as follows:

- o How can monitoring regulations be developed to provide states with an active role such that resources are efficiently utilized?
- o What minimum requirements should be set?
- o What distinctions should be made between ground and surface water systems?
 - What locations for sampling?
 - Number of samples per system?
 - One-time monitoring or monitoring over a period of time? Should minimum repeat frequencies be established? What frequency and upon what basis?
 - How much time should be allowed for public water systems to complete the monitoring requirements?
 - What is the cost of monitoring per system?
- o What sampling requirements should be set?
- o What follow-up actions may be needed to assist the public water systems and the states when positives are reported?
 - Follow-up confirmation sampling?
 - Health and treatment advisories?
- o What reporting and public notice requirements should be set?

EPA believes that all Community Water Systems (CWS) should conduct at least one initial round of monitoring to determine the extent of contamination of water supplies and to provide maximum consumer protection. EPA also believes that there should be minimum requirements for repeat sampling since the vulnerability of a system to VOC contamination may change with changing land and water use and waste disposal practices. The repeat sampling requirements should reflect the potential for contamination of the system (i.e., the most vulnerable systems should monitor the most frequently). The states should recertify the vulnerability status of each system on an annual basis. Systems should notify the state whenever a significant change takes place that could affect the vulnerability of the system (e.g., change in water source, new VOC-based industry nearby, or a positive VOC analysis).

Several approaches to monitoring requirements have been considered by EPA. Three specific options are outlined below. In each option, requirements are displayed for (1) an initial round of monitoring, and (2) repeat monitoring. In addition, different requirements are set within each option for ground water systems (about 45,000) and surface water systems (about 15,000). The primary differences between the options relate to the extent of specific sampling requirements and the provision of state discretion. In each option, monitoring for vinyl chloride would not be required for all systems. Ground water systems would be required to analyze for vinyl chloride only when other chlorinated 2-carbon VOCs (TCE, PCE, 1,2-DCA or 1,1,1-TCA) had been detected and no requirements would be set for vinyl chloride monitoring in surface water systems. This is because EPA has concluded that the most likely explanation for vinyl chloride detection in ground waters is from in situ transformation.

In each option, monitoring requirements are proposed to be phased in depending upon the size of the systems. Phasing in requirements over four or five years allows public water systems and states sufficient time to efficiently allocate the necessary resources to conduct the monitoring. Systems that are most vulnerable to VOC contamination should sample first; while EPA studies have not shown a clear relationship between potential sources of contamination and actual VOC contamination that could be used to pinpoint specific systems that would be vulnerable to VOC contamination, the Ground Water Supply Survey (GWSS) found the best correlation was between the size of systems and VOC contamination. Therefore, monitoring requirements are proposed to be phased in by system size with the largest systems sampling first.

EPA is proposing that Option 2 be selected as the minimum federally enforceable monitoring requirement. Option 2 provides for reasonable minimum federal requirements while also providing for state discretion in their application. While the requirements are phased in by size of system, states will be encouraged to sample vulnerable systems as early as possible.

Option 1. This option would require all systems to monitor at least once over a four year period. The federally mandated monitoring requirements would be relatively stringent under this option. The monitoring requirements would be phased-in based on the size of the population served by the CWS, as follows:

<u>System size</u> (population served)	<u>Completed by</u>
>10,000	End of 1 year
3300-10,000	End of 2 years
<3300	End of 4 years

- o Ground water systems would be required to sample quarterly for one year at each entry point to the distribution system. Confirmation of positive samples also would be required.
- o Surface water systems would be required to sample quarterly for one year. The minimum number of samples would be one sample per source in the distribution system.

All systems (i.e., ground and surface) would sample quarterly for one year, and would be required to resample any positives. Costs are based on an assumption that the rate of positive samples will be 20 percent.

Repeat monitoring would be based on prior monitoring results and the vulnerability of the system to VOC contamination. The repeat monitoring frequency would be as follows:

<u>Status*</u>	<u>Frequency</u>
VOCs not detected and not vulnerable	Repeat in 5 years**
VOCs not detected and vulnerable	Repeat in 3 years**
VOCs detected	Monthly

*States would annually recertify the vulnerability status of systems.

**Surface water systems sample during four consecutive quarters.

The estimated costs of this option at \$150 per sample are as follows:

Initial round	\$25 million/year (average) for 4 years
Repeat monitoring	\$63.7 million/year

Option 2. The federally mandated monitoring requirements would be less stringent under this option than in Option 1. All systems would monitor at least once over a four year period but fewer samples would be required than in Option 1. Implementation of the monitoring program would be the same as in Option 1, phased in based on the size of the population served by the CWS:

<u>System size</u> (population served)	<u>Completed by</u>
>10,000	End of 1 year
3300-10,000	End of 2 years
<3300	End of 4 years

- o Ground water systems would be required to sample at each entry point to the distribution system. The minimum number of samples for ground water systems would be one sample per entry point to the distribution system, per quarter for one year. If no VOCs are detected in the initial sample and the system is not considered vulnerable to contamination, states would have discretion to reduce the sampling requirements to that initial sample.
- o Surface water systems would sample at points representative of each source. The minimum number of samples would be one sample per source, per quarter for one year. States would have discretion on requiring confirmation samples for positive results.

All systems would be required to conduct repeat monitoring except for surface water systems that were not vulnerable and did not detect any VOCs in the first round of sampling. The frequency of such monitoring would be based on prior monitoring results and the vulnerability of the system to VOC contamination. The monitoring frequency would be as follows:

<u>Status*</u>	<u>Ground Water</u>	<u>Surface Water**</u>
VOCs not detected and not vulnerable	Repeat in 5 years	State discretion
VOCs not detected and vulnerable	Repeat in 3 years	Repeat in 3 years**
VOCs detected	Quarterly	Quarterly

*States would annually recertify the vulnerability status of systems.

**Surface water systems sample during four consecutive quarters.

The estimated costs of this option at \$150 per sample are as follows:

Initial round	\$9.3 million/year (average) over 4 years
Repeat monitoring	\$17.4 million/year

Option 3. More state discretion is provided under this option than the previous options. All ground water systems would monitor at least once over a five year period. Monitoring of surface water systems would be at state discretion based upon vulnerability. The monitoring program would be phased-in based on the size of the population served by the CWS as described in the previous options except that systems serving less than 3300 people would have five years from the date of promulgation to complete the initial monitoring, as follows:

<u>Size of System</u> (population served)	<u>Complete by</u>
>10,000	End of 1 year
3300-10000	End of 2 years
<3300	End of 5 years

Ground water systems would be required to sample in the distribution system at points representative of each well at least once during the initial monitoring period; if VOCs were detected, three additional quarterly samples would be required. States would have discretion on requiring confirmation samples. Specific requirements for surface water systems would be up to state discretion based upon a vulnerability assessment. Repeat compliance monitoring requirements would only be for those systems that detected VOCs in the initial monitoring round. States would have discretion in the frequency of monitoring for those systems where VOCs were not found. The monitoring frequency would be as follows:

<u>Status*</u>	<u>Ground Water</u>	<u>Surface Water</u>
VOCs not detected and not vulnerable	State discretion	State discretion
VOCs not detected and vulnerable	State discretion	State discretion
VOCs detected	Annually	State discretion
VOCs > MCL	Quarterly	State discretion

*States would annually recertify the vulnerability status of systems.

The estimated costs of this option at \$150 per sample are as follows:

Initial round	\$3.8 million/year (average) 5 years
Repeat monitoring	\$2.9 million/year

EPA is proposing Option 2. This option provides minimum monitoring requirements for all systems. For those systems using both ground and surface waters, the monitoring requirements would apply individually to each type of source. The monitoring frequency includes sampling for four consecutive quarters during the monitoring period for surface water systems since variability of surface waters is expected to be influenced more by seasonal and weather conditions. Ground water systems would be required to collect four quarterly samples unless the first sample did not detect VOCs and the system was not considered vulnerable; in these cases states could waive the additional three samples. States are expected to have a major role in implementation of these monitoring requirements; assessments of vulnerability, extent of contamination, and individual system factors will determine the amount of monitoring properly conducted at each system.

