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Report to the Chairman, Subcommittee on Hazardous Wastes and Toxic Substances, Committee on Environment and Public Works, U.S. Senate

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GROUNDWATER PROTECTION

The Use of Drinking Water Standards by the States

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Program Evaluation and
Methodology Division

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The Honorable Max Baucus
Chairman, Subcommittee on Hazardous Wastes
and Toxic Substances
Committee on Environment and Public Works
United States Senate

Dear Mr. Chairman:

In your letter of January 9, 1986, you requested that we study a number of questions concerning groundwater standards. In our first report in response to your request, Groundwater Quality: State Activities to Guard Against Contaminants (GAO/PEMD-88-5, Feb. 1988), we found, among other things, that when drinking water standards are already available, states that set numeric groundwater standards (with rare exception) applied these drinking water standards as groundwater standards. In our second report, Groundwater Standards: States Need More Information From EPA (GAO/PEMD-88-6, Mar. 1988), we found that the Environmental Protection Agency does not provide adequate information to the states to allow the development of technically sound groundwater standards.

In your request letter, you also asked that we examine whether EPA drinking water standards are appropriate for use as groundwater standards. We address that issue in this report. We do not take a position on the necessity of uniform national standards to protect groundwater.

Results in Brief

We found that states continue to use drinking water standards as groundwater standards. However, the appropriateness of doing so is debatable. We found that groundwater quality in 91.8 percent of the locations we studied surpassed drinking water standards for all substances measured. That is a positive result. However, in examining the implications of adopting drinking water standards as groundwater protection standards we found that their adoption would allow the potential for degradation of a considerable amount of groundwater (to the level of contamination allowed by drinking water standards). That is, contaminant levels might gradually increase to about that allowed by the standards. The significance of this finding depends on whether the goal of groundwater protection should be nondegradation or limited degradation. The question of which of these goals is appropriate was beyond the scope of this report.

Groundwater has several uses other than for drinking. It is also used for irrigating crops, watering livestock, and supporting aquatic life by serving as a source of surface water. Drinking water standards are at least as stringent as guidelines published by the National Academy of Sciences (NAS) for irrigating crops and watering livestock. However, we found that current or anticipated federal drinking water standards of 17 substances are less stringent than guidelines published by EPA and NAS to protect aquatic life. Therefore, applying these standards to aquifers that replenish particularly sensitive ecosystems could endanger aquatic life.

Background

We focused on the use of drinking water standards for groundwater protection because of their importance within the groundwater protection framework. The Environmental Protection Agency has established drinking water standards as targets or goals for the prevention and cleanup of groundwater contamination in several programs. Moreover, the information that we gathered in our two previous reports made it clear that standards play a central role in many states' groundwater protection programs and that most states that have numeric groundwater standards base them on federal drinking water standards. Consequently, the use of drinking water standards as groundwater standards is a critical feature of groundwater protection programs at the federal and state levels.

EPA has issued, or expects to issue in the near future, 54 drinking water standards; but it does not issue groundwater standards. Drinking water standards are used to ensure that the public water supply is acceptable for drinking and other consumptive uses, whereas groundwater standards are ambient standards and are applied to water in a natural state in the environment. This difference is reflected in findings from our earlier studies.

For example, we noted that the summary opinion of independent experts and state officials we interviewed was that groundwater protection standards should be based on 12 specific factors: analytical chemistry, environmental fate, presence of contaminants in groundwater, amount and location of production and disposal of wastes, monitoring methods, technological feasibility of control, human exposure, human health effects, existing guidelines and standards, references for further information, contacts for additional information, and how to use the information. (See GAO/PEMD-88-6 for a more detailed discussion of these items.) Yet not all factors viewed as important for groundwater protection are appropriate when EPA sets drinking water standards. For example, environmental fate is not considered when EPA sets drinking water standards.

In one of our earlier studies (GAO/PEMD-88-5), we reported that more than half the state respondents we spoke to told us that drinking water standards "should" or "probably should" be adopted as groundwater standards. EPA does not support the adoption of uniform national groundwater standards. However, we found four programs in which EPA has taken a position on the use of drinking water standards as groundwater standards in localized situations with known contamination sources. In three programs it largely accepts the appropriateness of using drinking water standards as representing an acceptable level of groundwater contamination, and in one it uses drinking water standards as goals for prevention of groundwater contamination. First, through its Groundwater Protection Strategy, EPA has encouraged states to classify aquifers (sources of groundwater) largely according to their suitability as sources of drinking water. Second, the approach used by EPA to trigger corrective action cleanups of hazardous waste sites under the Resource Conservation and Recovery Act largely relies on maximum contaminant levels (MCLs) for 14 substances. An MCL is a primary drinking water standard issued by EPA under authority of the Safe Drinking Water Act. Third, guidelines established by EPA for cleaning up abandoned hazardous waste sites under the Superfund law also specify applying MCLs "in most situations."[1] Finally, in contrast to the positions outlined above, in a recent guidance document the Office of Pesticide Programs argues that steps should be taken to ensure that the concentration of pesticides in groundwater does not reach drinking water standard levels. In this "yellow-light, red-light" approach, actions would be taken before contamination reached maximum contaminant levels. More stringent steps would be taken once contamination had reached maximum contaminant levels.

An assumption common to all of these policies is that MCLs play a key role in helping to determine the need and scope of regulatory actions, and when coupled with appropriate control techniques and programs, their use will result in an acceptable level of groundwater protection. In this report, we examine this assumption by answering four evaluation questions:

[1]However, these guidelines allow for more stringent cleanup standards when aquatic life may be harmed by contamination at the maximum contaminant level.

1. Are states continuing to rely on EPA drinking water standards when setting numeric groundwater standards?

2. How are existing numeric groundwater standards used in state groundwater protection programs?

3. What is the potential for groundwater quality degradation if drinking water standards are used as groundwater protection standards?

4. How do drinking water standards (maximum contaminant levels, in particular) compare to guidelines for protecting uses of groundwater other than for drinking (that is, as a source of water for aquatic life, irrigation, and livestock watering)?

We employed a different method for each evaluation question. A complete discussion of our methodology is contained in appendix I.

Principal Findings

States' Reliance on EPA Drinking Water Standards

In our first study (GAO/PEMD-88-5), we found that those 26 states that have numeric groudwater standards have relied to a large extent on EPA maximum contaminant levels.[2] Since we completed our survey of the states for that report in fall 1986, EPA has issued MCLs for eight volatile organic compounds (VOCs) for which it had already issued maximum contaminant level goals (MCLGS). For five of the eight substances, the MCL and MCLG were set at different levels (with the MCLG being equal to zero). This meant that, for the first time, states had a choice between using MCLs and MCLGs when setting their groundwater standards. (MCLs are set taking into account both health and technological considerations. This is termed a "feasibility-based standard." MCLGs are set at a level at which there will be no harmful health effects.)

To determine whether the reliance on drinking water standards has continued and whether states are relying on MCLGs or some other health-based standard—such as a level associated with an excess risk of cancer

[2]Texas was listed in our earlier report as having numeric standards. Upon further inquiry we determined that the standards do not apply to raw groundwater and, therefore, decided not to include Texas in this particular evaluation.

of one in a million[3] —instead of MCLs, we updated the information in this area through a follow-up survey in February 1988. The questionnaire was sent only to those 25 states that we had found to have numeric groundwater standards in our earlier study. (See appendix I for a list of the states; appendix VI contains the questionnaire.)

We found that 10 of the 25 states have issued groundwater standards since EPA issued its VOC drinking water standards.[4] All 10 relied on EPA drinking water standards to do so. Of the 15 other states, 10 told us that they plan to rely on EPA drinking water standards should they adopt or revise groundwater standards for the VOCs. We also found that 24 of the 25 states would "probably issue groundwater standards for all or most" substances regulated in the future by EPA as drinking water contaminants.

It also appears that MCLs will continue to be the standard most often chosen by the states we studied for groundwater standards. As of March 1988, 15 states had either adopted or planned to adopt an MCL as a groundwater standard for at least one of the five substances for which the MCL and MCLG are not equal. Only one state, Idaho, had adopted an MCLG as a groundwater standard (for one of the five VOCs for which the MCLG is not equal to its MCL), and no state had firm plans to adopt an MCLG in the future. Respondents indicated that the MCL is a more reasonable standard than the MCLG because, in addition to health concerns, it takes into account other concerns such as technological feasibility and enforcement. One problem with using an MCLG as a groundwater standard is that enforcing a "zero" standard can be seen as unrealistic. For instance, North Carolina sometimes sets groundwater standards at more stringent levels than MCLs. It uses the most stringent of four guideline levels (the MCL, the level associated with a one-in-one-million risk of cancer, the no observable adverse effect level, and the threshold of taste and odor) rather than the MCLG.

Thus, in answer to the first evaluation question, we found that states in our sample continue to rely on EPA drinking water standards when setting groundwater standards. Drinking water standards are used both as an indicator of what substances to regulate and as an indicator of the

[3]This is commonly referred to as a 10^{-6} cancer risk.

[4]Eight other states also have groundwater standards for some or all of the VOCs. However, these standards were issued, or were planned, prior to EPA's promulgating its standards. Four of the remaining seven states anticipate that they will set groundwater standards while the other three are less certain of their future actions.

level at which to set the groundwater standards. More detailed findings are presented in appendix II.

State Use of Groundwater Standards

The existence of groundwater standards in and of itself is not enough to guarantee that groundwater will be adequately protected. The effectiveness of groundwater standards depends on how they are used in a number of activities commonly engaged in by states. It is through this use that groundwater standards can play an important role in preventing contamination from occurring and in helping a state to deal with areas that have already been contaminated. For this reason, it is important to characterize how groundwater standards are used to promote groundwater quality.

To address this issue we asked officials of the 25 states with groundwater standards (through the same survey discussed earlier) several questions about their consideration of groundwater protection and their use of groundwater standards in 15 different regulatory activities. We found that of the 15 activities where groundwater protection could be a factor in making decisions, the states, on average, focused on eight activities to a moderate or greater extent: licensing or permitting surface discharges, setting effluent limits, requiring designs for waste disposal facilities, requiring designs for bulk storage facilities, licensing well drillers, controlling the siting and installing of wells, requiring adherence to aquifer recharge standards, and containing or cleaning up hazardous waste sites.

