SPECIAL REPORT

The Arsenic Controversy

On the final day of the Clinton presidency last January 19, the Environmental Protection Agency (EPA) approved a new health and safety standard for public water systems. Under the standard, the allowable concentration of arsenic in drinking water would be reduced from 50 micrograms per liter (µg/L) — a standard that has been in place for nearly two decades — to 10 µg/L by 2006.

One day later, new White House Chief of Staff Andrew Card issued a memo directing all incoming Bush officials to delay any Clinton administration-approved regulations that had not yet appeared in the *Federal Register,* to allow for review by the new administration. Despite the memo, the arsenic rule appeared in the *Register* two days later, making it final.

However, Bush officials did push back the initial implementation date of the rule to February 2002, though the 2006 deadline remains in effect. The administration also requested the National Academy of Sciences to study the health effects of low-level ingestion of arsenic. Those moves touched off the first policy controversy of the new administration, as scientists, economists, public health experts, and political talking heads argued over the health effects and costs of the new standard.

Difficult analysis Anyone who has seen *Arsenic and Old Lace* knows that the chemical is toxic. However, EPA concerns over the 50-µg/L limit do not involve fear of poisoning. Despite the claims of some politicians in the opening days of the controversy, the scientific community seems in agreement that toxicity risks at 50 µg/L are minimal and are better combated by supplying susceptible persons with bottled water rather than mandating extensive changes to water treatment systems.

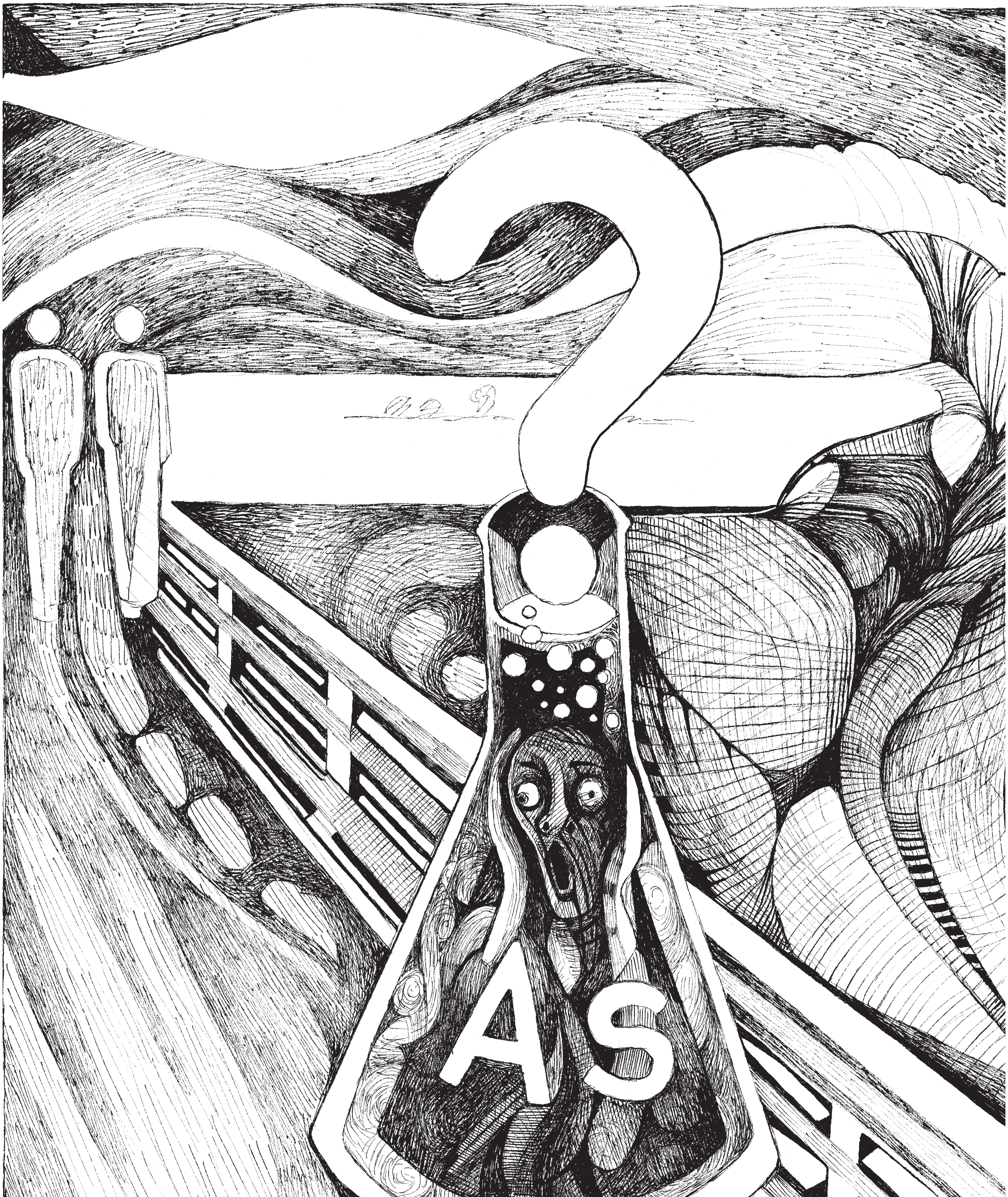
However, science is much less certain about the cancer risk associated with ingesting arsenic in small concentrations. Historically, scientists discounted the risk, but some recent studies have brought that view into question.

There is very little data on the health effects of low-level arsenic exposure. Because of that, EPA researchers were forced to extrapolate risk from studies of cancer rates in countries like Chile and Taiwan, where the chemical is present in water systems in considerably higher concentrations than in the United States. The extrapolations gave rise to an issue that is hotly debated among researchers: Is the cancer risk from low levels of arsenic proportional to the risk at higher levels? Or does discernible risk arise only after arsenic concentrations reach a certain threshold?

Costs and benefits A second issue concerning the new rule is whether its costs will outweigh its benefits. In accordance with a 1996 amendment to the Safe Drinking Water Act, EPA conducted monetized cost-benefit analysis as part of the arsenic rulemaking. The agency estimated that the new standard would produce qualitative benefits worth about $170 million a year, while the costs from implementation would total about $200 million a year. EPA justified the apparent net loss of the rule by asserting that non-quantitative benefits of the new standard would outweigh the $30 million difference.