Monitoring for Unregulated Contaminants

Because similar analytical procedures for the nine VOCs can also measure numerous other VOCs at relatively small additional cost, monitoring regulations will be proposed for other VOCs. Monitoring for most pesticides and other SOCs is more costly and additional time is needed to develop analytical methods and baseline data (i.e., which pesticides should be monitored and in what locations) such that directed monitoring requirements can be developed (i.e., systems vulnerable to contamination would be required to monitor). The National Pesticides Survey, currently being conducted by the Agency, will provide much of this preliminary data. Three options were considered for unregulated VOCs, similar to the VOC compliance monitoring requirements; the options presented range from an extensive federally mandated specific monitoring program to a monitoring program whose specifics (e.g., repeat monitoring frequencies) would be largely determined by the states. The middle option will be proposed by EPA; a monitoring program providing reasonable minimum federal requirements with provisions for state discretion in their application.

Insofar as possible, the monitoring requirements for unregulated VOCs will be similar to those proposed for compliance monitoring under the NPDWR so that systems will be allowed to use the same samples for analysis of both the unregulated VOCs and the nine VOCs for which MCLs are proposed. In addition, provisions for "grandfathering" previous data of acceptable quality are included. The three options for minimum federally mandated monitoring requirements outlined below generally correspond to the three options described earlier for compliance monitoring for the nine VOCs; Option 2 will be proposed by EPA.

Option 1. This option proposes relatively stringent monitoring requirements and includes minimum repeat monitoring for all systems. The monitoring program will be phased-in over a four year period based on the size of the population served by the CWS in a similar manner as described under Option 1 of the proposed compliance monitoring requirements. Ground water systems would be required to sample once at the well head rather than in the distribution system. Surface water systems would be required to sample quarterly for one year in the distribution system at points representative of each source. All systems would be required to resample positive samples. All systems would be required to repeat monitoring every 10 years.

Option 2. This option is the same as Option 1 above except that it provides for state discretion on resampling positive results and on repeat monitoring requirements. Exhibit 7-4 presents the proposed requirements.

EXHIBIT 7-4

PROPOSED MONITORING FOR UNREGULATED VOCs

Initial Monitoring

- o All systems monitor once over four years
- o Requirements are by system size:

<u>Size of System</u>	<u>Complete by End of</u>
>10,000	1 year
3300-10,000	2 years
<3300	4 years

- o Ground Water Systems: One sample per well at the well head
- o Surface Water Systems: Quarterly samples per each source for one year at points in distribution system representative of each source

Repeat Monitoring

- o State discretion for repeat sampling; dependent upon vulnerability and results of first round of monitoring.

Option 3. Under this option all systems would monitor once over a five year period. Monitoring would be phased-in by the size of population served by the CWS as described under Option 3 of the compliance monitoring requirements. Ground water

systems would be required to sample only 25 percent of their wells and the sampling would be done at the well head. The State would have discretion on whether to require confirmation samples. Also, States would have discretion on whether to require surface water systems to monitor based upon a vulnerability assessment. There is no repeat monitoring requirement under this option.

EPA considered two approaches in the selection of unregulated VOCs to be included in a monitoring regulation. The first and most comprehensive approach is to include approximately 60 VOCs that are detected using purge and trap gas chromatography techniques. The second approach considered is to include only those VOCs which may be of concern because of their possible occurrence in drinking water supplies and potential adverse health effects. EPA believes that the monitoring efforts should be limited to the chemicals that have been detected or are likely to occur in drinking water and that may pose an adverse health risk. EPA is proposing that the 50 VOCs listed in Exhibit 7-5 be considered for a monitoring regulation as part of this proposal. The compounds have been selected based on present regulatory interest and available occurrence information. The compounds listed include:

- o four trihalomethanes in the November 29, 1979 Federal Register;
- o additional VOCs being considered for later phases of the Revised Regulations; and
- o VOCs not included above but detected in the Ground Water Supply Survey and various Federal and State surveys;
- o VOCs that have potential for occurrence in drinking water; VOCs detected in waste waters, surface or ground waters or have widespread dispersive use patterns and high production.

The VOCs in Exhibit 7-5 can be measured in a single analysis by GC/MS or by four separate analyses using GC. Estimated costs are \$150 to \$200 for the GC/MS and about \$100 per GC analysis. The four analyses include:

- A Purgeable halogenated hydrocarbons
- B Purgeable aromatics
- C Highly volatile substances
- D Low sensitivity (or low limits of detection required)

Analysis C of the highly volatile substances can be incorporated into the procedures for the purgeable hydrocarbons through minor adaptations (e.g., change the trapping device). Analysis D (EDB and DBCP) is estimated to cost an additional \$50.00 per sample. Monitoring for EDB and DBCP will only be required for systems considered to be vulnerable to EDB or DBCP contamination.

EXHIBIT 7-5

UNREGULATED VOCs CONSIDERED FOR MONITORING

A	Chloroform	A	Chloromethane
A	Bromodichloromethane	A	Bromomethane
A	Chlorodibromomethane	A	Bromochloromethane
A	Bromoform	A	1,2,3-Trichloropropane
A	trans-1,2-Dichloroethylene	B	1,2,3-Trichlorobenzene
A	Chlorobenzene	B	n-Propylbenzene
A	m-Dichlorobenzene	A	1,1,1,2-Tetrachloroethane
A	Dichloromethane	A	Chloroethane
A	cis-1,2-Dichloroethylene	A	1,1,2-Trichloroethane
A	o-Dichlorobenzene	A	Pentachloroethane
A	1,2,4-Trichlorobenzene	A	bis-2-Chloroisopropyl ether
C	Fluorotrichloromethane	A	sec-Dichloropropane
C	Dichlorodifluoromethane	B	1,2,4-Trimethylbenzene
A	Dibromomethane	B	n-Butylbenzene
D	1,2-Dibromoethane (EDB)	B	Napthalene
D	1,2-Dibromo-3-chloropropane (DBCP)	B	hexachlorobutadiene
B	Toluene	B	o-Chlorotoluene
B	p-Xylene	B	p-Chlorotoluene
B	o-Xylene	B	1,3,5-Trimethylbenzene
B	m-Xylene	B	p-Cymene
A	1,1-Dichloroethane	A	1,1-Dichloropropane
A	1,2-Dichloropropane	B	iso-Propylbenzene
A	1,1,2,2-Tetrachloroethane	B	tert-Butylbenzene
B	Ethylbenzene	B	sec-Butylbenzene
A	1,3-dichloropropane		
B	Styrene		
A	Bromobenzene		

NOTE:

- A - Can be analyzed using the Purgeable Halogenated Hydrocarbon Method
- B - Can be analyzed using the Purgeable Aromatic Hydrocarbon Method
- C - Highly volatile substances
- D - Low sensitivities (requires a low limit of detection)

Analyses are to be conducted in certified laboratories if such data are to be used for compliance with MCLs for the nine VOCs in this proposal. Because the monitoring for unregulated contaminants will be required before full certification programs can be implemented, interim certification will be provided to those laboratories presently certified for trihalomethane analyses and, those that analyze performance evaluation samples for additional VOCs within acceptable limits.

Estimated costs for the three options are shown in Exhibit 7-6.