We then evaluated, for each of these eight activities, the extent to which groundwater standards were used, on average, by those states that had considered groundwater protection to at least a moderate extent. We found that groundwater standards were used to a moderate or greater extent in five of the eight activities: licensing or permitting surface discharges, setting effluent limits, requiring designs for waste disposal facilities, requiring adherence to aquifer recharge standards, and containing or cleaning up hazardous waste sites. These findings thus describe the major ways in which groundwater standards are used, in answer to our second evaluation question. A more detailed discussion is presented in appendix III.

Drinking Water Standards and Potential Degradation of Groundwater

We used data from the U.S. Geological Survey's (USGS) WATSTORE data base to determine whether the use of MCLs, MCLGs, and levels associated with a one-in-one-million risk of cancer would ensure nondegradation of groundwater resources. We accessed these data from EPA's water data base, STORET.

The question we examined should not be construed to imply that EPA or the states depend solely upon ambient standards to control groundwater contamination. In fact, EPA and the states have provisions for other regulatory mechanisms, such as source controls, to manage contamination of groundwater resources. These programs are aimed at limiting the migration of contamination from specific pollution sources into the environment. However, because of the inherent nature of standards as limiting values and the incomplete protection afforded by source controls, there is a potential for allowing degradation to occur to the standards' levels under an approach employing ambient standards and source controls.

The groundwater quality data were collected between 1976 and 1987. The data base contained information on 43 of the 54 substances for which EPA has issued drinking water standards or, according to EPA officials, will be issuing new or revised standards in the near future.[5]

Several of the 42 substances are present in groundwater from natural sources as well as through introduction by man. We are unable to determine how much of the contamination at sites we studied is due to natural sources. As used in this context "contamination" denotes pollution from natural sources as well as from human activities.

To analyze the data, we divided the country into one-square-mile "cells," each containing from 0 to 114 wells at which the USGS had conducted chemical analyses. We then used the most recent measurement for each substance from all the wells in each cell. We found that one or more substances had been measured in 12,072 cells out of a potential 3.6 million in the United States.

The data from these cells are not a random sample of the nation's groundwater and cannot be used to develop a quantitative portrayal of

[5]For a complete listing of these substances and standards, see appendix IV, table IV.1. Turbidity is one of the drinking water standards set by EPA. However, we did not include turbidity as one of the standards we examined since it can be an artifact caused by the water testing process rather than a true indicator of groundwater contamination. As a result, our analysis was of 42, not 43 measures.

groundwater quality throughout the nation. However, according to officials at USGS, the data are the most comprehensive validated data on groundwater quality that exist. The strengths and limitations of the data set and our analytic methodology are discussed in appendix I. However, one point should be made here. According to officials at the Geological Survey, much of the data contained in its WATSTORE data base were collected in response to perceived pollution problems. Therefore, the contaminant levels in the USGS wells will tend to be high and our findings very likely underestimate the percentage of groundwater that could be degraded in the nation as a whole if pollution levels were allowed to increase to the level of the drinking water standards. The implications of this for our conclusions are discussed in appendix IV.

We used the USGS data set to compare the concentration in groundwater of drinking water contaminants to drinking water MCLs and other guidelines. Of the 12,072 cells in our study, 91.8 percent had groundwater that met EPA maximum contaminant levels if those standards were applied by the states.[6] Approximately 85 percent of the time, it was contamination by heavy metals and bacteria that exceeded the MCL level (850 cells exceeded one or more inorganic compounds, 22 cells exceeded one or more pesticides, 135 cells exceeded one or more nonpesticidal organic compounds).

When we compared the latest reading at each cell against EPA's MCLGS, we found that 71 percent of the cells met the MCLG standard (for most of the 42 substances, the MCL is equal to the MCLG).[7] We also compared the latest reading at each cell against a third set of guidelines for the 13 (out of 42) contaminants that EPA has identified as causing cancer in humans: a level associated with a one-in-one-million risk of cancer. Measurements at 42.5 percent of the cells met the guideline level associated with a one-in-one-million risk of cancer for one or more of the 13 substances, whereas 96.4 percent met MCLs and 9.1 percent met MCLGS for one or more of the 13.

Therefore, in answer to our third question we found, using the USGS data set, that approximately 92 percent of the cells met the standard limits if MCLs are adopted as groundwater protection standards. If MCLGS are adopted, 71 percent met the standard limits. In addition, approximately

[6]This statement refers only to the substances measured in the cell. In no cell were measurements taken of every substance.

[7]An MCLG could not be assigned for 3 of the 42 substances, and in these cases we employed the MCL. Restricting our analysis to the 39 would change the findings from 71.0 percent to 71.3 percent.

43 percent of the cells met a limit associated with a one-in-one-million risk of cancer for one or more of 13 carcinogens. Adopting any of these standards or guidelines as groundwater standards would potentially allow for degradation of the nation's groundwater resources because contaminants could be allowed to increase to the maximum concentrations allowed by the standards. Again, these numerical findings cannot be generalized nationally because the data set was not randomly constructed with respect to the nation's groundwater resources. More detailed findings about the relationship of groundwater quality to these guidelines is presented in appendix IV.

Comparison With Other Uses of Groundwater

Groundwater has several uses besides drinking. It is used to irrigate crops and water livestock. It affects the habitat of aquatic life because it flows into bodies of surface water. Applying drinking water standards to groundwater could jeopardize other uses that require standards higher than those for drinking. We compared EPA maximum contaminant levels with guidelines for other uses published separately by EPA and the National Academy of Sciences. We found that EPA maximum contaminant levels are at least as stringent as all published guidelines for livestock watering and irrigation and therefore would protect these uses. However, we found that the MCLs for 17 substances are less stringent than EPA and NAS aquatic life guidelines and therefore would not always protect aquatic life.

Using the same techniques outlined in the previous section, we examined how often the cells exceeded the more stringent of the MCLs and aquatic life guidelines. Whereas we had found earlier that 91.8 percent of the cells met the MCLs, we next found that when the aquatic life guidelines are substituted for the MCLs (for those substances that have an aquatic life guideline that is more stringent than its MCL), 66.9 percent of the cells met the recommended levels. A decision to apply EPA maximum contaminant levels as groundwater standards, without allowing for greater stringency when local conditions warrant it (such as in ecosystems that are sensitive to these particular substances or that are in areas of high groundwater recharge with low surface water dilution) could jeopardize sensitive species of aquatic life. More detailed findings can be found in appendix V.

Agency Comments

We received written comments on this report from the Environmental Protection Agency after the 30 calendar days specified by law; therefore, they have not been reproduced in the report. However, we did obtain informal comments in time to incorporate them into our report where appropriate.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until after its issue date. At that time, we will send copies to the Administrator of the Environmental Protection Agency, to interested organizations, and to others upon request. If you have any questions or would like additional information, please call me at 202-275-1854.

This report was prepared under the direction of Michael J. Wargo, Associate Director. Other major contributors are listed in appendix VII.

Sincerely yours,

Eleanor Chelimsky

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Abbreviations

EPA	Environmental Protection Agency
GAO	General Accounting Office
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
NAS	National Academy of Sciences
STORET	Storage and retrieval data base
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WATSTORE	Water Data Storage and Retrieval System

Objective, Scope, Methodology

Objective

We were asked by Senator Max Baucus to determine whether drinking water standards are directly appropriate as groundwater standards. To answer this question we formulated four evaluation questions:

1. Are states continuing to rely on EPA drinking water standards when setting numeric groundwater standards?

2. How are existing numeric groundwater standards used in state groundwater protection programs?

3. What is the potential for groundwater quality degradation if drinking water standards are used as groundwater protection standards?

4. How do drinking water standards (maximum contaminant levels (MCLs), in particular) compare to guidelines for protecting uses of groundwater other than for drinking (that is, as a source of water for aquatic life, irrigation, and livestock watering)?

Scope and Methodology

States' Reliance on and Use of EPA Standards

The scope and methodology used to address each evaluation question varied. We based our work for the first two evaluation questions on a survey sent to the 25 states that had numeric groundwater protection standards as of fall 1986. Those states are Alaska, Arizona, California, Colorado, Florida, Georgia, Idaho, Illinois, Maine, Maryland, Massachusetts, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oklahoma, South Carolina, Virginia, Wisconsin, and Wyoming. The results from the survey were published in 1988.[1]

Then in 1988 we conducted structured interviews with representatives of the same 25 states. In February, we sent a questionnaire to one respondent in each of these states. (See appendix VI.) We acquired answers to the questionnaire through telephone interviews with respondents in all 25 states. When our respondent could not provide all of the information that we needed, we asked for the names of other officials

[1]See Groundwater Quality: State Activities to Guard Against Contaminants (GAO/PEMD-88-5, Feb. 1988).

who could provide the information and then obtained it from them. The number of responses varied for each questionnaire because of differences in state programs and nonresponses. We asked follow-up questions through July 1988.

We used this approach of combining mailed questionnaires with follow-up telephone interviewing because it has the advantages of both methods. That is, each respondent had an opportunity to consider the questions before responding, unlike conventional telephone interviews. And, we had the flexibility to answer the respondent's questions, to clear up misunderstandings, and when appropriate, to gather additional information not directly requested in the questionnaire we had mailed.

The principal focus of the 1988 survey was to identify states' actions to set groundwater standards for eight volatile organic compounds (VOCs) for which EPA had issued maximum contaminant levels and maximum contaminant level goals (MCLGs) after we had completed our 1986 survey. We also asked about the states' plans for issuing further groundwater standards and their use of groundwater standards.

For the first evaluation question, we focused on the quantitative level of the states' groundwater standards. We categorized states according to how their standards compared to EPA maximum contaminant levels and MCLGs for volatile organic compounds. The five categories were: equal to the MCL, equal to the MCLG, more stringent than the MCL but not equal to the MCLG, less stringent than the MCL, and no standard. Our analysis consisted of calculating for each substance its frequency of occurrence across the states in each category. We were also able to classify the states by their expected reliance on EPA standards in the future. We did this by seeking information on their expected response to EPA's issuance of further drinking water standards (issue groundwater standards at the MCL level, issue standards at the MCLG level, issue standards at the MCL or MCLG level, issue standards but not necessarily at the MCL or MCLG level, and undecided as to whether standards would be issued). We then calculated the frequencies of the possible responses.

