CONF-900802 - 11

CONF-900802--11

DE91 002000

RISK MANAGEMENT AT HAZARDOUS WASTE SITES

Curtis C. Travis
Carolyn B. Doty

DISCLAIMER

Office of Risk Analysis
Health and Safety Research Division
Oak Ridge National Laboratory*
Oak Riuge, Tennessee 37831

*Operated by Martin Marietta Energy Systems, Inc. under Contract No. DE-AC05-840R21400 with the U. S. Department of Energy.

The Superfund Amendments and Reauthorization Act of 1986 (SARA) provided the Environmental Protection Agency (EPA) with additional resources and direction for the identification, evaluation, and remediation of hazardous waste sites in the United States. SARA established more stringent requirements for the Superfund program, both in terms of the pace of the program and the types of remedial alternatives selected. The central requirement is that remedial alternatives be "protective of public health and the environment" and "significantly and permanently" reduce the toxicity, mobility, or volume of contaminants. The mandate also requires that potential risk be considered in the decision-making process. Legislation, however, has not provided easy solutions to the historical hazardous waste problem. Terms such as *protective*, *permanent*, and *potential risk* have not been clearly defined by either Congress or the EPA, and the program appears to suffer from a basic inconsistency between what society wants and what technology can provide.

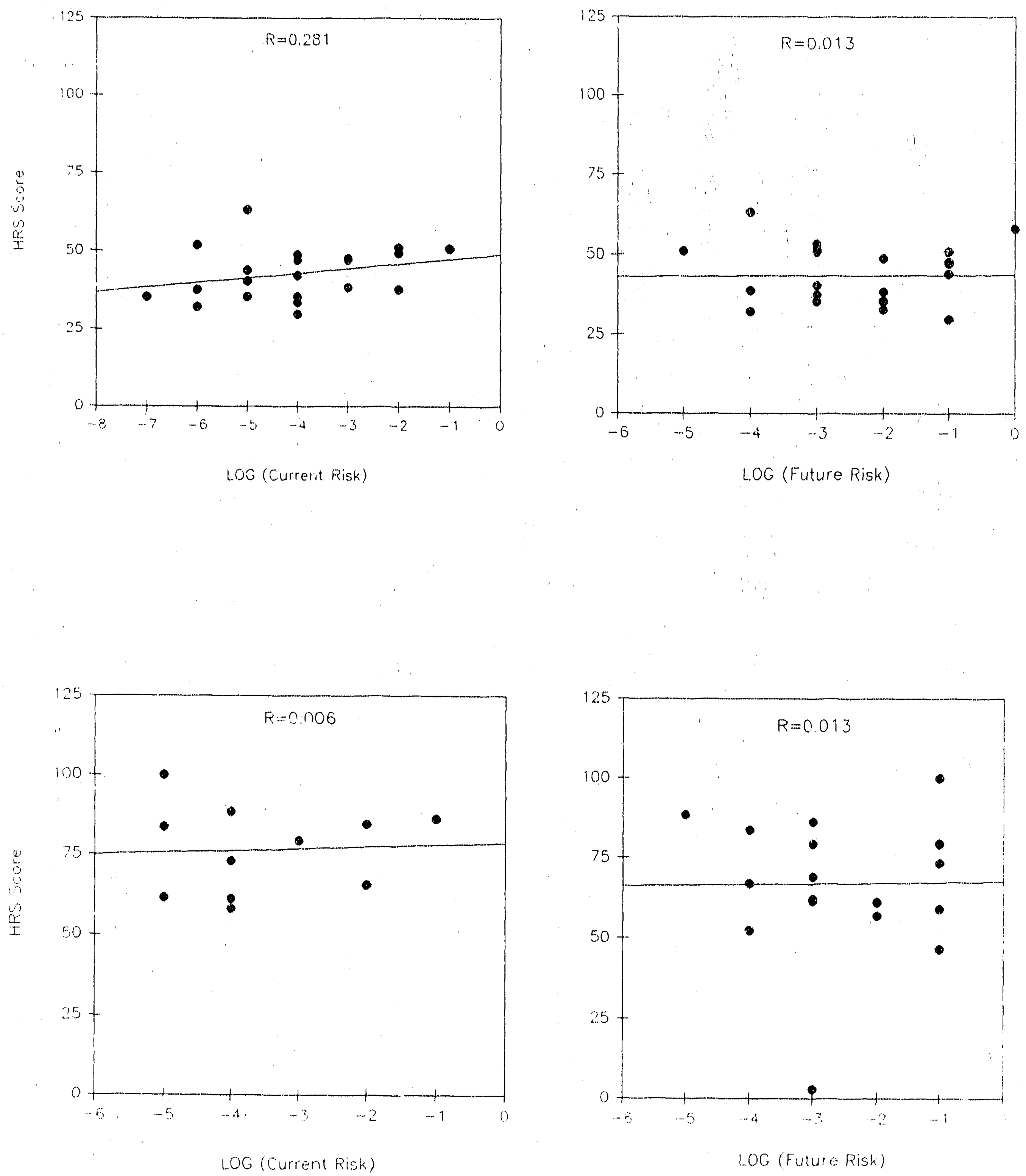
As an overall measure of Superfund program effectiveness, the degree of public health risk reduction achieved as a result of the program has been difficult to determine thus far. However, several indicators of effectiveness can be examined. Reducing public health risk involves not only defining risk, but it also involves using risk assessment as a priority-setting tool and defining risk reduction within the confines of the current state of technology and the resources available with which to address risk. Thus, our analysis of Records of Decision (RODs)[1,2] and subsequent analysis of remedial action implementation have centered on the these fundamental elements of the decision-making process. Our findings suggest that the current system is not effectively integrating risk reduction into the decision process. The Hazard Ranking has not proved to be an adequate screening tool for determining which sites should be placed on the NPL, and many decisions to remediate have been made at sites where no current exposure exists and potential risk is not well-defined. Remediation to health-based standards has been selected for almost all NPL sites without a systematic framework for using risk assessment as a priority-setting tool. At the same time, the majority of remedial alternatives have been selected without adequate support for rationales indicating their effectiveness in meeting health-based cleanup standards, even at sites which pose an urgent threat to human health.