EXHIBIT 7-6

COSTS FOR MONITORING UNREGULATED VOCs

	<u>Option 1</u>	<u>Option 2</u>	<u>Option 3</u>
Initial Round	\$2.7 million	\$2.3 million	\$0.5 million
Repeat Monitoring	\$2.7 million	0	0

8. SUMMARY OF COSTS AND BENEFITS

8.1 Introduction

This chapter summarizes the results of the cost and benefit analyses (Chapters 4 and 5) performed at the aggregate or national level and of the net benefits analysis (Chapter 6) performed at the level of individual water systems of varying sizes. Together, these analyses provide a complete evaluation of the regulatory alternatives.

8.2 Probable Actions, Health Benefits and Costs

As discussed in Chapter 3, alternative EPA actions fall into three categories: 1) no action (other than existing health advisories); 2) monitoring and reporting requirements (in addition to health advisories); and, 3) MCLs, RMCLs, and monitoring and reporting requirements. MCLs are the most probable action based on the results of benefit and cost analyses.

The aggregate results indicate that such regulatory action is warranted due to the nature and extent of VOC occurrence and the carcinogenic potential of most of the chemicals under study. At present, the baseline level of exposure to VOCs in drinking water is estimated to be responsible for approximately 50 cases of cancer per year in the United States (see page IV-2).

The extent to which the health effects of VOC exposure can be reduced by regulatory action will vary depending upon the levels chosen for the MCLs. There are, of course, trade-offs between the level of stringency required in such regulation and the costs incurred. Exhibits 8-1 and 8-2 present summaries of the aggregate cost and benefit estimates in a manner which allows a comparison of the total national cost on an annual basis versus the number of cases of cancer avoided.

The diagrams presented in Exhibits 8-1 and 8-2 are designed to take explicit account of the uncertainties involved in making such estimates at a national level. The sources and magnitudes of the uncertainties in both the benefit and the cost analyses were analyzed in detail in Chapters 4 and 5. In these Exhibits, the ratio of the standard error in the cost estimate to that of the benefit estimate for each MCL was entered into a table of circular error probabilities to obtain the radii of the circles that include respectively, 68 percent and 95 percent of the volume under the joint probability surface. Thus, the "true" values for each MCL's cost and benefit fall inside the circles with either 68 percent or 95 percent probability.

The diagrams in Exhibits 8-1 and 8-2 display two clusters of circles: one relatively high cost cluster representing MCLs of 0.5 and 1.0 ug/l and another relatively low cost cluster representing MCLs of 5.0, 10.0, and 20.0 ug/l. The obvious

EXHIBIT 8-1

**68% CONFIDENCE PLOT OF CANCER CASES AVOIDED
AS A FUNCTION OF ANNUALIZED COST**

(True values are expected to fall within the circles
with a probability of 68 percent.)

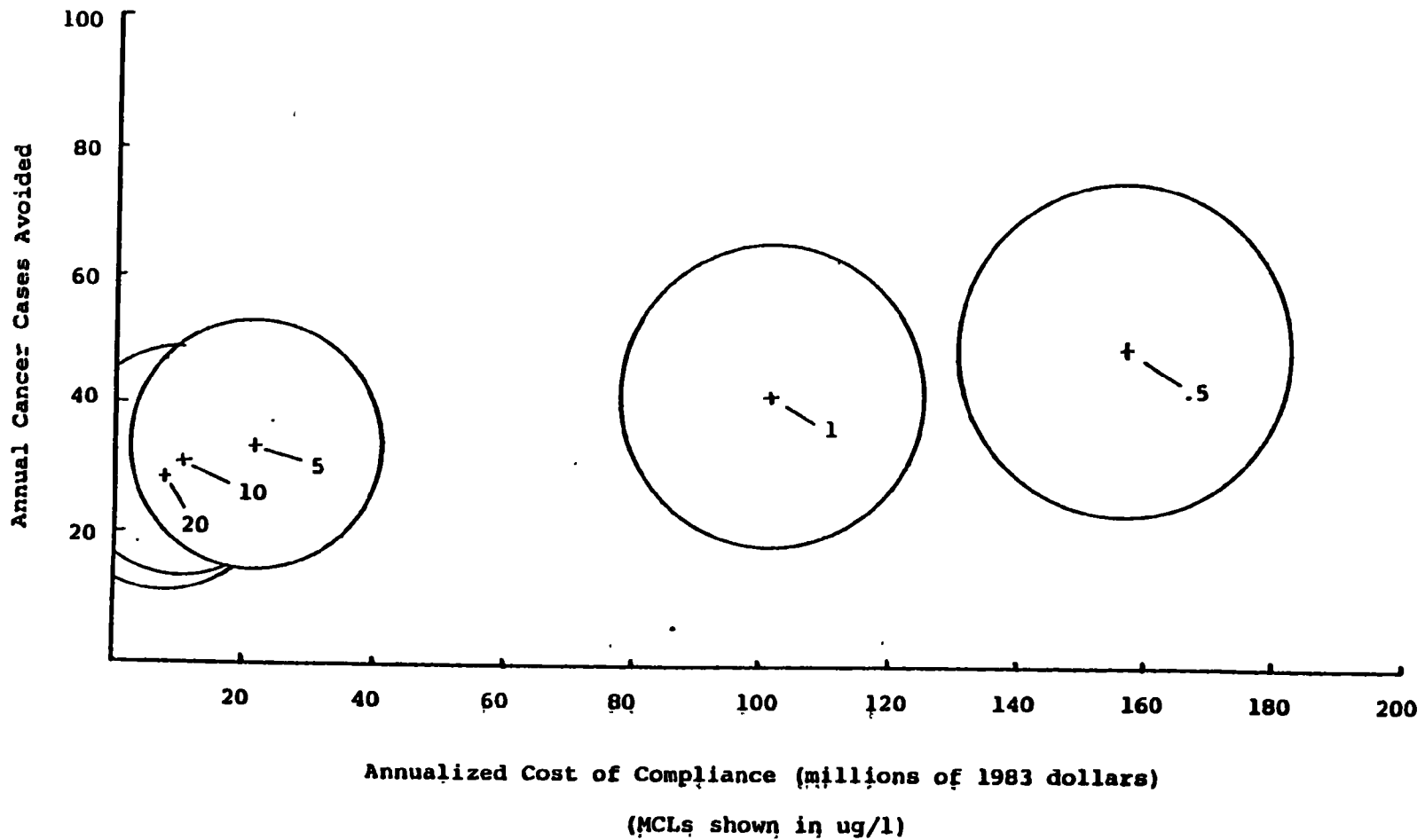
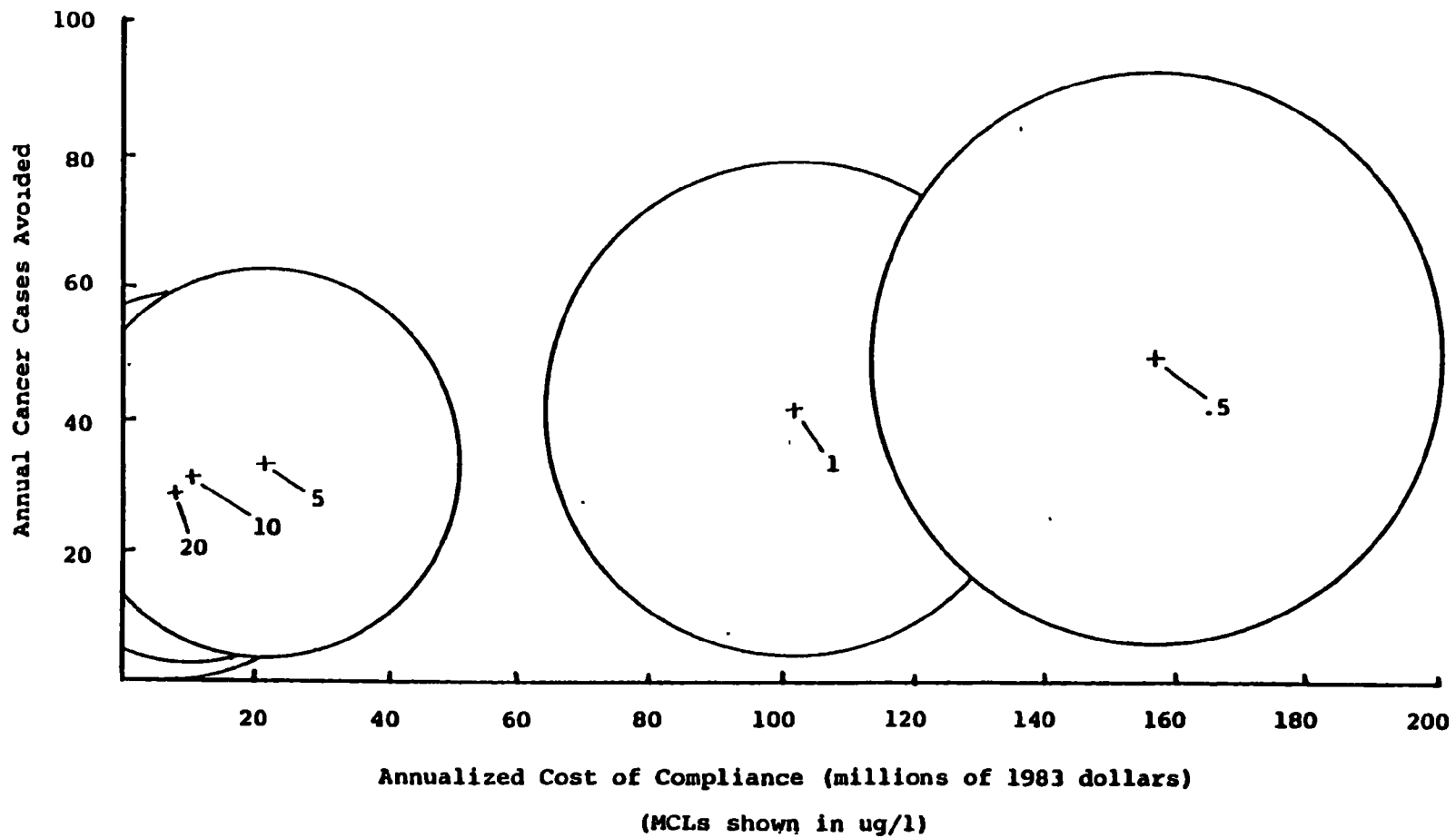