To address the second evaluation question, we concentrated on 15 activities commonly engaged in by state governments for which groundwater protection could be a consideration. We asked each respondent to indicate the extent to which groundwater protection is a consideration in their state in each of these activities. If the respondent answered that groundwater protection is considered to at least "some extent," we then asked the extent to which groundwater standards are used in that activity. Both sets of responses were on a five-point scale ranging from "little or no extent" to "a very great extent." We calculated the mean response over all 25 states for each activity. We then computed the mean response to the "use of standards" question for those states that answered "a moderate extent," or greater.

Drinking Water Standards and Potential Degradation of Groundwater

The third evaluation question pertains to how groundwater quality compares to standards in all 50 states for contaminants for which EPA has issued or expects to issue drinking water standards (MCLs and MCLGs). We accessed groundwater data from EPA's water quality data base, STORET (storage and retrieval). The EPA data base contains information about wells from which groundwater contamination is determined: the location of the well (in latitude and longitude), the concentration of measured substances and the date each reading was taken.

Rather than analyze all of the groundwater data in the STORET data base, we confined our analysis to data that are contributed to STORET from the U.S. Geological Survey's (USGS) WATSTORE data base. We chose to analyze only data gathered at these wells for several reasons. USGS is the principal federal water data agency. Sixty percent of all wells used as sources of information for the STORET data base are part of the WATSTORE data base. Moreover, these data have a broad geographical breadth (we found USGS groundwater data for 48 of the 50 states). Although we cannot use the data base to generalize about the nation's groundwater quality (for reasons discussed below), our conclusions are based upon a large and varied set of sites. In addition, the quality assurance methods USGS uses make us more confident of the validity of its data than of some of the other groundwater data contained in the STORET data base. Whereas we were told that the groundwater quality data gathered and analyzed by USGS "are generally of high quality," according to an EPA document, much of the other groundwater data in STORET are of "uncertain quality." We did not independently review the validity of the data we used.

The USGS data came from a variety of networks and projects and were collected for a variety of purposes. According to officials at the Geological Survey, much of the data contained in the data base were collected by USGS in response to perceived pollution problems. Therefore, our findings very likely underestimate the percentage of groundwater that could be degraded in the nation as a whole if drinking water standards were used as groundwater standards. The implications of this for our conclusions are discussed in appendix IV.

We restricted our analysis to data collected between January 1, 1976, and December 31, 1987. USGS had groundwater quality data for 43 of the 54 drinking water substances, and we limited our analysis to 42.[2] We found that one or more of them had been measured at 23,021 wells over the 12-year period.

In some geographical areas, there is a heavy clustering of sampled wells (typically because the USGS engaged in a detailed study related to known or suspected contamination). To reduce the distorting effect that the clustering would have on our findings, we grouped together wells that were in close proximity. We did this by dividing the entire country into approximately 3.6 million one-square-mile cells. Using latitude and longitude readings to demarcate its location, we assigned each of the 23,021 sampled wells to its appropriate cell. The cell was our unit of analysis. We found 12,072 cells in the United States in which one or more wells had measurements for one or more of the 42 substances.[3] We used the most recent measurement for each substance from all sites in the cell.

As would be expected, the data we analyzed are not uniformly distributed by geographical location. There were no sites in two states, Vermont and West Virginia, yet we found 3,764 cells with wells in South Dakota. In addition to this variation in geographical location, we found a large degree of variation in the number of cells in which the 42 substances were measured. For example, whereas several metals were measured in more than 5,000 cells, aldicarb was measured in only four cells. Also, the number of substances measured in each cell varied. Between one and six substances were measured in about 62 percent of the cells. Fifteen or more substances were measured in approximately 2,000 of the 12,072 cells.

We analyzed the data by writing computer programs to compare each measurement for each of the 42 substances against its MCL and MCLG. For

[2]Turbidity is one of the drinking water standards set by EPA. However, we did not include turbidity as one of the standards we examined since it can be an artifact caused by the water testing process rather than a true indicator of groundwater contamination. As a result, our analysis was of 42, not 43 measures.

[3]Although approximately 9,000 cells had only one well, several cells had a large number of wells. We found one cell on Cape Cod with 114 wells.

those 13 substances that EPA has identified as causing cancer, we compared each measurement to the level associated with a one-in-one-million risk of cancer.[4] We provide information on the number and percentage of cells that could be potentially degraded should drinking water standards be adopted as groundwater protection standards. In addition, we present detailed information in appendix IV on the number and percentage of cells at which contamination concentration levels exceeded (were greater than) the drinking water standards (see tables IV.2, IV.3 and IV.4).

Comparison With Guidelines for Other Uses of Groundwater

For the final evaluation question, we examined the 54 contaminants for which standards have been issued or anticipated. We compared EPA drinking water standards with consensus documents published separately by EPA and the National Academy of Sciences. These documents give maximum recommended contaminant levels for groundwater that is to be used by aquatic life and for irrigation and livestock watering. There were recommended aquatic life guidelines for 29 of the 54 drinking water substances. There were 10 guidelines for livestock watering and eight for irrigation. We compared these recommended levels to EPA's maximum contaminant levels. We also used the USGS groundwater data base to examine how often the "cells" exceeded either the aquatic life guidelines or the MCLs. When there was no aquatic life guideline or the MCL was more stringent than the aquatic life guideline, the measured cell value was compared to the MCL. Otherwise, the measured value was compared to the guideline.

Our review was conducted in accordance with generally accepted government auditing standards.

[4] Only 13 of the 43 contaminants had MCLGs different from their MCLs. These 13 were also the only contaminants that EPA has identified as carcinogens and for which the agency has estimated the concentration associated with a 10^{-6} cancer risk.

State Groundwater Standards

Our first evaluation question is: "Are states continuing to rely on EPA drinking water standards when setting numeric groundwater standards?" The findings from a questionnaire we administered to the 25 states that have numeric groundwater standards are detailed below.

Background

In our report (GAO/PEMD-88-5) based on interviews conducted in fall 1986, we found that 26 states had numeric groundwater standards. In addition, we found that states relied heavily on EPA drinking water standards when setting groundwater standards. In summer 1987, EPA issued drinking water standards for eight volatile organic compounds (VOCs). The following spring, we revisited 25 of these states to determine whether their reliance on EPA drinking water standards as a basis for groundwater standards had continued, both in general and for the VOCs in particular.[1]

Findings

Drinking is viewed by the state respondents as the most important use of groundwater. Nineteen of 20 respondents indicated that drinking water considerations greatly influenced the level at which they set groundwater standards.

Twenty-four of the 25 states either had groundwater standards for one or more of the VOCs prior to EPA's issuance of standards or have adopted or plan to adopt standards for one or more of the VOCs as a result of EPA's actions.

State reliance on EPA drinking water standards for groundwater protection continues. Twenty states (80 percent) either have adopted EPA's VOC drinking water standards as groundwater protection standards or say that if they revise existing standards or issue new ones, they will use EPA maximum contaminant levels or MCL goals.

EPA maximum contaminant levels provide a baseline in terms of protection. Of the 23 states that could characterize their current or expected groundwater standards for the VOCs, only one (New Mexico) had the majority of its standards set at a level less stringent than the MCL. The New Mexico standards were established prior to EPA's issuance of drinking water standards for the VOCs. The respondent indicated that any revisions to its standards would probably be based on EPA standards.

[1] As noted on p. 4, we did not include Texas in this particular evaluation.

For the volatile organic compounds, the states we surveyed have relied or plan to rely on MCLs, not MCLGs (see tables II.1 and II.2).

Table II.1: Current or Expected Levels of State VOC Standards For Selected Substances[a]

State	Benzene	Carbon tetrachloride	Para-dichlorobenzene[b]
Alaska	MCL	MCL	MCL/MCLG
Arizona	MCL	MCL	MCL/MCLG
California	MCL	MCL	MCL/MCLG
Colorado	MCL	MCL	MCL/MCLG
Florida	Other (M)	Other (M)	None
Georgia	MCL	MCL	MCL/MCLG
Idaho	None	None	None
Illinois[d]			
Maine	MCL	MCL	MCL/MCLG
Maryland	MCL	MCL	MCL/MCLG
Massachusetts	MCL	MCL	MCL/MCLG
Minnesota[d]			
Missouri	Other (L)	Other (M)	None
Montana	MCL	MCL	MCL/MCLG
Nebraska	MCL	MCL	MCL/MCLG
New Hampshire	MCL	MCL	MCL/MCLG
New Jersey	Other (M)	Other (M)	Other (M)
New Mexico	Other (L)	Other (L)	None
New York	Other (M)	MCL[c]	Other (M)
North Carolina	Other (M)	Other (M)	Other (M)
Oklahoma	Other (M)	Other (M)	None
South Carolina	MCL	MCL	MCL/MCLG
Virginia[e]	MCL/MCLG	MCL/MCLG	MCL/MCLG
Wisconsin	Other (M)	None	Other (L)
Wyoming	MCL	None	None

1,2-dichloroethane	1,1-dichloroethylene[b]	1,1,1-trichloroethane[b]	Trichloroethylene	Vinyl chloride
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
Other (M)	None	MCL/MCLG[c]	Other (M)	Other (M)
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
None	None	None	MCLG	None
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
MCL	MCL/MCLG	Other (M)	Other (M)	MCL
Other (M)	MCL/MCLG	MCL/MCLG	Other (M)	MCL
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
Other (M)	Other (M)	Other (M)	Other (M)	Other (L)
Other (L)	Other (M)	Other (M)	Other (L)	Other (M)
Other (M)	Other (M)	Other (M)	Other (L)	Other (L)
Other (M)	MCL/MCLG	MCL/MCLG	Other (M)	Other (M)
Other (M)	Other (M)	Other (M)	Other (M)	Other (M)
MCL	MCL/MCLG	MCL/MCLG	MCL	MCL
MCL/MCLG	MCL/MCLG	MCL/MCLG	MCL/MCLG	MCL/MCLG
Other (M)	Other (M)	MCL/MCLG	Other (M)	Other (M)
None	None	None	MCL	None

[a]Other (M) = more stringent than MCL; Other (L) = less stringent than MCL.

[b]For this substance, the MCL is equal to the MCLG.

[c]This standard is equal to the MCL or the MCLG by coincidence.