Not only are incomplete or inadequate rationales for selection provided in the RODs, but some of the treatment remedies currently being implemented do not appear to be providing cost-effective solutions to the Superfund problem. Retrospective evaluations of the pump and treat remedy for contaminated groundwater indicate that aquifer restoration to health-based standards is not achievable within a reasonable time frame given the current state of technology. Moreover, few source treatment technologies other than incineration have been successfully implemented at Superfund sites thus far. This central weakness in the basic framework of the Superfund program has resulted in the spending of millions of dollars with little to show for it in the way of permanent remediation of hazardous waste sites.

SELECTION OF SITES FOR PLACEMENT ON THE NATIONAL PRIORITY LIST (NPL)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 mandated that EPA develop a list of the nation's worst hazardous waste sites based on relative risk. The Hazard Ranking System, the system by which sites are ranked and placed on the NPL, was developed in response to this mandate. To date, more than 1,200 sites have been placed on the NPL with estimated cleanup costs ranging from $32 billion to $80 billion.[3]

In an attempt to see if the proper sites have been placed on the NPL, we studied the correlation between HRS scores and actual risk levels at hazardous waste sites where risk levels have been estimated.[1,4] Our analysis indicates that no significant correlation exists between HRS scores and total baseline risk levels (Figure 1). Even less correlation exists between groundwater HRS scores and risk levels for groundwater. Many sites are placed on the NPL which may pose little or no risk to human health. Not only are they placed on the NPL, but most are remediated. Conversely, one may assume that there are sites with significant health and environmental risk that are not on the NPL.