EXHIBIT 8-2

**95% CONFIDENCE PLOT OF CANCER CASES AVOIDED
AS A FUNCTION OF ANNUALIZED COST**

(True values are expected to fall within the circles
with a probability of 95 percent.)



implication of this diagram is that the high cost cluster implies costs that are four to five times as high as the low cost cluster whereas the difference in benefits is only on the order of a factor of two. On the basis of aggregate costs and benefits, the lower cost cluster appears to be a better bargain.

Results of aggregate analysis must be supplemented with analysis of costs and benefits at the level of individual water systems. The net benefits analysis in Chapter 6 performed such analysis. The system level analysis showed that in terms of the marginal cost per cancer case avoided, MCLs in the vicinity of 1.0 and 0.5 ug/l are very expensive for VOCs that pose low to moderate cancer risks. Net benefits of such levels of regulation would be positive only for the relatively high cancer risk VOCs such as vinyl chloride, carbon tetrachloride, and 1,1-dichloroethylene.

The system level analysis also showed that MCLs in the vicinity of 5.0, 10.0, and 20.0 ug/l do not achieve positive net benefits for the VOCs posing only low and moderate degrees of cancer risk. Control of these "weaker" carcinogens to these levels does not produce benefit estimates high enough to equal the high initial fixed cost of treatment equipment.

However, nearly 50 percent of all VOC occurrence is multiple occurrence where several VOCs are present together. Vinyl chloride and 1,1-dichloroethylene occur with particular frequency in such mixtures making the average risk posed by these mixtures relatively high. There is suspicion that vinyl chloride may exist in some of these circumstances as a by-product of the biological breakdown of the other VOCs. The presence of higher risk mixtures may greatly increase the net benefits of controlling all VOCs.

Exhibit 8-3 presents other summary statistics characterizing the impacts and benefits of VOC control.

EXHIBIT 8-3

SUMMARY OF IMPACTS OF THE REGULATORY OPTIONS

	Regulatory Options		
	<u>1 ug/l</u>	<u>5 ug/l</u>	<u>10 ug/l</u>
Systems Impacted	3,800	1,300	800
National Cost of Control			
Total (\$ millions)	\$1,300	\$ 280	\$ 150
Annual (\$ millions)	100	21	11
National Cost of Monitoring			
Compliance (\$ millions)		\$ 14	
Unregulated Contaminants		3	
Annual Cost per Family (\$/year)			
System Size (people served):			
Very Small (25-500)	\$ 96	\$ 91	\$ 90
Small (501-3,300)	47	41	42
Medium (3,301-50,000)	12	12	11
Large (over 50,000)	8	3	1
Typical Rate Increases (\$/1000 gal)			
Very Small (25-500)	\$ 0.58	\$ 0.54	\$ 0.58
Small (501-3,300)	0.33	0.29	0.29
Medium (3,301-50,000)	0.07	0.07	0.07
Large (over 50,000)	0.04	0.02	0.01
Annual Cancer Cases Avoided			
Total	42	32	31
Attributable to Vinyl Chloride	37	29	27
Average Cost/Case Avoided			
(millions)			
Very Small (25-500)	\$ 10	\$ 5	\$ 4
Small (501-3,300)	7	3	2
Medium (3,301-50,000)	2	0.6	0.4
Large (over 50,000)	2	0.2	0.04

APPENDIX A -- HEALTH EFFECTS OF INDIVIDUAL CHEMICALS

BENZENE

Benzene is a chemical that effects multisystems, but the hematopoietic and immune systems appear to be most sensitive. Maltoni has published several papers that demonstrate that benzene causes leukemia as well as hard tissue cancers in animals. Leukemia has been associated with exposure to benzene in humans.

A suggested Adjusted ADI was calculated based on data from a subchronic gavage study in rats in which leucopenia was observed at specific dose levels. A value of 0.025 mg/1 was calculated using a no-observed-adverse-effect level of 1 mg/kg and an uncertainty factor of 1,000, since a study with less than lifetime exposure was used.

The EPA's Carcinogen Assessment Group (CAG) calculated projected excess cancer estimates with the linearized non-threshold multistage model and data from an epidemiologic study of workers exposed to benzene vapors on their jobs. An increased risk of one excess cancer per 1,000,000 people corresponds to lifetime exposure to a benzene level of 0.67 ug/1 in drinking water.

Benzene is placed in category 1 by the IARC and category A by the EPA, because the strength of evidence for its carcinogenicity is sufficient in humans with supportive evidence in animals.

CARBON TETRACHLORIDE

The main toxic effects of carbon tetrachloride in humans occur in the liver, kidney, and lung. Toxic effects from carbon tetrachloride exposure in animals include kidney and lung damage and fatty infiltration and necrosis in the liver. Carbon tetrachloride has been shown to be carcinogenic in rats, mice and hamsters.

A suggested Adjusted ADI was calculated based on data from a 12-week gavage study in rats in which liver toxicity was evident at specific dose levels. A value of 0.025 mg/1 was calculated using a no-observed-adverse-effect level of 1 mg/kg and an uncertainty factor of 1,000, since a study with less than lifetime exposure was used.

The EPA's Office of Health and Environmental Assessment calculated projected excess cancer estimates with the linearized non-threshold multistage model and the geometric mean of four cancer studies in animals (NCI, 1976 - mice, NCI, 1976 - rats, Edwards et al., 1942 - mice, Della Porta et al., 1961-hamsters).