Proponents and critics of the new rule dispute EPA's estimated values of the costs and benefits. Critics charge that the benefits are significantly exaggerated, while proponents assert that the annual costs will be much lower and the true value of the benefits much higher than EPA calculated. As with the dispute over how to extrapolate cancer rates, it appears that there is no easy resolution to the issues surrounding the cost-benefit analysis of the new rule.

The arsenic controversy In the following articles, we will examine opinions on both sides of the debate over tightening the arsenic limit. Jason K. Burnett and Robert W. Hahn of the AEI-Brookings Joint Center for Regulatory Studies argue that their own cost-benefit analysis of epa's new rule raises questions about its value. Harvard physicist Richard Wilson examines the scientific evidence indicating a link between arsenic and cancer, and argues that the link is more significant than historically has been thought. Finally, Cato Chairman William A. Niskanen offers his comments on the controversy and the preceding papers. R



MORGAN BALLARD

A Costly Benefit

Economic analysis does not support EPA's new arsenic rule.

By Jason K. Burnett and Robert W. Hahn
AEI-Brookings Joint Center for Regulatory Studies

The U.S. Environmental Protection Agency (EPA) recently finalized a rule that would reduce the maximum allowable level of arsenic in drinking water by 80 percent, from the current limit of 50 micrograms per liter (µg/L) to 10 µg/L. As soon as the rule was announced last January, it became the center of controversy as some experts argued that it was appropriate and necessary while others questioned whether the costs of implementation justified the benefits to human health. That controversy will continue over the next several months, following the Bush administration's decision to reconsider the standard before its implementation in 2006. On the basis of currently available information, we must side with those who question the rule's benefits in relation to its costs. As we explain in this article, we believe the costs will exceed the benefits by over $100 million annually.

PROJECTING RISK

The risks of high-level exposure to arsenic have been well documented. As stated in a 1999 report to EPA by the National Research Council (NRC), arsenic in drinking water causes bladder, lung, and skin cancer when consumed in high concentrations. However, the report continues, evidence of risk at lower doses is very weak. The report notes, "No human studies of sufficient statistical power or scope have examined whether consumption of arsenic in drinking water at the current maximum contaminant level… results in an increased incidence of cancer or noncancer effects."

Because of the lack of data, quantification of possible low-dose risks from arsenic is difficult and must be inferred from animal and epidemiological studies of high-level exposure. In formulating the new rule, EPA used such inferences to estimate the risk of bladder and lung cancers given certain low levels of arsenic in water supplies. The agency did not carry out similar projections for other forms of cancer, claiming that such risk assessments are "nonquantifiable."

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The authors would like to thank Patrick Dudley and Erin Layburn for valuable research assistance.

The data and methodology that EPA employed to estimate the risk of bladder cancer raise concerns. In its calculations, the agency assumed that risk is linearly related to arsenic concentration. That is, from empirical data showing the risk of exposure to high concentrations of arsenic, researchers drew a "straight line" downward to project the risk of low-level exposure.

We believe that arsenic exposure risk levels would be better represented by a curve, so that exposure at levels the body can metabolize would show almost no risk. Given our opinion, we further believe that the actual risk from low-level exposure is likely to be much less than EPA's linear dose-response model indicates. Unfortunately, the agency did not attempt to quantify the extent that the linear dose-response model may overestimate the actual risks of arsenic.