[d]Illinois and Minnesota have not yet decided at what levels their standards will be set.

[e]Virginia has not yet decided whether to adopt MCLs, MCLGs, or some combination.

Table II.2: Number of States With Groundwater Standards for Volatile Organic Compounds[a]

Substance	MCL	MCLG	Other (M)[b]	Other (L)[b]	None
Benzene	13	0	6	2	1
Carbon tetrachloride	13[c]	0	5	1	3
Para-dichlorobenzene	12	[d]	3	1	6
1,2-dichloroethane	12	0	7	1	2
1,1-dichloroethylene	14	[d]	5	0	3
1,1, 1-tricholoroethane	15[e]	[d]	5	0	2
Trichloroethylene	12	1	7	2	0
Vinyl chloride	13[c]	0	5	2	2

[a]Illinois, Minnesota, and Virginia are not included in this table because their plans at the time of the interview were uncertain.

[b]Other (M) = more stringent than MCL; Other (L) = less stringent than MCL.

[c]One of these cases is equal to the MCL by coincidence.

[d]The MCL and MCLG are equal for this substance.

[e]One of these cases is equal to the MCL and MCLG by coincidence.

Of the 10 states (Arizona, Colorado, Georgia, Idaho, Maryland, Massachussetts, Missouri, Nebraska, New Hampshire, Wyoming) that have set groundwater standards for one or more of the VOCs since EPA issued its drinking water standards, only Idaho has adopted an MCLG (for one substance) when the MCL and MCLG were not equal. The other nine have used MCLs. Seven (Arizona, Colorado, Georgia, Maryland, Nebraska, New Hampshire, Wyoming) have used MCLs for all the VOCs they regulated.

Four states anticipate that they will set groundwater standards for the VOCs. Three of them (California, Montana, South Carolina) expect to set their standards at the MCL level for all eight substances. The fourth state (Virginia) has not yet decided whether to adopt MCLS, MCLGS, or some combination.

Three other states are less certain of their future actions. Two of these (Alaska, Maine) indicated that if they do adopt VOC standards, they will most likely be set at the MCL level. The third state (Minnesota) does not expect to issue standards based on the MCLs and is uncertain if it will use the MCLG.

The other eight states (Florida, Illinois, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Wisconsin) had or were in the process of establishing groundwater standards for some or all of the VOCs when

EPA set its drinking water standards. Four of these states (Florida, Illinois, New Mexico, Wisconsin) expect to use the EPA drinking water standards should they adopt new, or revise existing, VOC groundwater standards.

States will continue to rely on EPA drinking water standards in the future. Twenty-four of 25 state respondents said that if EPA promulgates additional drinking water standards, then their states will most likely issue groundwater standards for previously unregulated contaminants or will revise existing standards for those substances already regulated. Thirteen of the 24 states will probably set standards at the EPA level (MCL or MCLG). The other 11 states would not necessarily set their groundwater standards at the MCL or MCLG.

Summary and Conclusions

The 25 states that had established numeric groundwater standards as of fall 1986 have continued to rely heavily on EPA drinking water standards when setting additional groundwater standards. With EPA's issuance of MCLs and MCLGs for eight volatile organic compounds last spring, states were, for the first time, able to choose between using a purely health-based criterion (MCLG) and a feasibility-dependent criterion (MCL) when setting groundwater standards. When presented with this choice, states have based their groundwater standards on MCLs. The implication of this, along with the respondents' contention that their states will continue to rely on EPA drinking water standards, is that the states' dependence on MCLs for setting groundwater standards will continue.

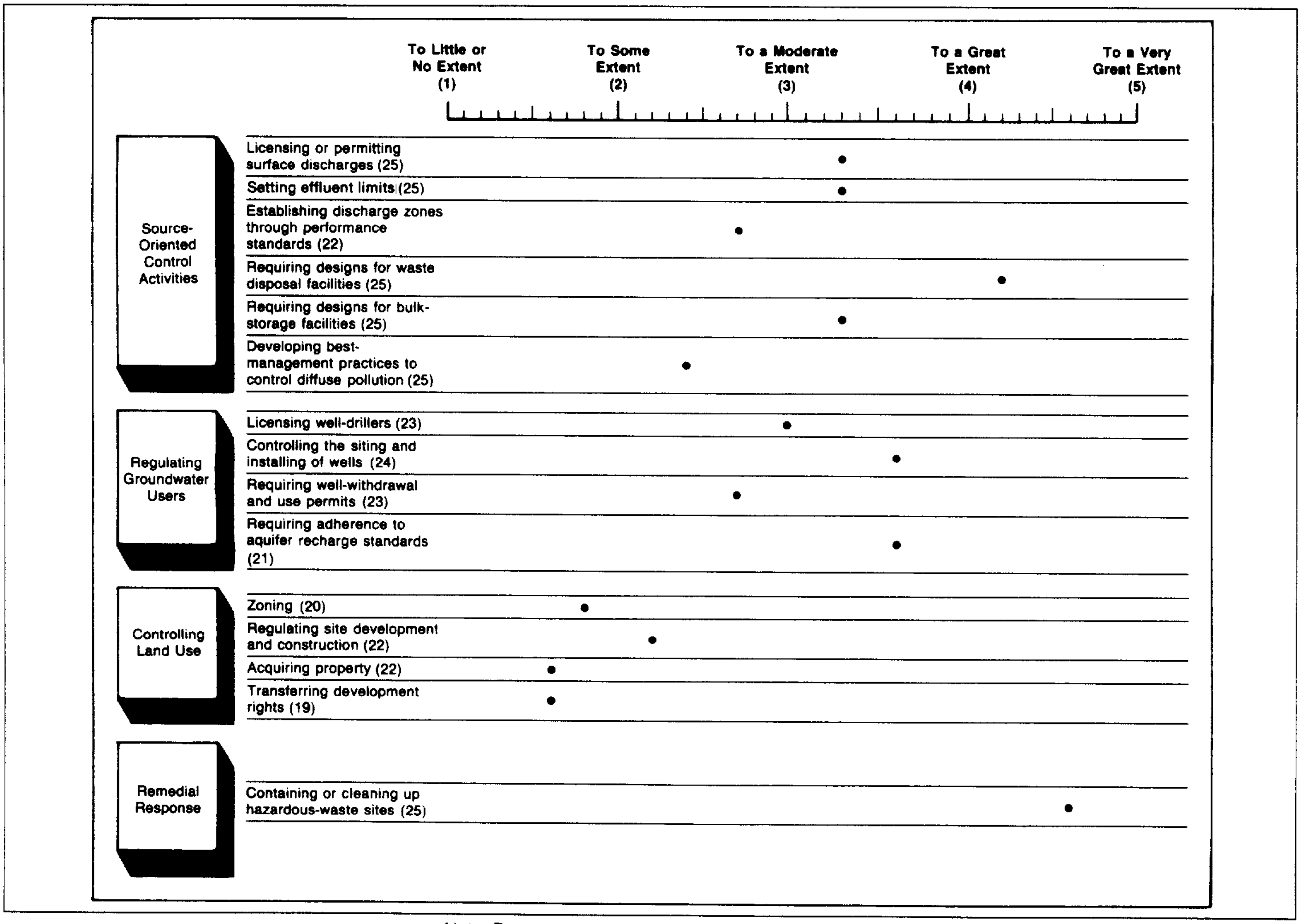
Use of Groundwater Standards

Our second evaluation question was: "How are existing numeric groundwater standards used in state groundwater protection programs?" The findings from our survey of the 25 states that have numeric groundwater standards are detailed below.

Findings

Among the 25 states, groundwater protection has been considered to at least a moderate extent (on average) in eight of 15 activities in which protection could be a factor in decision-making (see figure III.1).

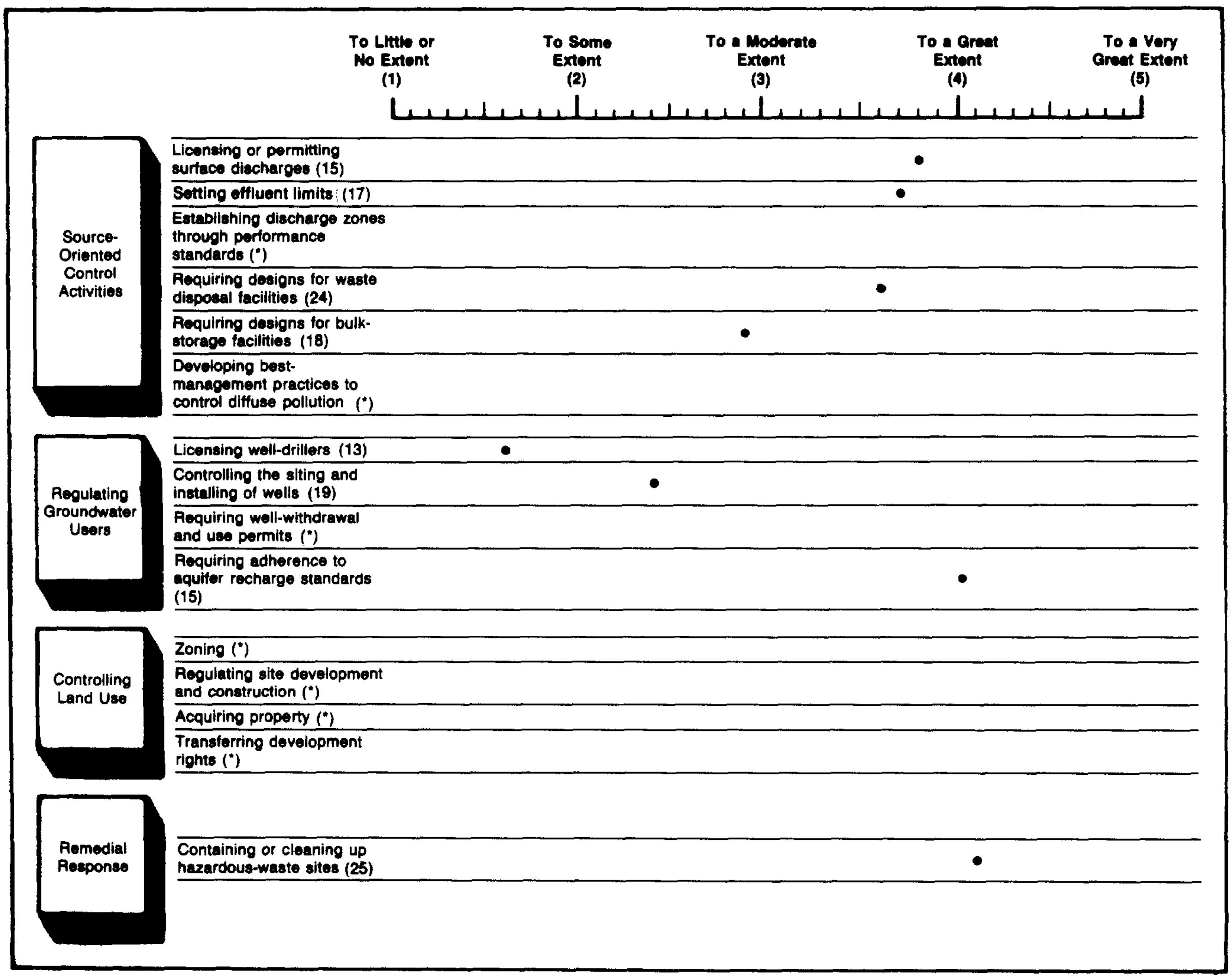
Figure III.1: Extent Groundwater Protection Is Considered in 15 Activities



Note: Dots represent the average response from the state respondents. The numbers in parentheses indicate the number of responses for that activity.