An increased risk of one excess cancer per 1,000,000 people corresponds to lifetime exposure to a carbon tetrachloride level of 0.27 ug/1 in drinking water.

Carbon tetrachloride has been classified as a 2B and B2 carcinogen by the IARC and EPA, respectively, based on conclusions of sufficient evidence in animals and inadequate evidence in humans.

p-DICHLOROBENZENE

In animals, p-dichlorobenzene has induced liver and kidney damage, porphyria, pulmonary edema and congestion, and splenic weight changes. In humans, exposure to dichlorobenzenes has been reported to result in anorexia, nausea, yellow atrophy of the liver, and blood dyscrasias.

A suggested Adjusted ADI was calculated based on toxicity data from a subchronic gavage study in rats. A value of 3.75 mg/1 was calculated using a no-observed-adverse-effect level of 150 mg/kg and an uncertainty factor of 1,000, since a study with less than lifetime exposure was used.

Because there is no evidence for carcinogenic effects, a strength of evidence judgement and a risk assessment are not applicable for p-dichlorobenzene.

1,2-DICHLOROETHANE

Noncarcinogenic effects observed in animals and humans include liver and kidney damage, central nervous system depression, gastrointestinal distress, adrenal and lung effects, and circulatory disturbances. 1,2-dichloroethane has been shown to significantly increase tumor incidences at several sites in both rats and mice when administered by gavage, but not following inhalation exposure.

A series of inhalation studies where several animal species were exposed to 1,2-dichloroethane were selected for calculation of an Adjusted ADI. Several toxic effects were observed in these studies. A value of 0.26 mg/1 was calculated using a no-observed-adverse-effect level of 100 ppm (405 mg/m³) and an uncertainty factor of 1,000, since a study with less than lifetime exposure was used.

The CAG calculated projected excess cancer estimates with the linearized non-threshold multistage model and NCI carcinogenicity bioassay data. An increased risk of one excess cancer per 1,000,000 people corresponds to lifetime exposure to a 1,2-dichloroethane level of 0.5 ug/1 in drinking water.

1,2-Dichloroethane has been categorized as a group 2B and Group B2 carcinogen by the IARC and EPA, respectively, based on conclusions of sufficient evidence in animals and inadequate evidence in humans.

1,1-DICHLOROETHYLENE (VINYLIDENE CHLORIDE)

Toxic effects of 1,1-dichloroethylene in animals include liver and kidney damage, central nervous system depression, and sensitization of the heart. Although 1,1-dichloroethylene has been reported to be a renal carcinogen in one mouse study and positive in mouse skin as an initiator with phorbol esters as the promoter, most of the carcinogenicity studies have failed to demonstrate significant carcinogenic activity for this agent.

A suggested Adjusted ADI was calculated based on data from a chronic drinking water study in rats in which toxic liver effects were found with specific dose levels. A value of 0.35 mg/l was calculated using a no-observed-adverse-effect level of 10 mg/kg and an uncertainty factor of 100.

The CAG calculated projected excess cancer estimates with the linearized non-threshold multistage model and renal adenocarcinoma data in a carcinogenicity study with mice exposed to 1,1-dichloroethylene by inhalation. An increased risk of exposure to a 1,1-dichloroethylene level of 0.24 ug/l in drinking water. However, the EPA's Science Advisory Board has questioned the validity of the study on which this risk assessment is based.

1,1-Dichloroethylene is placed in category 3 by the IARC and category C by the EPA, because the strength of evidence for its carcinogenicity is limited in animals and inadequate in humans.

TETRACHLOROETHYLENE

Principal noncarcinogenic effects of tetrachloroethylene in humans and animals include liver and kidney damage, congestion and edema in lungs, hyperemia of the kidney and lungs, and central nervous system depression. Tetrachloroethylene is positive as a liver carcinogen given to mice by gavage.

The Adjusted ADI has been revised as a result of public comments. In lieu of what is in the June 12, 1984, Federal Register proposal (0.085 mg/l), the Adjusted ADI is presently 0.68 mg/l based on a no-observed-adverse-effect level of 70 ppm (475 mg/m³) in a subchronic inhalation toxicity study in rats and an uncertainty factor of 1,000, since a study with less than lifetime exposure is used.

The CAG calculated projected excess cancer estimates with the linearized non-threshold multistage model and liver carcinogenicity data for mice given tetrachloroethylene by gavage in a NCI bioassay. An increased risk of one excess per 1,000,000 people corresponds to lifetime exposure to a tetrachloroethylene level of 1 ug/l in drinking water.

Tetrachloroethylene has been classified as a Group 3 and a Group C carcinogen by the IARC and EPA, respectively, based

on conclusions of limited evidence in animals and inadequate evidence in humans.

1,1,1-TRICHLOROETHANE (METHYL CHLOROFORM)

The principal toxic effects of 1,1,1-trichloroethane at high doses in animals and humans are depression of the central nervous system, increase in liver weight and cardiovascular changes.

Liver toxicity is the most sensitive end-point with respect to adverse health effects. An inhalation study (McNutt et al., 1975) which examines exposure of mice to 1,1,1-trichloroethane is used to calculate a suggested Adjusted ADI of 1.0 mg/l. This study demonstrates changes in the livers of mice at dose levels.

Two animal carcinogenic bioassays by the National Toxicological Program have been conducted in rats and mice (1977; 1983). In the earlier bioassay, 3 percent of the animals had survived to the end of the experiment (chronic murine pneumonia, etc.). Because of this, it was concluded that carcinogenicity could not be determined from this study. A repeat carcinogenesis bioassay of 1,1,1-trichloroethane was conducted in which doses of 3,000 or 1,500 mg/kg were administered by gavage to both sexes of mice, and rats were given doses of 750 or 375 mg/kg in corn oil. In the preliminary report of this study, 1,1,1-trichloroethane was carcinogenic in both male and female mice showing an increased incidence of hepatocellular carcinomas but not in rats; however, these initial results have been questioned.

IARC has not classified 1,1,1-trichloroethane for carcinogenic potential and EPA cancer guidelines has classified 1,1,1-trichloroethane Group D (inadequate data to classify).

TRICHLOROETHYLENE

Trichloroethylene has been shown to exhibit noncarcinogenic effects in humans as well as in dogs, rabbits, guinea pigs, rats and mice. Major effects include liver and kidney damage, central nervous system effects and myocardial contractility. Trichloroethylene was reported as carcinogenic in mice.

A suggested Adjusted ADI was calculated based on data from a 14-week inhalation study in rats in which elevated liver weights were observed with each exposure level. A value of 0.257 mg/l was calculated using a lowest-observed-adverse-effect level of 55 ppm (300 mg/m³) and an uncertainty factor of 1,000, since a no-observed-adverse-effect level was not identified and a study with less than lifetime exposure was used.

The CAG calculated projected excess cancer estimates with the linearized non-threshold multistage model and liver carcinogenicity data for mice given trichloroethylene by gavage in a NCI

bioassay. An increased risk of one excess cancer per 1,000,000 people corresponds to lifetime exposure to a trichloroethylene level of 1.8 ug/1 in drinking water.

Trichloroethylene has been classified as a Group 3 carcinogen by the IARC based on conclusions of limited evidence in animals and inadequate evidence in humans. On the basis of evidence obtained after the IARC review, the EPA has raised the strength of evidence in animals to sufficient which consequently places trichloroethylene in the B2 category in the EPA classification scheme.