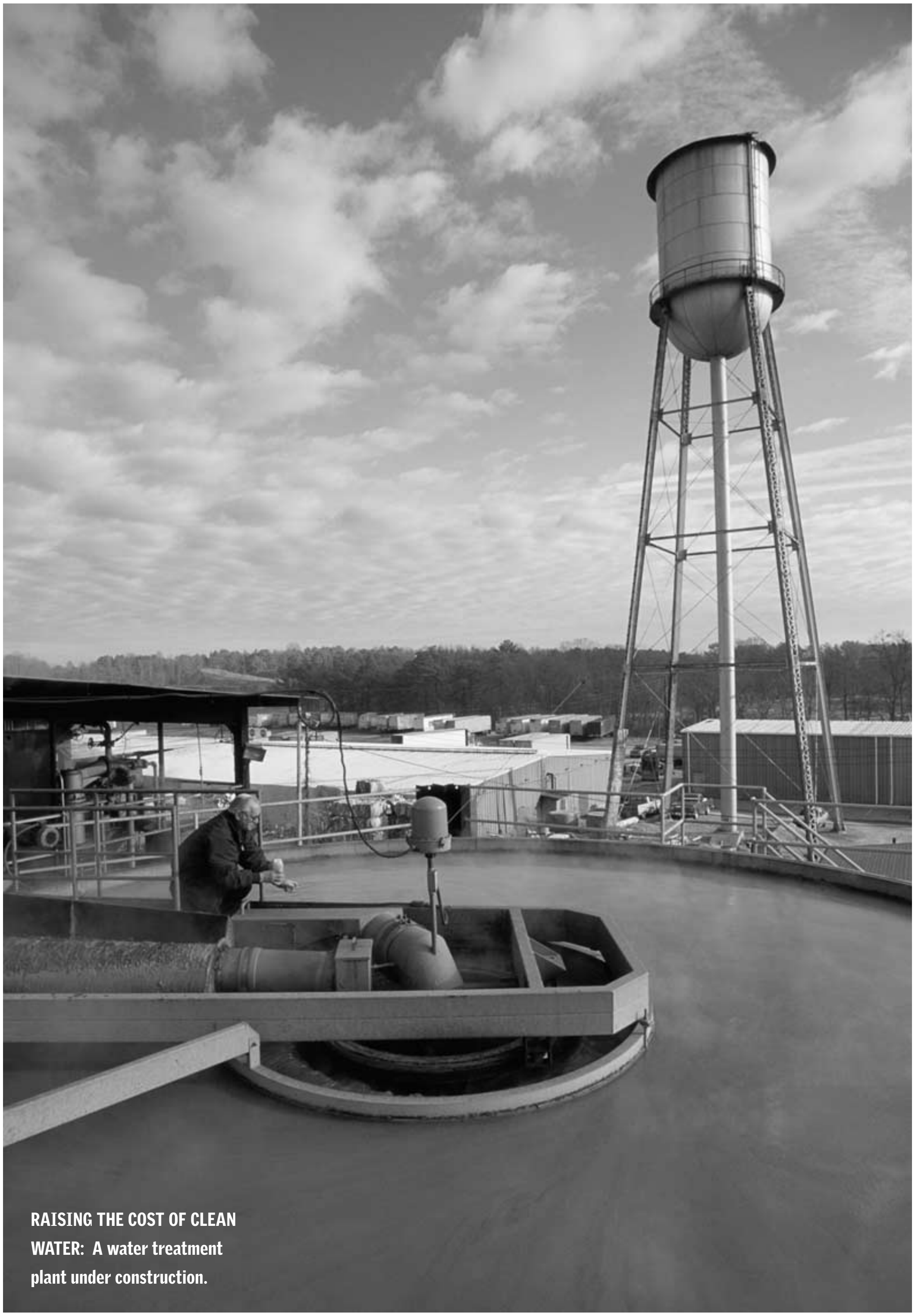
COSTS AND BENEFITS

The Safe Drinking Water Act, as amended in 1996, leaves a certain amount of discretion to EPA when setting standards for arsenic. But the act does instruct the agency to use economic analysis to choose the standard. Accordingly, EPA performed a detailed assessment of the benefits and costs of regulating arsenic. The agency's analysis is long and complex, yet fails to provide even rough estimates for certain health benefits that influenced the final decision.

EPA found that the primary costs of the rule are the capital costs of installing water treatment facilities and the costs of operating them. Of course, the lower the allowable limit, the higher would be the cost because more water systems would need to be upgraded to meet the tighter standard. EPA ultimately determined that the cost for the 10 µg/L standard would be over $200 million annually.

Measuring the benefits Juxtaposed against those costs are the benefits. EPA, which considered only the "quantifiable" benefits from reduced incidences of bladder and lung cancers, determined that the benefits have a value of about $170 million annually.

In reaching that figure, the agency did not take into account when the benefits are likely to occur. That is, EPA did not "discount" the value of the benefits in light of the lag time between the rule's implementation and the time in which the benefits will begin to emerge. Most cancers have a latency period between the exposure to a carcinogen and



RAISING THE COST OF CLEAN WATER: A water treatment plant under construction.

FLIP CHALFANT/IMAGE BANK

the development of cancer — often a period of several years or a few decades. Bladder cancer is known to have a long latency period, so it is unlikely that benefits would accrue immediately.

Adjusting for the delay would reduce benefits. But even without adjusting for the timing of the mortality risk reductions, EPA's own analysis shows that the monetized costs of the new rule exceed the monetized benefits. Nonetheless, EPA asserted that the benefits of the arsenic rule justify the costs, and therefore chose to finalize the rule. The agency suggested that other "nonquantifiable" benefits were sufficient to make up for the imbalance between monetized benefits and costs.

EPA made several questionable decisions in calculating the benefits and costs. One such decision was the use of a linear response curve. As has been noted, we believe the risks from low-level exposure to arsenic are likely to be sublinear, so the benefits from the new rule are likely to be so as well. What is more, the agency used an upper bound as its best estimate at several points. Finally, the agency did not take into account the timing of the benefits, and thus did not discount them appropriately.

OUR ANALYSIS

To gain a better approximation of the new rule's costs and benefits, we conducted our own analysis. Our work differs from EPA's in several ways: First, we explicitly estimated the benefits and costs of the rule, which enabled us to estimate the standard that would maximize net benefits — the difference between marginal benefits and marginal costs — under different assumptions. Second, we explicitly took account of the effects of latency — that is, the lag between exposure and the onset of disease — on net benefits. Third, we quantified the indirect effects of the rule on lives saved, as well as the direct effects. Fourth, we examined a wider range of policy alternatives than EPA considered, including targeting particular water systems and allowance trading. Finally, we considered several sensitivity analyses and introduced an estimate for EPA's "nonquantifiable" benefits category.

While we believe that our analysis is more realistic than EPA's, it has some flaws. In particular, we did not have a strong basis for choosing particular numbers for certain variables such as latency, the non-linear relationship between dose and response, and the non-quantifiable benefits. We tried to use the best available evidence to make educated guesses; we also did sensitivity analyses to see how changes in key assumptions affected results. We would have preferred to have scientific experts make such judgments in their fields of expertise; however, they were reluctant to do so. Now that arsenic has become a "hot" issue, we are hopeful that better judgments can be obtained on the likely values for key variables.

Our analysis assumed that if the effects of arsenic exposure are delayed many years, the benefits of reducing that exposure will also be delayed many years.

Value of life EPA used a figure of $6.1 million as the value of a statistical life in its benefits analysis of the new rule. By "value of a statistical life," EPA means that people are typically willing to pay up to $6.1 million per life saved to implement a policy that would reduce health and safety risks. However, in using that figure, EPA did not account for the timing of the benefits in the agency's best estimate. In the final rule, the agency did account for latency, but only included those numbers in a sensitivity analysis.

In our analysis, future benefits were discounted just as future costs were. If the effects of arsenic exposure are delayed many years, the benefits of reducing arsenic exposure are also likely to be delayed. We assumed a latency period of twenty years, a standard discount rate of seven percent, an income growth rate of one percent, and an income elasticity of one percent. Those assumptions resulted in a best estimate of $1.8 million. We use that figure as part of our analysis.

Scenarios As shown in Table 1, our analysis considered five different scenarios. Only the first scenario used EPA's analysis of the risk of arsenic and its assumption on the value of a statistical life ($6.1 million). The second through fifth scenarios used our derived value of $1.8 million that was adjusted for the impact of latency.