For each of the eight activities, we calculated the average use of standards by those states that considered groundwater protection to at least a moderate extent. Groundwater standards were used to a moderate or greater extent in five of the eight activities (see figure III.2).

Figure III.2: Extent Groundwater Standards Are Used in Eight Activities



Note: Results are displayed for the eight activities in which groundwater protection was considered to at least a moderate extent. Activities marked with an asterisk did not meet this criterion. Dots represent the average response from the state respondents. The numbers in parentheses indicate the number of responses for that activity.

Twenty of the 25 states have used standards to estimate the impact of proposed activities on groundwater quality. This predictive application of standards is shown in table III.1. Some states used formal analytical techniques to assess alternatives; others, less formal. Also shown in table III.1 are the 17 states that have used standards as part of monitoring requirements to assess the impact of regulated actions on groundwater quality. Where they have identified violations of groundwater standards, states have responded by shutting down operations, restricting operations, monitoring for further violations, or cleaning up contaminated aquifers (see table III.2).

Table III.1: Application of Groundwater Standards

	Predictive		
State[a]	Formal	Less formal	Monitoring
Alaska	•	•	•
Arizona	•	•	•
California	•	•	•
Colorado	•	•	•
Florida			•
Georgia		•	
Idaho		•	•
Illinois	•	•	•
Maine		•	
Maryland		•	•
Massachusetts	•	•	•
Minnesota	•	•	•
Missouri		•	
Montana			•
Nebraska		•	•
New Hampshire			•
New Jersey	•		
New Mexico	•	•	
New York		•	
North Carolina	•	•	•
Oklahoma	•	•	•
South Carolina			•
Virginia		•	
Wisconsin	•	•	•
Total	**12**	**19**	**17**

[a]States with empty cells did not use the standard. Of the 25 states, Wyoming did not provide information in this area.

Table III.2: Responses to Violations of Groundwater Standards

State[a]	Shut down operation	Restrict operation	Monitor operation	Clean aquifer
Alaska	•	•	•	•
Arizona	•	•	•	•
Colorado	•	•	•	•
Florida	•	•	•	•
Georgia		•	•	•
Idaho		•	•	
Illinois	•	•	•	•
Maine			•	•
Maryland	•	•	•	•
Massachusetts	•	•	•	•
Minnesota		•	•	•
Missouri		•	•	•
Montana	•	•	•	•
Nebraska		•	•	•
New Hampshire		•	•	
New Jersey	•	•	•	•
New Mexico	•	•	•	•
New York	•	•	•	•
North Carolina			•	•
South Carolina	•	•	•	•
Virginia	•	•	•	•
Wisconsin	•	•	•	•
Wyoming	•		•	•
Total	**15**	**20**	**23**	**21**

[a]California and Oklahoma were not asked to provide information in this area because they do not have statewide groundwater standards for any of the 22 substances with primary drinking water standards.

Summary

Within their regulatory programs, 25 states have used standards in several activities where groundwater contamination needs to be considered. They used the standards to estimate the impact of proposed activities on groundwater quality, to monitor groundwater quality, and to perform investigatory and remedial activities.

Potential Degradation of Groundwater

Our third evaluation question was: "What is the potential for groundwater quality degradation if drinking water standards are used as groundwater protection standards?" Detailed findings for this question are presented below.

Background

The question we examined should not be construed to imply that EPA or the states depend solely upon ambient standards to control groundwater contamination. In fact, EPA and the states have provisions for other regulatory mechanisms, such as source controls, to manage contamination of groundwater resources. These programs are aimed at limiting migration of contamination from specific pollution sources into the environment. However, because of the inherent nature of standards as limiting values and the imperfect protection afforded by source controls, there is a potential for allowing degradation to occur to the standards' levels under an approach employing ambient standards and source controls.

EPA has issued, or anticipates issuing in the near future, drinking water standards for 54 substances (see table IV.1).[1] As noted, the U.S. Geological Survey's water data base (WATSTORE) contains data on 43 of those substances at wells throughout the United States.[2] A map of the United States, with a total area of more than 3.6 million square miles, can be thought of as a grid of square-mile cells. Wells contained in WATSTORE that have measurements for one or more of these substances exist in 12,072 of those cells (see figure IV.1).

We analyzed the USGS data by creating a separate data set of the most recent measurement of each substance in each cell. We then wrote computer programs to compare each measurement for each of the 42 substances against three values: its MCL, its MCLG, and the level associated with a one-in-one-million risk of cancer (for those 13 substances that EPA has identified as causing cancer). Our findings are reported as the percentage of cells meeting the applicable guideline values for all substances measured.

[1]EPA's practice has been to set MCLs and MCLGs at the same level except when the MCLG has been set at zero.

[2]Turbidity is one of the drinking water standards set by EPA. However, we did not include turbidity as one of the standards we examined since it can be an artifact caused by the water testing process rather than a true indicator of groundwater contamination. As a result, our analysis was of 42, not 43 measures.

Table IV.1: EPA Drinking Water Standards Set and Anticipated[a]

Substance	Current MCL	Anticipated MCL	Current MCLG	Anticipated MCLG	One-in-one-million cancer risk
Inorganics					
Arsenic[b]	50.0	30.00		0	0.0022
Asbestos		7.00[c]		7.0[c]	
Barium[b]	1,000.0	4,700.00		4,700.0	
Cadmium[b]	10.0	5.00		5.0	
Chromium[b]	50.0	120.00		120.0	
Copper[b]		1,300.00		1,300.0	
Fluoride[b]	4,000.0		4,000		
Lead[bd]	50.0				
Mercury[b]	2.0	4.00		4.0	
Nitrate[b]	10,000.0	10,000.00		10,000.0	
Selenium[b]	10.0	45.00		45.0	
Silver[bd]	50.0				
Pesticides					
Alachlor[b]		2.00		0	0.5000
Aldicarb[b]		9.00		9.0	
Atrazine[b]		3.00		3.0	
Carbofuran[b]		40.00		40.0	
Chlordane[b]		2.00		0	0.0270
Dibromochloropropane		0.20		0	0.0250
2,4-D[b]	100.0	70.00		70.0	
1,2-dichloroproprane[b]		5.00		0	0.5200
Endrin[bd]	0.2				
Ethylene dibromide		0.05		0	0.0004
Heptachlor[b]		0.40		0	0.0760
Heptachlor epoxide[b]		0.20		0	0.0380
Lindane[b]	4.0	0.20		0.2	0.0260
Methoxychlor[b]	100.0	300.00		300.0	
Pentachlorophenol[b]		200.00		200.0	
Toxaphene[b]	5.0	5.00		0	0.0300
2,4,5-TP[b]	10.0	50.00		50.0	

(continued)

Substance	Current MCL	Anticipated MCL	Current MCLG	Anticipated MCLG	One-in-one-million cancer risk
Other organics					
Acrylamide		0.60		0	0.0100
Benzene[b]	5.0		0		1.3000
Carbon tetrachloride[b]	5.0		0		0.2700
Ortho-dichlorobenzene[b]		600.00		600.0	
Para-dichlorobenzene[b]	75.0		75		
1,2-dichloroethane[b]	5.0		0		0.3800
1,1-dichloroethylene[b]	7.0		7		
Cis-1,2-dichloroethylene		70.00		70.0	
Trans-1,2-dichloroethylene		70.00		70.0	
Epichlorohydrin		2.00		0	3.5400
Ethylbenzene[b]		700.00		700.0	
Monochlorobenzene[b]		300.00		300.0	
PCBs[b]		0.70		0	0.0050
Styrene[b]		100.00		100.0	
Toluene[b]		2,000.00		2,000.0	
1,1,1-trichloroethane[b]	200.0		200		
Trichloroethylene[b]	5.0		0		2.6000
Vinyl chloride[b]	2.0		0		0.0150
Xylene[b]		12,000.00		12,000.0	
Radionuclides and others					
Alpha particle	15 pCi/l				
Coliform bacteria[b]	1/100 ml				
Beta particle	4 mrem/yr				
Radium 226 and 228	5 pCi/l				
Total trihalomethanes	100				
Turbidity	1–5 TU				