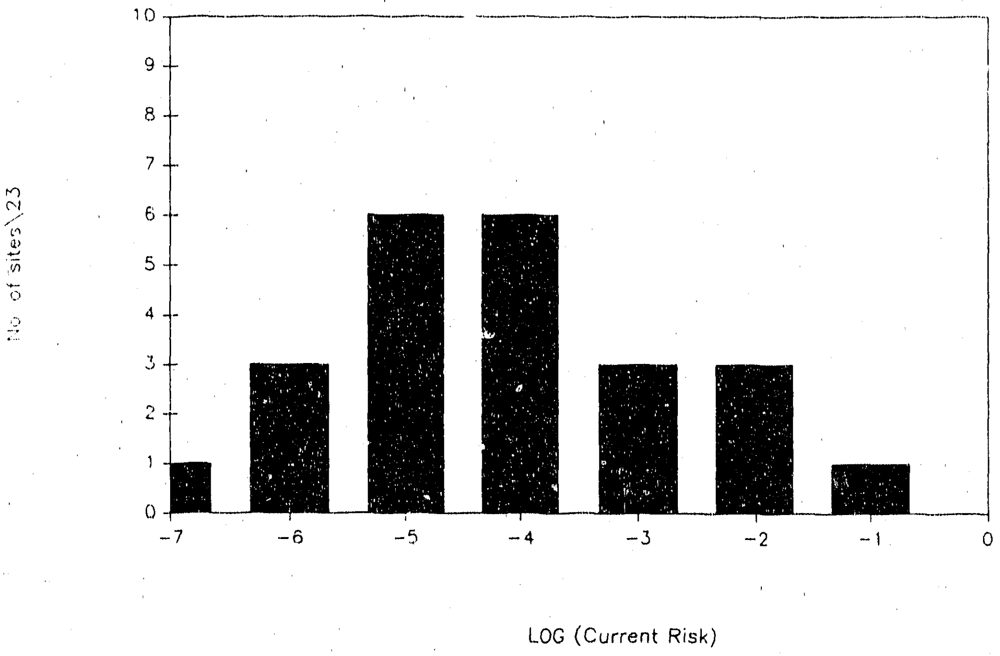
R=0.281
HRS Score
LOG (Current Risk)
R=0.013
LOG (Future Risk)
R=0.006
HRS Score
LOG (Current Risk)
R=0.013
LOG (Future Risk)

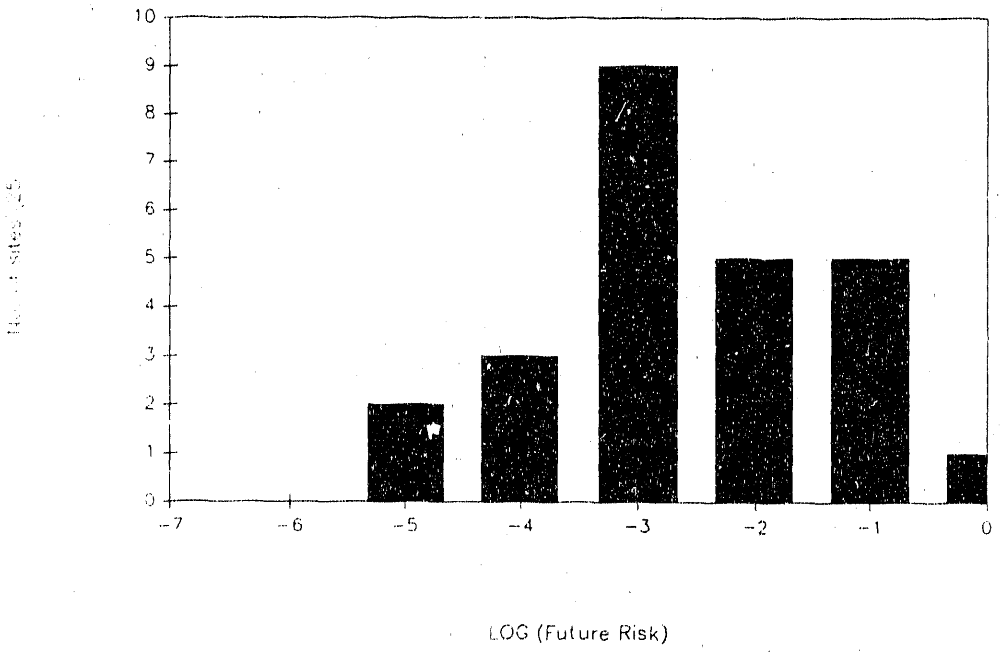
RISK ASSESSMENT AND THE DECISION PROCESS