The second scenario adjusted the value of a statistical life to account for latency, but otherwise applied EPA's basic approach — including its estimate of the reduced mortality. The third increased the estimate of lives saved by a factor of four to account for our upper-bound estimate of the "nonquantifiable" benefits, but the scenario did not account for the likely sublinear dose-response function of arsenic. The fourth accounted for our best estimate of the "nonquantifiable" benefits and the sublinear dose-response function. Finally, the fifth provided a reasonable lower bound estimate on the number of lives saved. Taken together, the scenarios suggest a range of five to 100 lives saved annually by the new rule.

The fourth scenario reflects our best estimate. We took EPA's costs as given because we had no other data on costs. We took EPA's estimate of 28 lives saved and adjusted it to account for both the value of "nonquantifiable" benefits

Table 1

What the New Rule Brings

The effects of EPA's arsenic rule, with different assumptions.

	Lives[1]	Benefit	Costs	Net costs[2]	Cost-effectiveness[3]
EPA's model without accounting for latency	28	$170 million	$210 million	$40 million	$7.5 million per statistical life
EPA's model accounting for latency	28	$50 million	$210 million	$160 million	$26 million per statistical life
Our high estimate[4]	110	$200 million	$210 million	$10 million	$6.4 million per statistical life
Our best estimate[5]	11	$20 million	$210 million	$190 million	$65 million per statistical life
Our low estimate	5.5	$10 million	$210 million	$200 million	$130 million per statistical life

1 Statistical lives saved shown here are not discounted for latency. **2** Net costs are costs minus benefits. Numbers may not add up, owing to rounding. **3** See article text for details. **4** We obtain our upper-bound estimate by taking EPA's model, including "non-quantifiable" benefits and accounting for latency. **5** Our best estimate includes "non-quantifiable" benefits, accounts for latency, and incorporates a sublinear dose-response function. See article text for details.

Figure 1

The Cost of Prevention

Marginal costs and benefits of arsenic reduction.

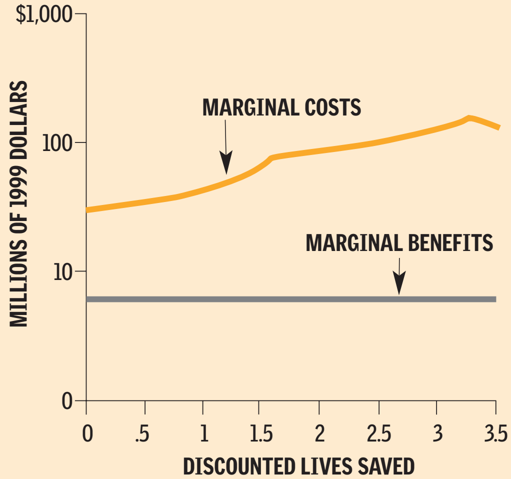
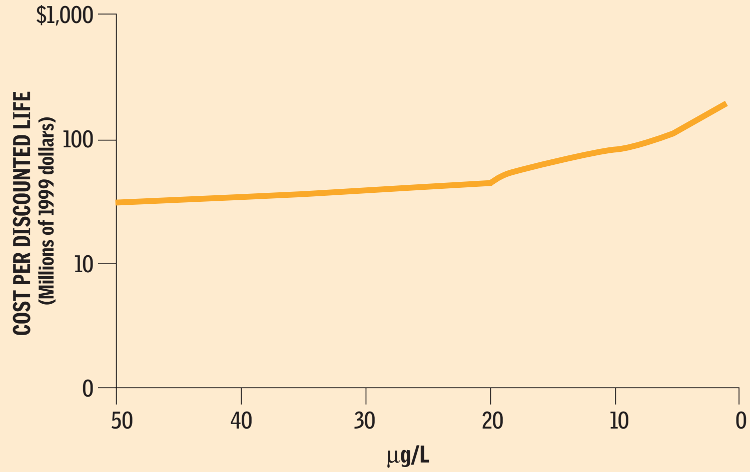


Figure 2

The Cost of Prevention

Cost-effectivness of arsenic reduction.



and our belief that arsenic risk would be best represented by a non-linear dose-response function.

To account for the nonquantifiable benefits, we multiplied the EPA-projected number of lives saved from reduced bladder and lung cancers by two. That number was derived from the National Research Council's estimate that total incidence of cancer may be as high as eight times the number of bladder cancer cases. The report does not indicate what the mortality rate of the other cancers might be. Our best estimate implies a mortality rate similar to the rate for bladder cancer. Our high estimate used an average of the mortality rates for bladder and lung cancers; our low estimate assumed there are no other cancers besides lung and bladder. Unfortunately, we are on uncertain ground in those calculations because scientists failed to provide much guidance on the issue.

Going from a linear dose-response to sublinear reduces the level of risk for a given dose. To account for that, we divided the benefits level by five, based on research that shows the body can metabolize 80 percent of ingested arsenic at low levels. There is uncertainty as to how much safer metabolized arsenic is, but we think an 80 percent reduction of risk is a reasonable estimate. On the basis of the assumptions, we determine that EPA's rule would save about 11 lives annually.

Results Table 1 summarizes some of the key results on benefits, costs, net benefits, and lives saved under different assumptions. The first column of the table specifies the particular scenario; the second, third, fourth, and fifth columns note the lives saved, benefits, costs, and net benefits, respectively. The final column provides an estimate of the cost per life saved. The calculation of the cost-effectiveness per life accounts for latency in all but the first scenario. That is accomplished by discounting the lives saved in the same way that benefits and costs are discounted.

The basic message of Table 1 is that EPA's new 10-µg/L standard makes no economic sense. Economic costs exceed economic benefits for the chosen standard and all alternatives considered by the agency. In our best estimate, net costs are close to $190 million and only 11 lives are saved.

Indeed, for all five scenarios, net costs are between $10 million and $200 million, and the cost-effectiveness is never less than $6.4 million per statistical life. In addition, the rule saves relatively few lives in all scenarios. With an affected population of about 10 million people, the annual risk reduction is about one in 1 million, which is so small as not to be worth addressing, given the uncertainties in the data and EPA's limited resources to develop regulations.