VINYL CHLORIDE

Vinyl chloride is toxic in lungs, kidneys and liver in animals. Exposure to vinyl chloride has been reported to induce acroosteolysis, pulmonary insufficiency, and disturbances in the cardiovascular, gastrointestinal, and central nervous systems in humans, liver angiosarcomas and tumors in the brain, lung and hematopoietic systems have been associated with vinyl chloride exposure in humans. Vinyl chloride is carcinogenic in rats, mice and hamsters, with major tumor types including liver angiosarcomas, hepatocellular carcinomas, brain tumors, and lung tumors.

The Adjusted ADI has been revised in light of a new carcinogenicity study on vinyl chloride in rats. In lieu of what is in the June 12, 1984, Federal Register proposal (0.06 mg/1), the Adjusted ADI is currently 0.046 mg based on a no-observed-adverse-effect level of 0.13 mg/kg in a carcinogenicity study in which liver toxicity was found at specific dose levels in rats given vinyl chloride monomer in the diet and an uncertainty factor of 100.

The CAG calculated projected excess cancer estimates with the linearized non-threshold multistage model and carcinogenicity data for rats given vinyl chloride monomer in the diet. An increased risk of one excess cancer per 1,000,000 people corresponds to lifetime exposure to a vinyl chloride level of 0.015 ug/1 in drinking water. The CAG is reviewing this risk assessment in view of a new carcinogenicity study with vinyl chloride in rats.

EXHIBIT B-1

PROBABILITY OF SYSTEM OF GIVEN SIZE AND WITH GIVEN INFLUENT CONCENTRATION SELECTING COMPLIANCE MEASURES FOR A GIVEN MCL
(Ground Source)

CONTAMINANTS: TRICHLOROETHYLENE, 1,1,1-TRICHLOROETHANE, TETRACHLOROETHYLENE, CARBON TETRACHLORIDE,
1,1-DICHLOROETHYLENE, 1,1-DICHLOROETHANE, BENZENE, AND TYPICAL MULTIPLE OCCURRENCE

COMPLIANCE MEASURES

System Size	Influent Concentration (ppb)	MCL (ppb)	GAC	Packed Tower	Diffused Air	Tray Aeration	PAC	Well Field Management	Source Protection	Regulation	Alternative Source	Do Nothing
Very small (25-500 pop)	0.5-5	0.5	.60	.05	0	.05	0	0	0	.05	.55	0
		5	0	0	0	0	0	0	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.55	.10	0	0	0	0	0	.05	.50	0
		5	.55	.25	0	.05	0	0	0	.05	.50	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	.55	.10	0	0	0	0	0	.05	.50	0
		5	.55	.10	0	0	0	0	0	.05	.50	0
		20	.55	.05	0	.05	0	0	0	.05	.50	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	.55	.10	0	0	0	0	0	.05	.50	0
		5	.55	.10	0	0	0	0	0	.05	.50	0
		20	.55	.05	0	.05	0	0	0	.05	.50	0
		50	.55	.05	0	.05	0	0	0	.05	.50	0
Small (501-3500 pop)	0.5-5	0.5	.10	.40	0	.05	0	0	0	.05	.40	0
		5	0	0	0	0	0	0	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.15	.40	0	0	0	0	0	.05	.40	0
		5	.10	.40	0	.05	0	0	0	.05	.40	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	.10	.40	0	0	0	0	0	.05	.40	0
		5	.10	.40	0	.05	0	0	0	.05	.40	0
		20	.10	.40	0	.05	0	0	0	.05	.40	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	.10	.40	0	0	0	0	0	.05	.40	0
		5	.10	.40	0	.05	0	0	0	.05	.40	0
		20	.10	.40	0	.05	0	0	0	.05	.40	0
		50	.10	.40	0	.05	0	0	0	.05	.40	0
Medium (3501-10,000 pop)	0.5-5	0.5	.10	.20	0	.10	0	.10	0	0	.50	0
		5	0	0	0	0	0	.10	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.10	.40	0	0	0	0	0	0	.50	0
		5	.10	.20	0	.10	0	.10	0	0	.50	0
		20	0	0	0	0	0	.15	0	0	.15	.70
		50	0	0	0	0	0	.10	0	0	.10	.80
	20-50	0.5	.10	.40	0	0	0	0	0	.10	.40	0
		5	.10	.35	0	.05	0	0	0	0	.30	0
		20	.10	.35	0	.05	0	0	0	0	.30	0
		50	0	0	0	0	0	.10	0	0	.10	.80
	50+	0.5	.10	.40	0	0	0	0	0	.10	.40	0
		5	.10	.35	0	.05	0	0	0	0	.30	0
		20	.10	.35	0	.05	0	0	0	0	.30	0
		50	.10	.35	0	.05	0	0	0	0	.30	0
Large (10,001 - 100,000 pop)	0.5-5	0.5	.10	.20	.05	.05	0	.30	0	0	.30	0
		5	0	0	0	0	0	.20	0	0	0	.80
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.10	.35	.05	0	0	.10	0	0	.40	0
		5	.10	.20	.05	.05	0	.30	0	0	.30	0
		20	0	0	0	0	0	.35	0	0	.05	.60
		50	0	0	0	0	0	.35	0	0	0	.65
	20-50	0.5	.10	.40	0	0	0	0	0	0	.40	0
		5	.10	.30	.05	.05	0	.10	0	0	.40	0
		20	.10	.20	.05	.05	0	.30	0	0	.30	0
		50	0	0	0	0	0	.35	0	0	.05	.60
	50+	0.5	.10	.40	0	0	0	0	0	0	.40	0
		5	.10	.30	.05	.05	0	.10	0	0	.40	0
		20	.10	.20	.05	.05	0	.30	0	0	.30	0
		50	.10	.20	.05	.05	0	.30	0	0	.30	0
Very Large (100,000+ pop)	0.5-5	0.5	.10	.20	0	.10	0	.60	0	0	0	0
		5	0	0	0	0	0	.60	0	0	0	.40
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.10	.35	.05	0	0	.30	0	0	.20	0
		5	.10	.20	.05	.05	0	.40	0	0	.20	0
		20	0	0	0	0	0	.90	0	0	0	.10
		50	0	0	0	0	0	.30	0	0	0	.50
	20-50	0.5	0	.30	0	0	0	.30	0	0	.20	0
		5	0	.45	.05	0	0	.30	0	0	.20	0
		20	0	.30	.05	.05	0	.40	0	0	.20	0
		50	0	0	0	0	0	.30	0	0	0	.50
	50+	0.5	0	.50	0	0	0	.30	0	0	.20	0
		5	0	.45	.05	0	0	.30	0	0	.20	0
		20	0	.30	.05	.05	0	.40	0	0	.20	0
		50	0	.30	.05	.05	0	.40	0	0	.20	0

Note: the probabilities have been revised so that a system always selects "do nothing" if the MCL is not exceeded

EXHIBIT B-2

PROBABILITY OF SYSTEM OF GIVEN SIZE AND WITH GIVEN INFLUENT CONCENTRATION SELECTING COMPLIANCE MEASURES FOR A GIVEN MCL
(Ground Source)
CONTAMINANTS: VINYL CHLORIDE*, 1,2-DICHLOROETHANE, AND TYPICAL WORST CASE MULTIPLE OCCURRENCE