Although the Superfund remedial action decision process is a complex process that involves a variety of technical, political, and economic considerations, the primary goal of site remediation is the protection of public health. Therefore, assessment of the presence and magnitude of public health risks under baseline (no-action) conditions is a key element of the decision-making process. Travis and Doty found that risk assessment is indeed a central element of the Superfund decision process.[1,2] A quantitative baseline risk assessment had been conducted for at least one medium for 72 percent of sites where a remediation decision had been made. Thus, the central question is not *whether* risk assessment is being used at Superfund sites, but *how* it is being used.

Risk assessment is the cornerstone of EPA's current decision-making process. However, it plays a limited role in defining cleanup priorities. Although only 11.5 percent of sites on the NPL involve actual or potential current human exposure,[5] eighty-eight percent of all sites reviewed by Doty and Travis[1,2] were remediated. Seventy percent of all these sites have current risk levels in the 10^{-4} to 10^{-7} range, the same range that the EPA targets as acceptable after remediation (Figure 2). Although estimates of future risks are often high, these estimates are based on hypothetical exposure scenarios. In addition, little correlation exists between risk levels and decisions to remediate. All sites with contaminated soils remaining on-site were remediated, regardless of risk levels or the likelihood of migration to groundwater. Risk ranges for contaminated groundwater were essentially identical for sites that were remediated and those that were not. Remediation decisions appear to be driven more by cost, EPA policy, compliance with state and federal environmental regulations, and professional judgment than by current or future risk levels.

Many uncertainties inherent in risk assessment methodology may affect the precision of risk calculations. The key issue in terms of prioritization, however, is not whether contamination exists and at what level, but which pathways of exposure are currently complete and which pathways are likely to become complete in the future. The answers to these questions do not come easily and require extensive information that has not been available to the risk assessor in the past. Since a


No of sites\23
10
9
8
7
6
5
4
3
2
1
0
-7
-6
-5
-4
-3
-2
-1
0
LOG (Current Risk)


10
9
8
7
6
5
4
3
2
1
0
-7
-6
-5
-4
-3
-2
-1
0
LOG (Future Risk)

risk assessment reflects risks at a site only to the degree that the assumptions used in the risk calculations reflect actual current or future site conditions, deficiencies in demographic data and other information regarding the likelihood of future exposure can be just as significant as can the lack of quantitative toxicological data. Approximately three-fourths of the sites on the NPL fall in the gray area of being potential public health concerns because of the lack of data needed to determine that the site is not a concern.[5]

RISK REDUCTION AND REMEDIAL ALTERNATIVE SELECTION

The lack of assessment of the degree of risk reduction associated with remedial alternatives constitutes a major weakness in the present decision-making process. Of the 50 sites reviewed by Doty and Travis, risk reduction was evaluated quantitatively for only 12 percent of the sites.[1,2] Thus, risk reduction played a limited role in the evaluation of remedial alternatives. Since the degree of risk reduction has not been determined, the cost-effectiveness of the remedies selected is not well-defined.

The selection of effective remedial alternatives is essential to the remediation process. However, remedial action decisions are currently made under a cloud of uncertainty regarding effectiveness. Sixty-eight percent of the remedies selected in Superfund decisions reviewed by Doty and Travis required additional studies to confirm the extent of contamination, the effectiveness of the technology, or its applicability under the site conditions.[1,2] Thus, despite the exorbitant costs of remediating sites currently on the NPL, remediation is not guaranteed at the majority of sites.

At some sites, the need for immediate action outweighs the necessity of resolving all uncertainties associated with a remedial alternative prior to selection. However, the majority of sites do not warrant such a degree of urgency. A fundamental need for Superfund is an expanded program to establish the effectiveness of remediation technologies and identify site-specific factors that influence effectiveness.