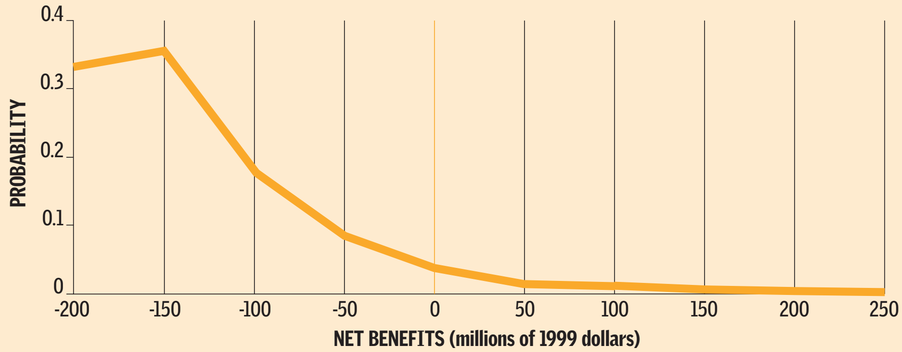
Increasing risk There is also a reasonable chance that the recent rule will actually increase overall health risks. The reason is that, when water utilities raise their rates to cover the costs of complying with the new rule, the higher water bills will reduce the amount of private resources that people have to spend on a wide range of activities, including health care, children's education, and automobile safety. When people have fewer resources, they spend less to reduce risks. The resulting increase in total risk counters the direct reduction in risk attributable to a government action such as the new arsenic rule. At its most extreme, if the direct risk reduction is small and the regulation is very ineffective relative to its cost, then total risk could rise instead of fall.

At what point would we see such an increase in risk? Economists have used a value of between $10 million and $50 million per statistical life saved for the point at which overall risk associated with the cost of a rule would actually increase net risk. A plausible best estimate is $15 million per life saved. On the basis of that analysis, our best estimate scenario — scenario four—indicates that it is likely the new rule will result in a net increase in risk, because the average cost per life saved is about $65 million.

Figure 3

Offering Little Gain

Monte Carlo simulation of net benefits.



Alternate standards One of the issues that EPA does not address carefully in its research for the new rule is whether there is a less stringent standard — greater than 10 μg/L but less than 50 μg/L — that would result in positive net benefits. Could there be a different standard level that would result in a higher level of net benefits?

Figures 1 and 2 offer some insight into a possible answer for that question. Figure 1 shows the marginal cost curve, based on our best estimate. The vertical axis is a logarithmic scale in millions of dollars, and the horizontal axis plots lives saved. The marginal benefit curve is horizontal and is based on a $6.1 million value of a statistical life.

The most important point to note about Figure 1 is that the marginal benefit curve and the marginal cost curve do not intersect for the case of our best estimate — marginal costs are everywhere greater than marginal benefits. A second point to note is that, for EPA's new standard (noted at the far right of the scale), the marginal costs exceed marginal benefits by well over $100 million annually. What is more, the previous standard itself may have been too high because, even at 50 μg/L, there are higher costs than benefits.

Figure 2 is based on the same data as Figure 1, but illustrates the ideas in terms of cost per life saved. The horizontal axis plots the maximum contaminant level, and the vertical axis is a logarithmic scale in millions of dollars per life saved. At EPA's new standard of 10 μg/L, the average cost per life saved is $65 million, which exceeds the standard $6.1 million value of a statistical life by a factor of 10. The same calculation can be made for other scenarios, but the qualitative conclusions remain the same; further regulation is justified only if the risk of arsenic is many times our best estimate.

EPA's new arsenic standard, and even its current 50 μg/l standard, makes no economic sense according to our cost-benefit analysis.

Results' sensitivity We checked our results by systematically changing a number of variables and examining how they influenced net benefits. In general, we found that it was very difficult to justify a standard below 20 μg/L on the basis of the economics alone.

One of the most sensitive parameters was the choice of a discount rate. We used seven percent in our best estimate calculations because that is the rate generally required in government analyses of regulations. If one changes the value to three percent — a reasonable lower bound for the discount rate — annual net benefits at a standard of 20 μg/L increase by about $23 million, but are still negative (-$42 million), meaning that the rule would still fail a cost-benefit test. Net benefits increase because the reduced mortality occurs 20 years in the future. Discounting the same number of lives back to the present at a lower rate gives a higher benefit for each life.

In addition to varying values one at a time, we did Monte Carlo simulations that varied parameters simultaneously based on probability distributions. Such simulations have the advantage that they can better reflect the underlying uncertainties. Figure 3 shows the results of one such simulation for a standard of 10 μg/L. The scenario assumes a triangular distribution over latency (from five to 30 years, with 20 years as the most likely value), a triangular distribution over the degree of sublinearity (from 0.1 to one, with 0.2 as the most likely value), a triangular distribution over the factor used for accounting for unquantified benefits (from one to four, with two as the most likely value), and equal likelihood on discount rates of three percent and seven percent.

Figure 3 shows that that incorporating key uncertainties gives rise to a distribution of net benefits. The expected value of that distribution is negative in this case (-$116 million), but in some cases net benefits will actually be positive. However, net benefits are negative for roughly 94 percent of the simulations, and positive for about six percent. So, although positive benefits are possible, they are very unlikely.

While policymakers often prefer to know things with certainty, the world is a very uncertain place. We thus think it is important to try to devise simple analytical tools for conveying the uncertainty, such as the one used here.

Alternative applications Some supporters of tighter arsenic regulation might propose amending the rule so that it targets particular water suppliers that have a relatively low cost per life saved. That way, regulators would increase the net benefits from the new rule while limiting its costs. Unfortunately, targeting is unlikely to produce returns that would be significantly better than the general rule. Figure 2 indicates that targeting the larger water systems with more users (and, thus, more beneficiaries) is not likely to result in net benefits when we use the best estimate of the risks of arsenic. That is because the average cost per life saved exceeds the value of a statistical life even at 50 µg/L.

Another approach EPA may want to consider is to allow different water suppliers to trade amongst themselves the rights to allow arsenic in the water supply. While we are doubtful that trading would yield positive net benefits for the rule that EPA chose to finalize, we think that the agency should seriously consider trading as a way of reducing costs while achieving similar levels of risk reduction.