COMPLIANCE MEASURES

System Size	Influent Concentration (ppb)	MCL (ppb)	CAC	Packed Tower	Diffused Air	Trey Aeration	PAC	Well Field Management	Source Protection	Regionalization	Alternative Sources	Do Nothing
Very small (25-500 pop)	0.5-5	0.5	.40	.05	0	.05	0	0	0	.05	.25	0
		5	0	0	0	0	0	0	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.35	.10	0	0	0	0	0	.05	.30	0
		5	.35	.05	0	.05	0	0	0	.05	.30	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	.35	.10	0	0	0	0	0	.05	.30	0
		5	.35	.10	0	0	0	0	0	.05	.30	0
		20	.35	.05	0	.05	0	0	0	.05	.30	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	.35	.10	0	0	0	0	0	.05	.30	0
		5	.35	.10	0	0	0	0	0	.05	.30	0
		20	.35	.05	0	.05	0	0	0	.05	.30	0
		50	.35	.05	0	.05	0	0	0	.05	.30	0
Small (501-3300 pop)	0.5-5	0.5	0	.50	0	.05	0	0	0	.05	.40	0
		5	0	0	0	0	0	0	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	0	.35	0	0	0	0	0	.05	.40	0
		5	0	.30	0	.05	0	0	0	.05	.40	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	0	.50	0	0	0	0	0	.05	.45	0
		5	0	.50	0	.05	0	0	0	.05	.40	0
		20	0	.50	0	.05	0	0	0	.05	.40	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	0	.50	0	0	0	0	0	.05	.45	0
		5	0	.50	0	.05	0	0	0	.05	.40	0
		20	0	.50	0	.05	0	0	0	.05	.40	0
		50	0	.50	0	.05	0	0	0	.05	.40	0
Medium (3301-10,000 pop)	0.5-5	0.5	0	.50	0	.10	0	.10	0	0	.50	0
		5	0	0	0	0	0	.10	0	0	0	.90
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	0	.50	0	0	0	0	0	0	.50	0
		5	0	.30	0	.10	0	.10	0	0	.50	0
		20	0	0	0	0	0	.15	0	0	.15	.70
		50	0	0	0	0	0	.10	0	0	.10	.80
	20-50	0.5	0	.50	0	0	0	0	0	.10	.40	0
		5	0	.45	0	.05	0	0	0	0	.50	0
		20	0	.45	0	.05	0	0	0	0	.50	0
		50	0	0	0	0	0	.10	0	0	.10	.80
	50+	0.5	0	.50	0	0	0	0	0	.10	.40	0
		5	0	.45	0	.05	0	0	0	0	.50	0
		20	0	.45	0	.05	0	0	0	0	.50	0
		50	0	.45	0	.05	0	0	0	0	.50	0
Large (10,001 - 100,000 pop.)	0.5-5	0.5	0	.50	.05	.05	0	.30	0	0	.30	0
		5	0	0	0	0	0	.20	0	0	0	.40
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	0	.45	.05	0	0	.10	0	0	.40	0
		5	0	.30	.05	.05	0	.30	0	0	.30	0
		20	0	0	0	0	0	.35	0	0	.05	.60
		50	0	0	0	0	0	.35	0	0	0	.65
	20-50	0.5	0	.60	0	0	0	0	0	0	.40	0
		5	0	.40	.05	.05	0	.10	0	0	.40	0
		20	0	.30	.05	.05	0	.30	0	0	.30	0
		50	0	0	0	0	0	.35	0	0	.05	.60
	50+	0.5	0	.60	0	0	0	0	0	0	.40	0
		5	0	.40	.05	.05	0	.10	0	0	.40	0
		20	0	.30	.05	.05	0	.30	0	0	.30	0
		50	0	.30	.05	.05	0	.30	0	0	.30	0
Very Large (100,000+ pop)	0.5-5	0.5	0	.50	0	.10	0	.40	0	0	0	0
		5	0	0	0	0	0	.40	0	0	0	.40
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	0	.45	.05	0	0	.30	0	0	.20	0
		5	0	.30	.05	.05	0	.40	0	0	.20	0
		20	0	0	0	0	0	.90	0	0	0	.10
		50	0	0	0	0	0	.50	0	0	0	.50
	20-50	0.5	0	.50	0	0	0	.30	0	0	.20	0
		5	0	.45	.05	0	0	.30	0	0	.20	0
		20	0	.30	.05	.05	0	.40	0	0	.20	0
		50	0	0	0	0	0	.50	0	0	0	.50
	50+	0.5	0	.50	0	0	0	.30	0	0	.20	0
		5	0	.45	.05	0	0	.30	0	0	.20	0
		20	0	.30	.05	.05	0	.40	0	0	.20	0
		50	0	.30	.05	.05	0	.40	0	0	.20	0

* For vinyl chloride, no CAC is selected. CAC probabilities should be allocated to packed tower aeration.

Note: the probabilities have been revised so that a system always selects "do nothing" if the MCL is not exceeded.

EXHIBIT B-3

PROBABILITY OF SYSTEM OF GIVEN SIZE AND WITH GIVEN INFLUENT CONCENTRATION SELECTING COMPLIANCE MEASURES FOR A GIVEN MCL
(Ground Source)
CONTAMINANTS: PARA-DICHLOROBENZENE

COMPLIANCE MEASURE

System Size	Influent Concentration (ppb)	MCL (ppb)	CAC	Packed Tower	Diffused Air	Tray Aeration	PAC	Well Field Management	Source Protection	Regulation	Alternative Sources	Do Nothing
Very small (25-500 pop)	0.5-5	0.5	.60	.05	0	.05	0	0	0	.05	.35	0
		5	0	0	0	0	0	0	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.35	.10	0	0	0	0	0	.05	.30	0
		5	.60	.05	0	0	0	0	0	.05	.30	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	.35	.10	0	0	0	0	0	.05	.30	0
		5	.35	.10	0	0	0	0	0	.05	.30	0
		20	.60	.05	0	0	0	0	0	.05	.30	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	.35	.10	0	0	0	0	0	.05	.30	0
		5	.35	.10	0	0	0	0	0	.05	.30	0
		20	.60	.05	0	0	0	0	0	.05	.30	0
		50	.60	.05	0	0	0	0	0	.05	.30	0
Small (501-3300 pop)	0.5-5	0.5	.15	.60	0	0	0	0	0	.05	.40	0
		5	0	0	0	0	0	0	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.15	.60	0	0	0	0	0	.05	.40	0
		5	.10	.60	0	.05	0	0	0	.05	.40	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	.10	.60	0	0	0	0	0	.05	.45	0
		5	.15	.60	0	0	0	0	0	.05	.40	0
		20	.10	.60	0	.05	0	0	0	.05	.40	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	.10	.60	0	0	0	0	0	.05	.45	0
		5	.15	.60	0	0	0	0	0	.05	.40	0
		20	.10	.60	0	.05	0	0	0	.05	.40	0
		50	.10	.60	0	.05	0	0	0	.05	.40	0
Medium (3301-10,000 pop.)	0.5-5	0.5	.15	.25	0	0	0	.10	0	0	.30	0
		5	0	0	0	0	0	.10	0	0	0	.90
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.10	.60	0	0	0	0	0	0	.30	0
		5	.10	.20	0	.10	0	.10	0	0	.30	0
		20	0	0	0	0	0	.15	0	0	.15	.70
		50	0	0	0	0	0	.10	0	0	.10	.80
	20-50	0.5	.10	.60	0	0	0	0	0	.10	.40	0
		5	.10	.35	0	.05	0	0	0	0	.30	0
		20	.10	.35	0	.05	0	0	0	0	.30	0
		50	0	0	0	.05	0	.10	0	0	.10	.80
	50+	0.5	.10	.60	0	0	0	0	0	.10	.40	0
		5	.10	.35	0	.05	0	0	0	0	.30	0
		20	.10	.35	0	.05	0	0	0	0	.30	0
		50	.10	.35	0	.05	0	0	0	0	.30	0
Large (10,001 - 100,000 pop)	0.5-5	0.5	.15	.25	0	0	0	.30	0	0	.30	0
		5	0	0	0	0	0	.20	0	0	0	.80
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.15	.35	0	0	0	.10	0	0	.40	0
		5	.10	.20	.05	.05	0	.30	0	0	.30	0
		20	0	0	0	0	0	.35	0	0	.05	.60
		50	0	0	0	0	0	.35	0	0	0	.65
	20-50	0.5	.25	.35	0	0	0	0	0	0	.40	0
		5	.10	.60	0	0	0	.10	0	0	.40	0
		20	.10	.20	.05	.05	0	.30	0	0	.30	0
		50	0	0	0	0	0	.35	0	0	.05	.60
	50+	0.5	.25	.35	0	0	0	0	0	0	.40	0
		5	.10	.60	0	0	0	.10	0	0	.40	0
		20	.10	.20	.05	.05	0	.30	0	0	.30	0
		50	.10	.20	.05	.05	0	.30	0	0	.30	0
Very Large (100,000+ pop)	0.5-5	0.5	.15	.25	0	0	0	.60	0	0	0	0
		5	0	0	0	0	0	.60	0	0	0	.40
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.15	.35	0	0	0	.30	0	0	.20	0
		5	.10	.20	.05	.05	0	.60	0	0	.20	0
		20	0	0	0	0	0	.90	0	0	0	.10
		50	0	0	0	0	0	.30	0	0	0	.30
	20-50	0.5	.10	.60	0	0	0	.30	0	0	.20	0
		5	.10	.35	.05	0	0	.30	0	0	.20	0
		20	0	.30	.05	.05	0	.60	0	0	.20	0
		50	0	0	0	0	0	.30	0	0	0	.50
	50+	0.5	.10	.60	0	0	0	.30	0	0	.20	0
		5	.10	.35	.05	0	0	.30	0	0	.20	0
		20	0	.30	.05	.05	0	.60	0	0	.20	0
		50	0	.30	.05	.05	0	.60	0	0	.20	0