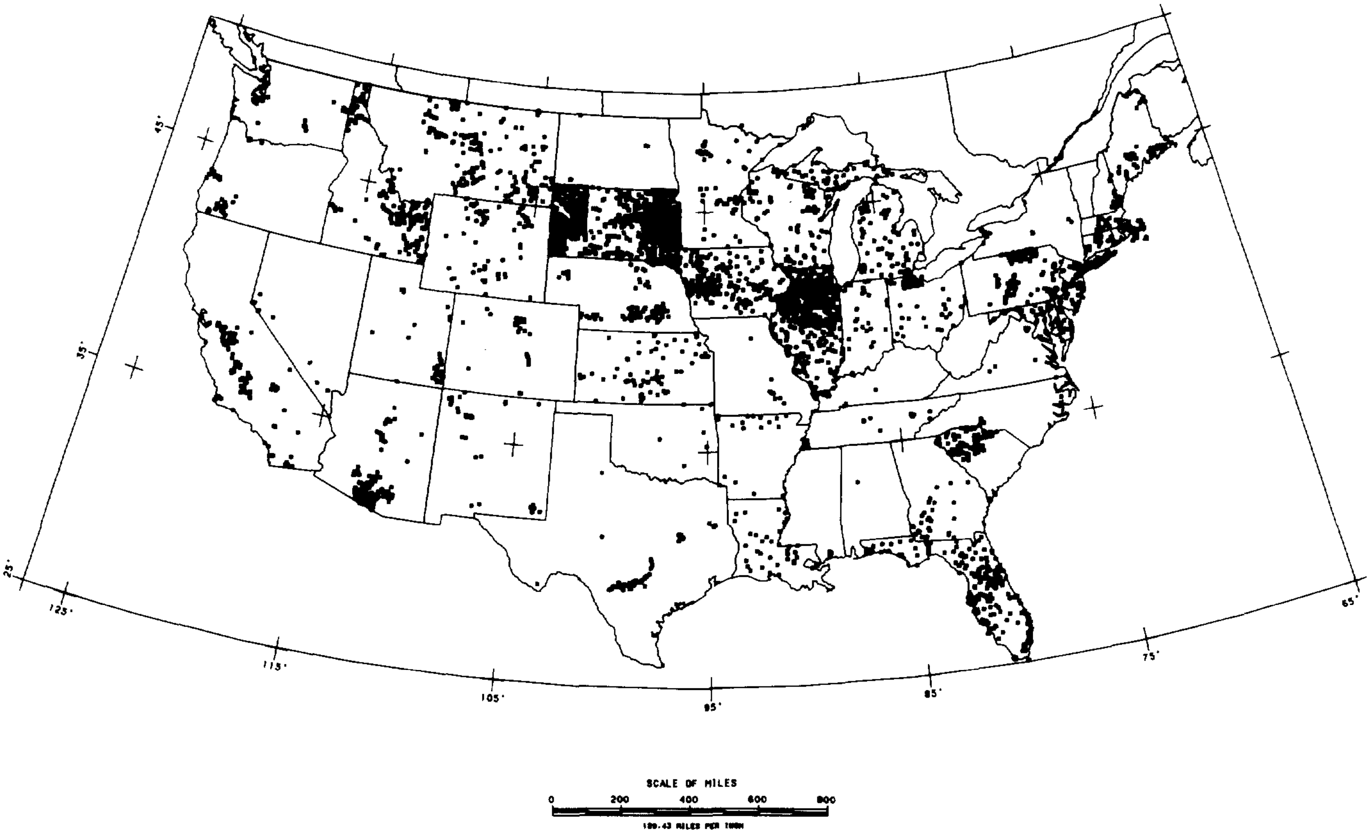
[a]Standards are expressed in micrograms per liter except where noted.

[b]This substance formed part of our analysis of groundwater quality.

[c]Standard expressed in millions of fibers of at least 10 micrometers in length per liter.

[d]EPA has not issued an MCLG for this substance.

Figure IV.1: Distribution of Wells Used in This Study



The number of cells differs among the three analyses because of restrictions placed on the data by the collecting agency. That is, some data have a "remark code" associated with them. One type of remark signifies that the actual concentration may have been lower than the value that was stored (that we used in our analyses). When this was the case and the stored value was higher than the guideline against which it was being compared, we excluded that particular observation from our analysis. As a result, at different guideline levels (MCL, MCLG, and one-in-one-million cancer risk), different numbers of cells count as measuring one or more contaminants.

Our findings about how groundwater compares to drinking water standards are qualified by the nonrandom distribution of cells with sites sampled. Although we cannot generalize from our sample of cells (12,072) to the universe of all possible cells (3.6 million), we base our conclusions on a large and varied sample. According to officials at the Geological Survey, much of the data contained in the WATSTORE data base were collected in response to perceived pollution problems. Therefore, the contaminant levels in the USGS wells will tend to be high and our findings will very likely underestimate the percentage of groundwater that could be degraded in the nation as a whole if pollution levels were allowed to increase to the level of the drinking water standards.

Findings

Maximum Contaminant Levels

We found that about 91.8 percent of cells with stations do not exceed EPA maximum contaminant levels for any contaminant measured. (Not all contaminants are measured at every station.)[3]

As shown in table IV.2, in 988 cells (8.2 percent) at least one MCL was exceeded. Of these, a single MCL was exceeded in 861 cells (7.1 percent), two were exceeded in 92 cells (0.8 percent), and between three and eight were exceeded in 35 cells (0.3 percent).

[3]Approximately 41 percent of the 12,072 cells with measurements are in South Dakota and Illinois. To determine the extent to which these two states affect the overall national totals, we also conducted an analysis that excluded them. We found that excluding these two states from the analysis changed the result from 92 to 89 percent.

Table IV.2: Cells Exceeding Maximum Contaminant Levels

Number of substances measured	Number of guidelines exceeded								Total
	0	1	2	3	4	5	6	8	cells
1	3,091	221	0	0	0	0	0	0	3,312
2	725	66	3	0	0	0	0	0	794
3	236	17	0	0	0	0	0	0	253
4	89	17	0	0	0	0	0	0	106
5	216	21	4	0	0	0	0	0	241
6	2,679	77	9	3	0	0	0	0	2,768
7	223	28	6	1	3	1	0	0	262
8	291	17	12	1	0	0	0	0	321
9	366	57	9	2	3	1	0	0	438
10	738	62	4	0	0	0	0	0	804
11	262	19	4	0	0	1	0	0	286
12	73	16	3	1	0	0	0	0	93
13	106	13	3	0	0	0	0	0	122
14	152	12	1	0	1	1	1	0	168
15	133	15	1	0	0	0	0	0	149
16	57	6	1	0	0	0	0	0	64
17	65	9	3	1	0	0	0	0	78
18	61	5	1	0	0	0	0	0	67
19	789	85	5	1	0	0	0	0	880
20	171	14	1	0	2	0	0	0	188
21	27	14	2	0	0	0	0	0	43
22	31	3	2	0	0	0	0	0	36
23	90	9	1	0	0	0	0	0	100
24	22	2	2	1	0	0	0	0	27
25	22	1	0	0	0	0	0	0	23
26	24	6	1	0	0	0	0	0	31
27	46	8	1	1	0	0	0	0	56
28	55	5	0	0	0	0	0	0	60
29	68	6	9	0	0	0	0	0	83
30	114	14	0	6	0	0	0	0	134
31	16	4	2	0	0	0	0	1	23
32	6	0	0	0	1	0	0	0	7
33	22	6	0	0	0	0	0	0	28
34	6	2	0	1	0	0	0	0	9
35	8	3	1	0	0	0	0	0	12
36	3	0	1	0	0	0	0	0	4
37	1	1	0	0	0	0	0	0	2
Total	**11,084**	**861**	**92**	**19**	**10**	**4**	**1**	**1**	**12,072**

MCLs for inorganic compounds were exceeded in 850 cells, MCLs for pesticides were exceeded in 22 cells, and MCLs for nonpesticidal organic compounds were exceeded in 135 cells. Six of 15 pesticides measured never exceeded the MCL level, while six others exceeded MCL levels in only one or two cells (see table IV.3).

Table IV.3: Cells With One or More Sites Exceeding MCLs and MCLGs

Substance	Total cells[a]	MCLs Number	MCLs Percent	MCLGs Number	MCLGs Percent
Inorganics and others					
Arsenic[b]	5,980	143	2.4	2,720	99.3
Coliform bacteria	1,606	235	14.6	235	14.6
Barium	5,110	17	0.3	17	0.3
Cadmium	3,232	162	5.0	162	5.0
Chromium	5,889	42	0.7	42	0.7
Copper	6,076	12	0.2	12	0.2
Fluoride	1,588	5	0.3	5	0.3
Lead	3,494	152	4.4	152	4.4
Mercury	3,343	14	0.4	14	0.4
Nitrate	3,838	156	4.1	156	4.1
Selenium	5,439	29	0.5	29	0.5
Silver	4,980	7	0.1	7	0.1
One or more	10,266	850	8.3	3,206	31.3
Pesticides					
Alachlor[b]	414	2	0.5	19	67.9
Aldicarb	4	0	0	0	0
Atrazine	942	4	0.4	4	0.4
Carbofuran	41	0	0	0	0
Chlordane[b]	1,243	2	0.2	21	5.3
2,4-D	1,220	0	0	0	0
1,2-dichloropropane[b]	1,533	3	0.2	32	82.1
Endrin	1,494	0	0	0	0
Heptachlor[b]	1,358	1	0.1	16	4.6
Heptachlor epoxide[b]	1,360	1	0.1	15	4.4
Lindane	1,489	2	0.1	2	0.1
Methoxychlor	1,147	0	0	0	0
Pentachlorophenol	298	1	0.3	1	0.3
Toxaphene[b]	1,311	9	0.6	11	2.6
2,4,5-TP	1,486	0	0	0	0
One or more	2,930	22	0.8	83	3.9

(continued)

Substance	Total cells[a]	MCLs Number	MCLs Percent	MCLGs Number	MCLGs Percent
Nonpesticidal organics					
Benzene[b]	2,651	34	1.3	97	95.1
Carbon tetrachloride[b]	2,588	6	0.2	26	78.8
Ortho-dichlorobenzene	887	0	0	0	0
Para-dichlorobenzene	826	0	0	0	0
1,2-dichloroethane[b]	2,558	13	0.5	70	92.1
1,1-dichloroethylene	2,480	5	0.2	5	0.2
Ethylbenzene	2,514	1	0	1	0
Monochlorobenzene	2,441	3	0.1	3	0.1
PCBs[b]	1,266	2	0.2	7	1.8
Styrene	460	0	0	0	0
Toluene	2,650	2	0.1	2	0.1
1,1,1-trichloroethane	2,600	7	0.3	7	0.3
Trichloroethylene[b]	2,582	85	3.3	202	96.7
Vinyl chloride[b]	565	16	2.8	26	76.5
Xylene	307	0	0	0	0
One or more	3,335	135	4.0	307	9.9

[a]The number of cells with one or more sites at which the substance was measured. Due to restrictions placed on the data, the actual number of cells that were included in our analysis may be different. This effect is particularly significant in our analysis of MCLGs for those substances that have, or are anticipated to have, an MCLG of zero.