The agency also should reconsider its timing for proposing and finalizing rules so that they better correspond with the completion of significant studies and analyses. One key advantage of waiting to regulate is that uncertainty over such matters as the risk from arsenic may be resolved. EPA has commissioned several studies on low-level exposure to arsenic that will report results in the next few years. The agency should delay implementation of the new arsenic rule at least until the results of the studies are available. The results could affect the selection of a particular standard.

EPA's role In many cases, drinking water issues are not national in scope. Most of the costs and benefits are borne by local communities. Most of us get drinking water courtesy of our local water utility or private wells. Thus, it is not clear that federal standards will achieve the solution that yields the highest net benefits for society.

We believe a much more limited role for the federal government and EPA should be considered, in which the federal government provides information on the risks and benefits of having different chemicals in drinking water and applying different control strategies. The task of setting drinking water standards could be left to either the states or municipalities.

In the case of arsenic, EPA did not do a very good job of justifying why it should be in the standard-setting business. Maybe the agency simply took it for granted, given the congressional mandate. Whatever the reason, the result of EPA's deliberations should give policymakers reason for pause.

The standard of 10 µg/L, which was pushed by EPA, is likely to flunk a cost-benefit test based on the agency's own analysis. Unfortunately, that is not the only case of a water regulation failing a cost-benefit test. We found a similar result in examining EPA's proposed rule to regulate radon in drinking water — the benefits do not justify the costs for taking the radon out of the water.

Is it not reasonable to think that municipalities might do a better job in selecting a standard that provides a higher level of net benefits? And for small communities with their own wells, why not let them choose what is best for them? We think that alternative deserves serious consideration by lawmakers. R

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Underestimating Arsenic's Risk

The latest science supports tighter standards.

By Richard Wilson
Harvard University

Arsenic has long been known to be acutely poisonous at high doses. However, if individuals ingest it at subacute doses, they become partially tolerant to the chemical. That makes arsenic the darling of detective story writers: A villain can take subacute doses for a week, and then share a meal containing arsenic with his victim. The villain lives but the victim dies, and the investigators have no reason to suspect that the meal served as the murder weapon.

But toxicity is only one hazard of arsenic; another is its carcinogenic properties. Scientific evidence of a link between cancer and arsenic dates back to the late nineteenth century when researchers found a connection between regular use of the medicinal Fowler's Solution (one percent arsenate) and skin cancer. In the following decades, similar connections were found among people who had regular exposure to arsenic-based pesticides and to the fumes produced during metal smelting.

More recently, researchers have given considerable attention to incidence of cancer among users of water supplies with high concentrations of arsenic. Earlier this year, the *New York Times* reported on a five-year study in Chile that showed some 700 people in excess of the background rate died from cancer that was linked to arsenic in drinking water at concentrations of 500 µg/L. In Bangladesh, 30 million people are exposed to similar levels of arsenic in their drinking water, and thousands of Bangladeshis have died from secondary effects of cancerous skin lesions.

Those studies involved arsenic levels that are significantly higher than what the U.S. Environmental Protection Agency (EPA) allows. But, concerning low-level exposure, scientists traditionally have believed that arsenic has few adverse effects. Standard experiments supported that belief: Test animals, particularly rats and mice, did not show any unusual incidence of cancer when they ingested arsenic concentrations proportional to concentrations ingested by the average American. Therefore, researchers have long believed that people do not develop cancer from low-level arsenic exposure.

However, that belief is now in question. A number of recent studies have indicated a potential link between low-level arsenic ingestion by humans and cancers of the bladder, kidney, and lung. What is more, Australian researchers have announced that they had induced mice to develop cancer using small doses of arsenic. Though there is still debate within the scientific community over those studies, evidence is now accruing that such a link exists.

That leads us to a crucial question: Given the recent scientific findings, should the United States lower the allowable limit for arsenic in drinking water below the 50 µg/L level? As often happens, the whole world is watching us as we discuss what to do.

ESTIMATING LOW-DOSE RISK

The fundamental issue in trying to answer that question is how to estimate arsenic risk at lower levels from the generally accepted measurements at higher exposure levels.

Some scientists and physicians argue that a linear dose-response model is appropriate. Under such a model, researchers would assume that the rate of cancer resulting from exposure to 50 µg/L of arsenic would be approximately 10 percent of the rate that results from 500 µg/L. But other scientists believe such a linear projection is inappropriate; they claim that there exists an exposure threshold below which no effect will be seen. According to their model, even if exposure to 500 µg/L of arsenic produces a certain incidence of cancer, it is possible that a 50-µg/L exposure would have no effect at all on cancer rates.

Linearity A half-century ago, Sir Richard Doll presented his

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multi-stage theory of cancer. Doll noted that most cancers caused by an external agent could not be distinguished from those that occur naturally and may be fundamentally indistinguishable. He thus reasoned that the external agent affected one stage in the cancer development in the same way as the natural processes do.

Twenty-five years later, a group of scientists — including one of Doll's collaborators, Sir Richard Peto — pointed out that Doll's theory is very general. If an agent increases the probability of any step in the cancer formation process in the same way as natural processes, then almost any biological dose-response relationship becomes linear at low doses.

That latter argument forms the basis for EPA's assumption of low-dose linearity as a default for all carcinogens. If one uses the default dose-response and starts from the data from Chile where there is a 10-percent increased mortality risk (mostly a lung cancer risk) for people who drink water containing 500 µg/L of arsenic, the default assumption leads to a one-percent projected risk for people drinking water with 50 µg/L of arsenic.

Non-linearity Some biologists and toxicologists insist that there is a threshold below which there is no effect, or at least that risk is below what is projected under the linear model. Until recently, animal experiments supported their beliefs: Low levels of arsenic did not cause cancer in animals and, it seemed reasonable to assume, was unlikely to cause cancer in people. But recent studies show that a metabolite of arsenic, DiMethylArsenic Acid (DMAA) does cause bladder cancer in rodents. What is more, a growing number of arsenic researchers appear to be changing their view about the usefulness of animal testing in determining human risk from low-level exposure to arsenic.

Until more research is done on arsenic exposure, I, as a risk assessor, would use a bimodal distribution for discussion of the probability of health effects corresponding to the differences in risk estimated from the two approaches. Moreover, I would carry the calculation through on both approaches and emphasize the difference to the final decision maker.