Another key factor in the attainment of remedial action goals is the selection of permanent remedies. Although SARA emphasizes the selection of permanent remedial alternatives, only 19 percent of the source remedies reviewed by Doty and Travis afford permanence to the maximum extent practicable.[1,2] Thirty-five percent of the remedies selected provide only a moderate (questionable) degree of permanence because the effectiveness of one or more components of the remedy has not been determined. Forty-five percent of the remedies provide minimal permanence because they provide for containment only, provide only partial treatment, or utilize a technology of questionable effectiveness and permanence. Thus, achieving long-term risk reduction is unlikely unless more attention is directed toward the development and selection of effective and permanent remedial alternatives.

AQUIFER RESTORATION

The prevailing view among environmentalists and Superfund managers is that aquifers at Superfund sites can be restored through groundwater pumping. In fact, approximately 68 percent of Superfund RODs select groundwater pumping and treating as the final remedy to achieve aquifer restoration.[1,2] In the past, Superfund managers have displayed so much certainty regarding the effectiveness of pumping that most RODs simply state that pumping will continue until drinking water standards are reached, without presenting any analysis demonstrating that these standards are indeed achievable.

The simple fact is: contaminated aquifers cannot be restored through pumping and treating. Two lines of evidence support this assertion. First, it is supported by extensive experience predicting the effectiveness of groundwater pumping using groundwater transport models. Leading groundwater scientists have predicted that continuous pumping for as long as 100 to 200 years may be needed in order to lower concentrations by a factor of 100, assuming the ideal conditions of a totally dissolved contamination in a homogeneous aquifer.[6-8] Aquifer restoration is less reliable at sites involving non-aqueous phase liquids (NAPLs) that either float on top of the water table or sink to the bottom of the aquifer. At best, even if eventual restoration is conceivable, it is impossible to predict how long pumping and treating will take to restore an aquifer.[6] In spite of this observation, aquifer restoration is the remedial objective at approximately 93 percent of the sites which are known to involve NAPLs.[9] The director of EPA's groundwater research laboratory in Ada, Oklahoma has pointed out that restoration could take thousands of years for water-insoluble constituents such as jet fuel.[7] When large pools of dense NAPLs are present at the bottom of an aquifer, meeting drinking water standards is unachievable at any cost.[10]

Further proof of the ineffectiveness of pumping and treating for aquifer restoration comes from direct experience in pumping contaminated aquifers over the past 10 years. A recent EPA study involving 19 sites where pumping and treating had been ongoing for up to 10 years concluded that although significant mass removal of contaminants had been achieved, there had been little success in reducing concentrations to the target levels.[9] The typical experience is an initial drop in concentrations by a factor of two to ten, followed by a leveling out with no further decline. To exacerbate the problem, once pumps are turned off, concentrations rise again.

Take, for example, the IBM Dayton hazardous waste site in New Jersey.[9] Groundwater at the site was contaminated with approximately 400 gallons of VOCs, primarily 1,1,1-trichloroethane (TCA) and tetrachloroethylene (PCE), with maximum groundwater concentrations ranging from 9,590 ppb for TCA to 6,132 ppb for PCE. Pumping with an average onsite extraction rate of 330 gpm between 1978 and 1984 lowered VOC concentrations to below 100 ppb. However, subsequent to shutdown of the operation in 1984, PCE concentrations rose to 12,558 ppb in 1988. Pumping was resumed in 1989, but the remedial objective was changed from restoration to containment. Thus, despite extensive groundwater pumping, this site is no closer to remediation than it was twelve years ago.

DISCUSSION

Thus far, the challenge of defining terms and setting realistic and well-defined goals for the Superfund program has not been met, and money is being spent with no guarantee that the program is providing adequate protection of public health and the environment. Inadequacies in the decisions we reviewed consist of both the lack of clear priorities in deciding which sites to remediate and to what degree a site should be remediated, and the lack of selection of remedial alternatives which afford effectiveness and permanence. As a result, the majority of resources are being directed toward the remediation of many low-risk sites using remedial alternatives of questionable effectiveness.