[b]For these substances, the actual (or anticipated) MCLG is (or it is anticipated will be set) equal to zero. For all other substances the MCLG is (or it is anticipated will be set) equal to the MCL.

One or more MCLs currently in force are exceeded in 926 cells. This compares with 988 cells in which one or more MCLs would be exceeded once EPA completes the next phase of its drinking water standards rule-making. This rough equivalence, in spite of the presence of 17 additional substances (for which monitoring data were available), is due to the fact that very few cells exceed anticipated MCLs for any of the substances that EPA is newly regulating (see table IV.4).

Table IV.4: Cells With One or More Sites Exceeding MCLs for Current and Anticipated Standards

Substance	Total cells[a]	Exceeds Current MCLs		Exceeds Anticipated MCLs	
		Number	Percent	Number	Percent
Inorganics and others					
Arsenic	5,980	74	1.2	143	2.4
Coliform bacteria	1,606	235	14.6		
Barium	5,110	63	1.2	17	0.3
Cadmium	3,232	66	2.0	162	5.0
Chromium	5,889	80	1.4	42	0.7
Copper	6,076			12	0.2
Fluoride	1,588	5	0.3		
Lead	3,494	152	4.4		
Mercury	3,343	18	0.5	14	0.4
Nitrate	3,838	156	4.1	156	4.1
Selenium	5,439	74	1.4	29	0.5
Silver	4,980	7	0.1		
Pesticides					
Alachlor	414			2	0.5
Aldicarb	4			0	0
Atrazine	942			4	0.4
Carbofuran	41			0	0
Chlordane	1,243			2	0.2
2,4-D	1,220	0	0	0	0
1,2-dichloropropane	1,533			3	0.2
Endrin	1,494	0	0		
Heptachlor	1,358			1	0.1
Heptachlor epoxide	1,360			1	0.1
Lindane	1,489	0	0	2	0.1
Methoxychlor	1,147	0	0	0	0
Pentachlorophenol	298			1	0.3
Toxaphene	1,311	9	0.6	9	0.6
2,4,5-TP	1,486	0	0	0	0

(continued)

Substance	Total cells[a]	Exceeds Current MCLs		Exceeds Anticipated MCLs	
		Number	Percent	Number	Percent
Nonpesticidal organics					
Benzene	2,651	34	1.3		
Carbon tetrachloride	2,588	6	0.2		
Ortho-dichlorobenzene	887			0	0
Para-dichlorobenzene	826	0	0		
1,2-dichloroethane	2,558	13	0.5		
1,1-dichloroethylene	2,480	5	0.2		
Ethylbenzene	2,514			1	0
Monochlorobenzene	2,441			3	0.1
PCBs	1,266			2	0.2
Styrene	460			0	0
Toluene	2,650			2	0.1
1,1,1-trichloroethane	2,600	7	0.3		
Trichloroethylene	2,582	85	3.3		
Vinyl chloride	565	16	2.8		
Xylene	307			0	0

[a]The number of cells with one or more sites at which the substance was measured . Due to restrictions placed on the data, the actual number of cells that were included in our analysis may be different.

Maximum Contaminant Level Goals

In 71 percent of the cells, concentrations did not exceed the MCLG for any substance measured.[4] The measured concentration of most pesticides usually met even the MCLG. Six of the 15 pesticides measured are anticipated to have MCLGs of zero. Eighty-three cells (3.9 percent of those cells with readings for at least one pesticide) exceeded an MCLG for one or more of the 15 pesticides (see table IV.4).

One-In-One-Million Cancer Risk

In 42.5 percent of the 5,114 cells in which an analysis of the measurement was possible, the contamination level was less than that associated with a one-in-one-million cancer risk for all of the 13 cancer-causing substances. This compares to 96.4 percent of 7,973 cells that met MCLs and 9.1 percent of 3,323 cells that met MCLGs for one or more of the 13 substances.

[4]An MCLG could not be assigned for 3 of the 42 substances, and in these cases we employed the MCL. Restricting our analysis to the 39 would change the findings from 71.0 to 71.3 percent. For 13 of the 42 substances, the MCLG is (or it is anticipated by EPA that it will be) set equal to zero. For all other substances, the MCLG is (or it is anticipated will be) set equal to the MCL. Arsenic is one of the substances that, based on information from EPA, we assigned an MCLG of zero. It also was measured in nearly half the cells. As a result, arsenic by itself accounted for 70 percent of the 3,500 cells that exceeded an MCLG.

Summary and Conclusions

Approximately 71 percent of the groundwater in our study met all MCLGS measured and approximately 92 percent met all MCLS measured. This means that if states use MCLS or MCLGS as "contamination ceilings," the quality of the vast majority of the groundwater we examined could degrade. The fact that the WATSTORE data base probably over-samples areas with pollution problems suggests that for the nation as a whole the potential impact of adopting these drinking water standards as groundwater standards could be even greater than is indicated by our findings.

Comparison of Guidelines for Groundwater Uses

Our fourth evaluation question was: "How do drinking water standards compare to guidelines for protecting uses of groundwater other than for drinking?" Our findings are presented below.

Background

Groundwater is widely used to irrigate crops and for livestock watering. Forty percent of crops and over 50 percent of livestock production rely on groundwater. Groundwater aquifers are also closely connected to rivers and lakes. EPA has estimated that groundwater is the source of approximately 30 percent of the nation's surface water.

Findings

The National Academy of Sciences has published recommended acceptable levels of contamination to protect irrigated crops for eight of the 54 substances and to protect livestock for 10 of the 54 (see table V.1). All of these are are metals and other inorganic compounds. In all cases, EPA maximum contaminant levels are at least as stringent as the guidelines established by NAS.

EPA has issued guidelines to protect aquatic life for 27 of the 54 drinking water contaminants under authority contained in section 304 of the Clean Water Act. The National Academy of Sciences has published recommended guidelines for two others (lindane and 2,4,5-TP). Fifteen of the 27 aquatic life guidelines issued by EPA are more stringent than their maximum contaminant levels for drinking water as are the two additional guidelines published by NAS (see also table V.1).

The concentration of groundwater contaminants exceeds the more stringent of the aquatic life guidelines and MCLs in 33.1 percent of the one-square-mile cells in which USGS measured groundwater contamination. When actual groundwater contamination is compared only to MCLs (see table IV.2 on p. 33), just 8.2 percent of the cells show excessive concentrations.

Table V.1: Comparison of Standards for Various Uses of Groundwater[a]

Substance	Drinking water MCL[b]	Aquatic life	Livestock	Irrigation
Inorganics				
Arsenic	30.00	190.0000	200	100
Asbestos	7.00[c]			
Barium	4,700.00			
Cadmium	5.00	0.6600[d]	50	10
Chromium	120.00	11.0000[d]	1,000	100
Copper	1,300.00	6.5000[d]	500	200
Fluoride	4,000.00		2,000	1,000
Lead	50.00	1.3000[d]	100	5,000
Mercury	4.00	0.0120[d]	10	
Nitrate	10,000.00		100,000	
Selenium	45.00	35.0000[d]	50	20
Silver	50.00	1.2000[d]		
Pesticides				
Alachlor	2.00			
Aldicarb	9.00			
Atrazine	3.00			
Carbofuran	40.00			
Chlordane	2.00	0.0043[d]		
Dibromochloropropane	0.20			
2,4-D	70.00	365.0000		
1,2-dichloroproprane	5.00	5,700.0000		
Endrin	0.20	0.0023[d]		
Ethylene dibromide	0.05			
Heptachlor	0.40	0.0038[d]		
Heptachlor epoxide	0.20			
Lindane	0.20	0.0100[d]		
Methoxychlor	300.00	0.0300[d]		
Pentachlorophenol	200.00	3.5000[d]		
Toxaphene	5.00	0.0002[d]		
2,4,5-TP	50.00	2.0000[d]		

(continued)

Substance	Drinking water MCL[b]	Aquatic life	Livestock	Irrigation
Other organics				
Acrylamide	0.60			
Benzene	5.00	5,300.0000		
Carbon tetrachloride	5.00	35,200.0000		
Ortho-dichlorobenzene	600.00	763.0000		
Para-dichlorobenzene	75.00	763.0000		
1,2-dichloroethane	5.00	20,000.0000		
1,1-dichloroethylene	7.00			
Cis-1,2-dichloroethylene	70.00			
Trans-1,2-dichloroethylene	70.00			
Epichlorohydrin	2.00			
Ethylbenzene	700.00	32,000.0000		
Monochlorobenzene	300.00	50.0000[d]		
PCBs	0.70	0.0140[d]		
Styrene	100.00			
Toluene	2,000.00	17,500.0000		
1,1,1-trichloroethane	200.00	9,400.0000		
Trichloroethylene	5.00	45,000.0000		
Vinyl chloride	2.00			
Xylene	12,000.00			
Radionuclides and others				
Alpha particle	15 pCi/l			
Coliform bacteria	1/100 ml			
Beta particle	4 mrem/yr			
Radium 226 and 228	5 pCi/l		5 pCi/1	5 pCi/1
Total trihalomethanes	100			
Turbidity	1–5 TU			

[a]Standards are expressed in micrograms per liter except where noted.

[b]The MCL standards shown are a combination of current and anticipated standards. The anticipated standard is used if the two differ.

[c]Standard expressed in millions of fibers of at least 10 micrometers in length per liter.

[d]More stringent than the MCL.

Summary and Conclusions

EPA maximum contaminant levels would protect livestock watering and crop irrigation with an ample margin of safety. However, we found that for several substances, MCLs may be too high to protect aquatic life. A decision to apply maximum contaminant levels as groundwater standards without allowing for greater stringency when local conditions warrant it (such as in areas of high groundwater recharge with low surface water dilution and ecosystems sensitive to these substances) could jeopardize sensitive species of aquatic life.