COSTS OF COMPLIANCE

Critics of EPA's effort to lower the allowable limit on arsenic have charged that the infrastructure costs that would result from tightening the allowable limit would outweigh the monetized benefits. However, the costs of any action to meet a regulation are far more uncertain, and often much

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Americans and Cost Discounting

In conducting a benefit analysis of a proposed new rule, should society discount the value of lives saved by the rule in the far future? In Bangladesh, the most important consequence of arsenic exposure is keratoses, which arise within a few years of exposure. Keratoses often leads to gangrene and the eventual amputation of limbs. But in the United States and for the longer term, cancers are the most likely consequence of arsenic exposure. Those cancers will occur some two or three decades after exposure, so, in conducting a cost- benefit calculation of tighter limits on arsenic, should one discount the cost of those future cancer cases?

Jason Burnett and Robert Hahn, in their article previous to mine, argue that one should employ such discounting, using the standard seven-percent discount rate used for money. Such a discount would, in effect, reduce the risk by a factor of between five and 10. Most economists agree with such a move, and merely argue about the expected valuation in the future. But a few others have disagreed with discounting.

The issue of whether or not — and how — to discount should have been discussed more thoroughly as part of EPA's rulemaking on the "cost of a statistical life." It was not well defined what "discounting" means, where in the calculation it should be applied, and whether EPA calculations already include some form of discounting. It would be logically superior to assign a cost to Years of Life Lost, rather than lives per se, which would take into account, in some part, the fact that the death of a 30-year-old is more significant than the death of an 80-year-old.

But it is abundantly clear that American society, as a whole, does not agree with discounting. For example, with a seven-percent discount rate on lives lost in the future, little money should be spent on toxic waste disposal. Indeed, with even a 0.1-percent discount rate, the United States is spending far too much on consideration of disposal of high-level nuclear waste. Yet the American public continues to offer strong support for toxic waste cleanup efforts, despite the costs and the supposedly questionable benefits.

To discount lives in a risk calculation is a policy decision that appears to conflict with the will of the American people. EPA utilization of such discounting would create profound precedents and should not be done lightly.

–Richard Wilson

lower, than opponents of the regulation tend to claim.

The most well known example of such an over-projection was the actual cost of reducing the occupational exposure to vinyl chloride in the polyvinylchloride (PVC) industry. In 1972, when the carcinogenicity of the monomer vinyl chloride became apparent, estimates for reducing the exposure were high. However, a temporary downturn in demand enabled the plants to be modified without disruption to overall supply. Manufacturers reduced worker exposure to the compound by sealing the equipment to stop fugitive emissions. When that was done, the manufacturers experienced a net saving of material and, as a result, a saving of money.

Implementation Those who are critical of EPA's new 10-µg/L standard assume that compliance requires infrastructure modification so that, at all times, the concentration of arsenic in all the water is below the permitted level. But that may not be necessary for meeting public health goals based on chronic — as distinct from acute — effects of arsenic. What is important is that the total amount of the chemical ingested over a long period — perhaps five years — is below the permitted level. That goal allows considerable flexibility in the employment of arsenic-removing equipment.

For example, the water supply of a large community might use filtration and the mixing of high- and low-arsenic-content water to meet the average required level. The Los Angeles water district uses the Los Angeles Aqueduct, which holds water from Mono Lake and Lake Crawley in the eastern Sierras. The water contains arsenic at an average level of 23 µg/L. But careful management, filtering, and mixing of water from other sources over the past 10 years brought that level down to only 2 µg/L in most locations.

Of course, smaller water systems may not be able to employ such methods to lower their arsenic concentrations. But those systems — with perhaps 1,000 to 5,000 users — should be allowed other options. Because only 0.1 percent of water entering a house is used for drinking, a utility could supply low-arsenic drinking water separately from the water used for such activities as washing. In my parents' house in a London suburb (in 1935), we had separate taps for drinking water and non-drinking water. Small systems could adopt such a structure, or could distribute bottled drinking water to customers.

Another option for those systems is a two-step regulatory system — a mandatory 50-µg/L standard and an advisory 10-µg/L standard for water systems with users who have active participation in the systems' decision-making. For those systems, all users would be informed of the calculated effects of arsenic exposure on health, and the costs of lowering arsenic concentrations in their water. They would then be able, through ordinary democratic procedures, to participate in the decision of whether to adopt the 10-µg/L standard for their system or to maintain the 50-µg/L standard.

Wells Among the strongest critics of the new standard are developers in the western states. Increasingly, they are dependent upon wells to supply water to their developments, instead of the surface waters that were almost universal in the past. Wells often contain arsenic and thus raise exposure problems that surface waters do not.

The U.S. Geological Survey (USGS) has indicated that it may be able to help drillers find aquifers that contain low levels of arsenic, at a cost that is quite inexpensive compared to the cost of removing arsenic from existing water supplies. That suggests that developers' fears about the cost of the new standard may be misplaced; the cost could be considerably lower than that proposed by the water industry and lower than that proposed by EPA.

CONSISTENCY

The cancer risk of arsenic in drinking water at a 500-µg/L lifetime exposure is approximately the same as the lifetime cancer risk of a heavy cigarette smoker. According to linear dose response, the risk at 50 µg/L is only 10 percent of the risk to smokers. Opponents of a further tightening of the allowable limit might suggest that the risk from arsenic at the 50-µg/L level is insignificant. But such an argument has never succeeded in public discussions of other agents and chemical pollutants.

Emerson once said that excessive consistency is the hobgoblin of small minds. Nonetheless, a regulatory agency such as EPA should have a very clear reason for any lack of consistency in its regulations involving acceptable risk. Unfortunately, over the 30 years of EPA's existence, observers have seen that clarity is not one of the agency's virtues.

For instance, EPA has strict regulations regarding concentrations of thrichloroethylene (TCE) in water supplies. If EPA wanted to set its allowable arsenic level at the same degree of risk as its allowable TCE level, then the agency would be trying to impose a .005-µg/L limit — an obviously unattainable goal. If the cost-benefit procedure used by EPA in its recent rulemaking on arsenic were to be applied to regulation of TCE or chromates, then TCE regulation would be far less severe than what it is today.