The present decision-making process reflects an ambiguous approach to addressing risk. Many sites are being cleaned up where no actual human exposure exists and potential public health risk is unlikely. Thus, minimization of the extent of environmental contamination per se seems to play a larger role in the selection of remedial alternatives than does protection of human health. The degree of risk reduction associated with the remedial alternatives considered is rarely evaluated quantitatively, and thus, cost-effectiveness discussions are undermined. Because the remedial alternatives selected often lack effectiveness and permanence, protectiveness of public health and the environment cannot be expected, even in cases where current human exposure to contamination does exist.

RECOMMENDATIONS

To meet the challenge of effectively remediating Superfund sites, we recommend that EPA make a serious committment to its renewed "worst sites first" policy, balancing a clear definition of worst sites with attainable expectations for addressing these sites. Therefore, Superfund policy-making should focus on the fundamental areas of setting priorities in the decision-making process and developing and selecting effective and permanent remedial alternatives.

Priorities in the Decision-Making Process

Goals and priorities need to be more clearly defined in the Superfund decision-making process. More emphasis needs to be placed on: (1) immediately identifying and remediating sites which pose a clear and present risk to human health; (2) defining the role of future risk based on hypothetical exposure in the decision-making process; (3) making the extensiveness and effectiveness of remediation correspond with the degree of current and/or future risk; and (4) establishing realistic goals given the state of technology, acknowledging that aquifer restoration is currently not technically feasible and recognizing that attempting to restore the environment to a pristine state is not always necessary.

Effectiveness and Permanence of Remedies

More attention needs to be directed toward determining the effectiveness of remedial alternatives selected. First, quantitative assessments of the degree of risk reduction associated with remedial alternatives should be conducted. Second, there is an urgent need for EPA to accelerate efforts in the areas of both field research and theoretical studies to demonstrate the effectiveness of classes of treatment alternatives under various field conditions. Environmental variables (i.e., soil type, pH, microbial content) should be identified that can be used to predict the effectiveness of a remedial alternative under a given set of environmental conditions. Without such information, EPA will continue to select alternatives for which effectiveness is uncertain.

More emphasis needs to be placed on the selection of permanent remedies where implementation of such remedies is technically feasible, particularly for source control. Since restoring groundwater to a condition compatible with health-based standards is difficult, if not impossible, remedial efforts should focus on developing and implementing permanent cost-effective source remedies.

REFERENCES

1. Doty, C. B. and C. C. Travis. "The Superfund Remedial Action Decision Process: A Review of 50 Records of Decision," *Journal of the Air and Waste Management Association*, 39(12): 1535-1543.

2. Travis, C. C. and C. B. Doty. "Superfund: A Program Without Priorities," *Environ. Sci. Technol.* 23(11):1333-1334.

3. "Impact Analysis of RCRA Corrective Action and CERCLA Remediation Programs," Chemical Manufacturers Association (1988).

4. "National Priorities List: Final and Proposed Sites, Route Scores," Environmental Protection Agency (February 1990).

5. Susten, A. Agency for Toxic Substances and Disease Registry, personal communication (1990).

6. Mackay, D. M. and J.A. Cherry. *Environ. Sci. Technol.* (23):630-636 (1989).

7. Hall, C. W. "Practical Limits to Pump and Treat Technology for Aquifer Remediation" in *Groundwater Quality Protection Pre-Conference Workshop Proceedings* (Water Pollution Control Federation, 1988).

8. Mackay, D. M. "Characterization of the Distribution and Behavior of Contaminants in the Subsurface," in *Proceedings of the National Research Council Water Science and Technology Board Colloquium* (1989).

9. "Evaluation of Groundwater Extraction Remedies," Office of Solid Waste and Emergency Response, EPA/504/0289/054 (1989).

10. Freeze, R. A. and J. A. Cherry. *Groundwater 27*(4):458-464 (1989).

List of Figure Captions

Figure 1. Correlation between baseline risks and HRS scores. The two upper graphs show the correlation between total baseline risk and HRS scores. The correlation coefficients *r* are shown. The two lower graphs show the correlation between baseline groundwater risk levels and HRS scores for the groundwater pathway.

Figure 2. Total baseline cancer risks for decisions to remediate.

END

DATE FILMED

12 / 03 / 90