Questionnaire

Survey of State Groundwater Protection/Standards Program

PART I: Groundwater Standards for Volatile Organic Compounds

1. EPA recently regulated eight volatile organic compounds (VOCs) as drinking water contaminants. [See table below for the Maximum Contaminant Levels (MCLs) and the Maximum Contaminant Level Goals (MCLGs) for these substances.] Which of the following best describes your state's position on setting groundwater standards for these VOCs? **(Check one.)**

1. [ ] We already had standards for or were in the process of regulating one or more of these compounds **prior to EPA's action. Go to question 3.**

2. [ ] We established or are in the process of establishing standards for one or more of these compounds **as a result of EPA's action. Go to question 4.**

3. [ ] We **do not presently have** nor are we in the process of establishing standards for these compounds. **Continue.**

EPA's Drinking Water Standards for VOCs

Substance	MCL(ug/l)	MCLG(ug/l)
Benzene	0.005	zero
Carbon tetrachloride	0.005	zero
para-dichlorobenzene	0.075	0.075
1,2-dichloroethane	0.005	zero
1,1-dichloroethylene	0.007	0.007
1,1,1-trichloroethane	0.20	0.20
Trichloroethylene	0.005	zero
Vinyl chloride	0.002	zero

2. Over the next year or two does your state **plan** to develop standards for the eight volatile organic compounds recently regulated by the EPA as drinking water contaminants? **(Check one.)**

1. [ ] Yes; **Continue.**

2. [ ] Probably yes; **Continue.**

3. [ ] Uncertain; **Continue.**

4. [ ] Probably not; **Continue.**

5. [ ] No; **Go to question 9.**

6. [ ] Have not considered the issue; **Go to question 9.**

3. If your state revises or develops new groundwater standards for the VOCs recently regulated by EPA, would these standards be based on EPA's drinking water standards? **(Check one.)**

1. [ ] Yes; **Continue.**

2. [ ] Probably yes; **Continue.**

3. [ ] Uncertain; **Continue.**

4. [ ] Probably not; **Go to question 9.**

5. [ ] No; **Go to question 9.**

6. [ ] Have not considered the issue; **Go to question 9.**

1

4. Please check the characterization which best corresponds to your present or planned groundwater standards for the eight VOCs. **[Note: If you plan to revise your present standards in the near future answer based on the planned revision. If you do not have a plan to regulate a specific VOC check "no standard" for that substance. Check one column for each substance.]**

VOC	MCL	MCLG	Other (specify)	No standard
Benzene	___	___	____________	___
Carbon tetrachloride	___	___	____________	___
para-dichlorobenzene	___	___	____________	___
1,2-dichloroethane	___	___	____________	___
1,1-dichloroethylene	___	___	____________	___
1,1,1-trichloroethane	___	___	____________	___
Trichloroethylene	___	___	____________	___
Vinyl chloride	___	___	____________	___

2

If you answered that the EPA MCL formed the basis for any VOC groundwater standard in the previous question, please answer Question 5; otherwise skip this question.

5. Which of the following best describes the reason(s) your state used the EPA MCL drinking water standards as the basis for your VOC groundwater standard? **[Check all choices that apply.]**

   1. [ ] The MCL reflects an integration of health protection concerns and technological feasibility considerations

   2. [ ] Enforcing the MCL is considered more reasonable than the MCLG

   3. [ ] If the MCL is deemed adequate by EPA for drinking water purposes then it is also acceptable for other uses of groundwater

   4. [ ] Other (please specify):

   ____

   ____

If you answered that the EPA MCLG formed the basis for any VOC groundwater standard please answer Question 6; otherwise skip this question.

6. Which of the following best describes the reason(s) your state adopted the EPA MCLG as the basis for your VOC groundwater regulation? **[Check all choices that apply.]**

   1. [ ] The MCLG reflects only health protection considerations

   2. [ ] The MCLG is perceived as being more stringent than the MCL

   3. [ ] Other (please specify):

   ____

   ____

If you answered "other" for any VOC please answer Question 7. Then continue with question 8.

7. Why has or will your state base its VOC standards on guidelines or information sources other than the MCL/MCLG?

   ____

   ____

   ____

   ____

3

8. The following points are arguments for or against using drinking water standards as groundwater standards. How important, if at all, were each of them in your state's deciding whether or not to adopt EPA's MCLs/MCLGs as its groundwater standards? **(Check one column for each point.)**

	Of Little or No Importance	Somewhat Important	Moderately Important	Very Important	Essential	Did Not Consider
1. Federal drinking water standards may not protect non-drinking-water designated uses of the groundwater resources in our state.						
2. Groundwater standards should reflect a non-degradation philosophy.						
3. In our state, using drinking water standards as groundwater standards assures non-degradation of groundwater.						
4. Drinking is the most important use of the groundwater resources of our state.						
5. Rather than having a single set of standards for groundwater contaminants, it would be more sensible for our state to have different sets of standards for different designated uses of groundwater.						

4

9. If the EPA promulgates additional drinking water standards beyond the eight volatile organic compounds discussed above, which of the following actions would your state likely take? **(Check one.)**

1. [ ] Probably issue groundwater standards for all or most of the substances, adopting the EPA drinking water MCL as the state groundwater standard.

2. [ ] Probably issue groundwater standards for all or most of the substances, adopting the EPA drinking water MCLG as the state groundwater standard.

3. [ ] Probably issue groundwater standards for all or most of the substances; adopting either the MCL or the MCLG as the state groundwater standard.

4. [ ] Probably issue groundwater standards for all or most of the substances, possibly, but not necessarily at the MCL or MCLG levels.

5. [ ] Undecided as to whether we would issue groundwater standards for all or most of the substances.

10. Consider basing groundwater standards for different locations on how the groundwater is used in that area. In your opinion, how should the standards that protect non-drinking-water designated uses (for example, aquatic life, irrigation and livestock watering) differ from the standards that are aimed at protecting the groundwater for drinking? **(Check one.)**

1. [ ] Groundwater standards should be less stringent than drinking-water-based standards.

2. [ ] Groundwater standards should be more stringent than drinking-water-based standards.

3. [ ] For some contaminants, they should be less stringent, while for others they should be as stringent or more stringent than drinking-water-based standards.

4. [ ] Undecided or no basis to say.

PART II: Using Groundwater Standards

In this section we would like you to provide information on how your state uses groundwater standards to protect its groundwater supplies. In these questions we draw a distinction between two types of activities: (1) those activities that are intended to prevent a contaminant release that could threaten groundwater and (2) those activities that respond to a contamination release. Part A is directed toward the first of these, i.e., prospective control activities; Part B is directed toward the second, i.e., responding to violations.

5

Part A

11. In making decisions in the following areas, states may consider groundwater protection. (1): For the following areas, please check to what extent, if at all, your state considers groundwater protection in making decisions. (2): If your state does consider groundwater protection to at least "some extent", please check the extent groundwater standards are used in reaching these decisions.

Area/Activity	Extent Groundwater Protection is a Consideration: To Little or No Extent	To Some Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent	Extent Groundwater Standards are Used: To Little or No Extent	To Some Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
I. Source-oriented control activities										
1. Licensing or permitting surface discharges (mandating compliance with operating requirements or performance standards)										
2. Setting effluent limits for dischargers										
3. Performance standards establishing zones of discharge										
4. Facility design requirements										
a. Waste disposal facilities										
b. Bulk storage facilities										
5. Developing best management practices to control diffuse pollution, eg. restricting pesticide application										
II. Regulating groundwater users										
1. Licensing well drillers										
2. Controlling the siting and installation of wells										
3. Withdrawal and use permits for wells										
4. Aquifer recharge requirements										
III. Controlling Land-Use										
1. Zoning										
2. Siting, development and construction regulations										
3. Public acquisition										
4. Transferable Development Rights										
IV. Containment or Clean-up Requirements of Landfills and Hazardous Waste Sites										
V. Other (please specify): ______________________										

Continue if you checked that groundwater protection standards were used in decision making concerning any of the area/activities listed on the previous page.

12. How were the groundwater protection standards applied? **(Check the answer that best describes your state's application of groundwater standards.)**

 1. [ ] Groundwater standards' numerical values were used in formal analytical techniques such as waste-load-allocation models in order to determine impacts of alternatives under consideration. **Continue.**

 2. [ ] Groundwater standards were used in less formal or less quantitative techniques in order to determine relative impacts of alternatives under consideration. **Continue.**

 3. [ ] Groundwater standards were not used to determine impacts of alternatives but were used as part of monitoring requirements required as part of the decision. **Go to question 15.**

 4. [ ] At different times all of the above. **Continue.**

 5. [ ] Other (please specify):

 ____

 ____

13. Consider the situation when groundwater standards were used in the analysis to determine impacts of alternatives being evaluated. In your experience, to what extent, if at all, did the level at which the groundwater standard was set (its numerical value) affect the management decision. (Given that many factors may be considered in any decision, we are asking about the sensitivity of the final decision to the level of the numerical standard.) **(Check one.)**

 1. [ ] To little or no extent. **Skip to question 15.**

 2. [ ] To some extent. **Skip to question 15.**

 3. [ ] To a moderate extent. **Skip to question 15.**

 4. [ ] To a great extent. **Continue.**

 5. [ ] To a very great extent. **Continue.**

 6. [ ] For some areas to a great extent, for other areas to a smaller extent. **Continue.**

14. Please list the areas/activities for which the level of the standard had a great impact on the final decision referring to the list on the previous page.

 ____

 ____

 ____

 ____

7

Part B

15. We have determined, based on information that you provided to us last spring, that your state has groundwater standards for 11 of the 22 substances that EPA had drinking water standards for at that time. For how many of the 11 has your state investigated potential groundwater standard violations? **(Fill in the number of contaminants involved).**

    ______ (Number of contaminants covered by groundwater standards for which the state has investigated violations) **If no potential violations were investigated, STOP. Otherwise CONTINUE.**

16. How many investigations of violations of groundwater standards have been settled? **(Fill in the number of settled investigations.)**

    ______ (Number of settled investigations)

17. Of the settled cases, how many violations of groundwater standards were found? **(Fill in the number of settlements.)**

    ______ (Number of violations)

18. In investigating potential violations, was a numerical groundwater standard used to determine that a response would be made by your state? **(Check one.)**

    1. [ ] Yes.
    2. [ ] No.
    3. [ ] Sometimes, but not always.

19. What responses were made to your state's finding of violations of groundwater standards? **(Check all that apply.)**

    1. [ ] Shutting down the operation
    2. [ ] Restricting the operation
    3. [ ] Monitoring for further contamination
    4. [ ] Cleaning the aquifer
    5. [ ] Other (please specify):

    ____

    ____

Thank you for your cooperation.

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