There would be a similar inconsistency with EPA's regulations concerning high-level nuclear waste, such as that which is to be stored at the Yucca Mountain facility. The Yucca Mountain regulations are intended to protect human health for as long as the waste poses a threat. But, unlike nuclear waste that eventually decays, arsenic remains carcinogenic forever. Arsenic rules that are consistent with the Yucca Mountain rules would have to protect human health forever, which means that most drinking water and farm fields that, at one time, were treated with arsenic would today be out of compliance. So, are EPA's regulations for Yucca Mountain excessively restrictive, or should the agency tighten its regulations concerning arsenic? Or is there some clear scientific reason for why arsenic risk should be considered more lightly than risk from nuclear waste?

What, then, do we make of the public opinions on acceptable risk that are implicit in such recent movies *A Civil Action* and *Erin Brokovich*? It seems to me that such movies, as representations of public opinion, cannot be ignored. Painful though it may be to revisit past decisions, the United States is ill-served if one does not learn from them. Of course it was not as expensive to regulate TCE as it will be to regulate arsenic, and even less expensive to continue to regulate TCE. Society may therefore wish to retain the existing TCE regulations, but that should be done after careful examination of the new perspective that, hopefully, regulators and the public will gain from the arsenic debate.

CONCLUSION

One of the important features of the 10-µg/L arsenic rule that EPA wants to implement is that it resulted from the first use of a cost-benefit analysis for a drinking water pollutant. In conducting that analysis, EPA deserves great praise.

The agency was unusually thorough in its study; regulators presented their proposal at scientific assemblies and other public meetings, and provoked discussion. EPA received over 1,000 public comments, and — although, as is the agency's bad habit, it never formally responded to or acknowledged the comments — it seems clear that many, if not all, of them were considered seriously.

Of course, critics of the new arsenic rule have offered thoughtful criticisms of how EPA carried out its analysis, and have offered alternate, logical procedures for cost-benefit calculation. It is of vital importance that the new EPA committees discuss such criticisms and alternative procedures. In doing so, committee members will become fully aware of the precedents that they are establishing for the future, and they will set those precedents with their eyes open. R

READINGS

- "Chronic Arsenic Poisoning: History, Study and Remediation" website, hosted by Harvard University's School of government. Found on the Web at: http://phys4.harvard.edu/~wilson/arsenic_project_main.html.
- "Discounting of Long Term Costs: What Would Future Generations Prefer Us to Do?" by A. Rabl. *Ecological Economics*, Vol. 17 (1996).
- "Evaluating Health Effects of Societal Decisions and Programs," by H. Raiffa, W. Schwartz, and M. Weinstein. In *Decision Making in the Environmental Protection Agency*, Vol. 2b. Washington, D.C.: National Academy of Sciences, 1977.
- "Lung and Kidney Cancer Mortality Associated with Arsenic in Drinking Water in Cordoba, Argentina," by C. Hopenhavyn-Rich et al. *International Journal of Epidemiology*, August 1998.
- "Marked Increase in Bladder and Lung Cancer Mortality in a Region of Northern Chile due to Arsenic in Drinking Water," by A. H. Smith et al. *American Journal of Epidemiology*, Vol. 147, No. 7 (April 1998).

COMMENTARY

Arsenic and Old Facts

By William A. Niskanen
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The Burnett-Hahn and Wilson analyses of the proposal to reduce the allowed concentration of arsenic in drinking water differ primarily on one issue: Is the dose-response relationship between arsenic concentrations and cancer sublinear (Burnett-Hahn) or linear (Wilson)? As an economist who has not read the underlying studies, I am not qualified to resolve that issue. Nor, I suspect, is anyone else.

ROY BOTTERELL/STONE

Local standard But the lack of a qualified analyst is irrelevant. The current arsenic controversy is a classic case for which no common national standard can be correct because all of the benefits of a given standard for arsenic accrue to those who drink water from a specific water system. In that case, there is every reason to respect the standard selected in each water system, based on the marginal cost of reducing the arsenic concentration specific to that system and the amount of insurance against health risks that the local community wants to buy.

Moreover, every household has the opportunity to choose a tighter standard than that chosen by the local water system. Because drinking water is usually only about one-tenth of one percent of total household water usage, the cost of a separate household drinking water control or of bottled water may be less than arsenic controls on all of the water supplied by the local water system.

In the absence of any external effects of the arsenic standard chosen by each local water system, the only national public good is succinct, accurate, and timely information about probable health effects of alternative local choices – a public good that is all too often in short supply. The Safe Drinking Water Act should be changed to permit the appropriate division of responsibility between the local community and the federal government.

Minor quibbles As for the preceding articles, I offer the following comments:

Burnett and Hahn, in a move that has become a reflex response by environmental economists, propose to allow trading of the rights to consume arsenic in drinking water. That presumably would lead a water system that faces a high marginal cost for meeting the arsenic standard to instead purchase allowances from another system that has a low marginal cost for reducing its arsenic concentration. What nonsense on stilts! Such rights trading makes sense when the environmental harm is a function of the aggregate emissions across jurisdictions, such as is probably the case with sulfur dioxide and may be the case with carbon dioxide. But such rights trading makes no sense when the threat to human health is specific to the level of arsenic concentration in each water system.

Richard Wilson, like many non-economists, is uneasy about discounting the benefits of future reductions in threats to health. I doubt, however, whether either he or the occasional critic of discounting would be indifferent among alternatives with the same costs and undiscounted benefits that accrue at widely different times. Early benefits trump later benefits of the same magnitude every time.

Wilson also makes a point that the proposed arsenic standard seems inconsistent with the much tighter standard for the Yucca Mountain nuclear waste facility. But a much tighter standard for Yucca Mountain may be appropriate if necessary to gain the approval of the local community, if the marginal cost of control is lower or the risks of underestimating the benefits of control are higher. Consistent standards are those that result from the same decision rule, even though they may have different levels of residual risk.

On the whole, I am pleased that the quality of the analyses of risk issues seems to be improving. Unfortunately, I remain pessimistic that the decisions of our national political authorities will have any relation to the best of those analyses. The current controversy over a national arsenic standard is only the most recent case in point. R