Note: the probabilities have been revised so that a system always selects "do nothing" if the MCL is not exceeded.

EXHIBIT B-4

PROBABILITY OF SYSTEM OF GIVEN SIZE AND WITH GIVEN INFLUENT CONCENTRATION SELECTING COMPLIANCE MEASURES FOR A GIVEN MCL
(Surface Source)
CONTAMINANTS: TRICHLOROETHYLENE, 1,1,1-TRICHLOROETHANE, TETRACHLOROETHYLENE, CARBON TETRACHLORIDE, 1,1-DICHLOROETHANE,
1,1-DICHLOROETHYLENE, BENZENE, PARA-DICHLOROBENZENE, METHYLENE CHLORIDE, AND TYPICAL MULTIPLE OCCURRENCE

COMPLIANCE MEASURE

System Size	Influent Concentration (ppb)	MCL (ppb)	GAC	Peaked Tower	Diffused Air	Tray Aeration	PAC	Well Field Management	Source Protection	Regionalization	Alternative Source	Do Nothing
Very small (25-500 pop)	0.5-5	0.5	.60	.05	0	.05	0	0	0	.05	.25	0
		5	0	0	0	0	0	0	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.35	.10	0	0	0	0	.10	.05	.20	0
		5	.35	.05	0	.05	0	0	.10	.05	.20	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0
Small (501-1300 pop)	0.5-5	0.5	.05	.30	0	0	0	0	.30	.05	.30	0
		5	0	0	0	0	0	0	.05	0	0	.95
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.05	.30	0	0	0	0	.30	.05	.30	0
		5	0	.10	.10	0	0	0	.65	.05	.10	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0
Medium (1301-10,000 pop)	0.5-5	0.5	.05	.05	.10	0	.05	0	.30	.05	.20	0
		5	0	0	0	0	0	0	.15	0	0	.65
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	.05	.05	0	0	0	0	.30	0	0	0
		5	0	0	.10	0	.10	0	.80	0	0	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0
Large (10,001 - 100,000 pop)	0.5-5	0.5	.05	.15	.10	0	.15	0	.35	0	0	0
		5	0	0	0	0	.10	0	.20	0	0	.70
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	0	.10	0	0	0	0	.30	0	0	0
		5	.02	.08	.10	0	.10	0	.70	0	0	0
		20	0	0	.05	0	.05	0	.10	0	0	.80
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	.30	0	0	.50
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0
Very Large (100,000+ pop)	0.5-5	0.5	.05	.15	.10	0	.15	0	.35	0	0	0
		5	0	0	0	0	.10	0	.20	0	0	.70
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-20	0.5	0	.10	0	0	0	0	.30	0	0	0
		5	.02	.08	.10	0	.10	0	.70	0	0	0
		20	0	0	.05	0	.05	0	.10	0	0	.80
		50	0	0	0	0	0	0	.10	0	0	.80
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	.30	0	0	.50
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0

Note: the probabilities have been revised so that a system always selects "do nothing" if the MCL is not exceeded.

EXHIBIT B-5

PROBABILITY OF SYSTEM OF GIVEN SIZE AND WITH GIVEN INFLUENT CONCENTRATION SELECTING COMPLIANCE MEASURES FOR A GIVEN MCL
(Surface Sources)
CONTAMINANTS: VINYL CHLORIDE*, 1,2-DICHLOROETHANE, AND TYPICAL WORST CASE MULTIPLE OCCURRENCE

COMPLIANCE MEASURE

System Size	Influent Concentration (ppb)	MCL (ppb)	CAC	Packed Tower	Diffused Air	Trey Activation	PaC	Well Field Management	Source Protection	Regionalization	Alternative Sources	Do Nothing
Very small (13-500 pop)	0.5-5	0.5	.60	.05	0	.05	0	0	0	.05	.15	0
		5	0	0	0	0	0	0	0	0	0	1.0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-10	0.5	.35	.10	0	0	0	0	.10	.05	.10	0
		5	.35	.05	0	.05	0	0	.10	.05	.10	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	10-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	0	0	0	1.0
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0
Small (501-1300 pop)	0.5-5	0.5	0	.35	0	0	0	0	.50	.05	.50	0
		5	0	0	0	0	0	0	.05	0	0	.75
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-10	0.5	0	.35	0	0	0	0	.50	.05	.50	0
		5	0	.10	.10	0	0	0	.45	.05	.10	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	1.0
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0
Medium (1301-10,000 pop)	0.5-5	0.5	0	.10	.10	0	.05	0	.50	.05	.50	0
		5	0	0	0	0	0	0	.15	0	0	.25
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-10	0.5	0	.10	0	0	0	0	.50	0	0	0
		5	0	0	.10	0	.10	0	.20	0	0	0
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	1.0
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0
Large (10,001 - 100,000 pop)	0.5-5	0.5	0	.20	.10	0	.15	0	.55	0	0	0
		5	0	0	0	0	.10	0	.20	0	0	.70
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-10	0.5	0	.10	0	0	0	0	.50	0	0	0
		5	0	.10	.10	0	.10	0	.70	0	0	0
		20	0	0	.05	0	.05	0	.10	0	0	.20
		50	0	0	0	0	0	0	0	0	0	1.0
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	.50	0	0	.50
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0
Very Large (100,000+ pop)	0.5-5	0.5	0	.20	.10	0	.15	0	.55	0	0	0
		5	0	0	0	0	.10	0	.20	0	0	.70
		20	0	0	0	0	0	0	0	0	0	1.0
		50	0	0	0	0	0	0	0	0	0	1.0
	5-10	0.5	0	.10	0	0	0	0	.50	0	0	0
		5	0	.10	.10	0	.10	0	.70	0	0	0
		20	0	0	.05	0	.05	0	.10	0	0	.20
		50	0	0	.05	0	.05	0	.10	0	0	.20
	20-50	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	.50	0	0	.50
	50+	0.5	0	0	0	0	0	0	1.0	0	0	0
		5	0	0	0	0	0	0	1.0	0	0	0
		20	0	0	0	0	0	0	1.0	0	0	0
		50	0	0	0	0	0	0	1.0	0	0	0

* For vinyl chloride, no CAC is selected. CAC probabilities should be allocated to packed tower aeration.

Note: the probabilities have been revised so that a system always selects "do nothing" if the MCL is not exceeded.