Chapter 1

Summary and Introduction

Contents

List of Tables

List of Figures

Chapter 1

Summary and Introduction

OVERVIEW

The Federal Superfund[1] program for cleaning up toxic waste sites has made progress, and much can be learned from its initial efforts to improve protection of public health and the environment.

The Environmental Protection Agency's (EPA) low estimate of Superfund costs can be traced to a lack of detailed planning for the program and optimism about both the number of toxic waste sites that will require cleanup and the effectiveness of cleanup technologies. *While EPA estimates that about* 2,000 *sites will reach the National Priorities List [NPL), OTA estimates that* 10,000 *sites (or more) may require cleanup by Super fund.* With Superfund's existing resources, it is not technically or economically possible to permanently clean up even 2,000 sites in less than several decades. OTA defines permanent cleanups to be those where the likelihood of recurring problems with the same site or wastes have been minimized through the use of treatment rather than containment technologies,

Only 50 percent of the 538 sites now on the NPL are receiving remedial cleanup attention, even though about $1 billion (two-thirds of the initial 5-year program's funding) have been committed. Initial actions and cleanups now emphasize the removal of wastes to land disposal facilities, which themselves may become Superfund sites, or wastes are left on the site. Current "remedial cleanups" tend to be impermanent. *Some sites get worse, and repeated costs are almost inevitable. Environmentally, risks are often transferred from one community to another, and to future generations,*

Underestimating national cleanup needs could result in an environmental crisis years or decades from now. With many more NPL sites, repeated responses, and uncertainty about private cleanups and contributions, cleanup needs could outstrip financial, personnel, and technological resources. Environmental damage could escalate. The issue now is not so much about whether or not to have a continued, expanded Superfund program as it is to choose to continue with the current approach or, on the basis of what we have learned so far, to restructure the program,

OTA finds that a two-part strategy (see below) offers cost and time advantages over the current program with its lack of attention to long-term factors. Even so, costs to Superfund could easily be $100 billion—out of total costs to the Nation of several hundred billion dollars, and it could take 50 years to clean 10,000 sites. The two parts of the strategy would overlap in time, but differ in focus and priorities. *This two-part strategy could be advantageous regardless of the size of the Superfund program.*

(I) In the near term, for perhaps up to 15 years, the strategy would focus on: a) early identification and assessment of potential NPL sites, b) initial response to *reduce near-term threats at all NPL sites and prevent sites from getting worse, c)* permanent remedial cleanups for some especially threatening sites, and d) developing institutional capabilities for a long-term program. A substantially larger Superfund program would be needed to carry out these efforts. Initial responses that accomplish the most significant and cost-effective reduction of risks and prevent sites from getting worse might cost about $1 million per site for

[1]This study is limited to one use of the Superfund program established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): the cleanup of uncontrolled hazardous waste sites. However, the Superfund program is very broad and other threats from releases of hazardous *substances* are managed, such as leaking underground storage tanks, spills from transportation accidents, and groundwater contaminated from pesticide use. The demands on Superfund from these uses in the future are uncertain but may also increase, This study does not consider federally owned uncontrolled sites, which are recognized to pose a large problem, but which do not qualify for cleanup under Superfund.

most sites. This is three times the current cost of immediate removal actions and about 10 percent of currently projected remedial cleanup costs. Case studies by OTA and others reveal that both immediate removals and remedial cleanups are ineffective for their intended purposes, Under the two-part strategy, initial responses would emphasize covering sites and temporarily storing wastes and contaminated materials to reduce groundwater contamination and, where technically and economically feasible, excavating wastes to minimize releases into the environment.

(II) Over the longer term, the strategy would call for more extensive site studies and focus on *permanent cleanups,* when they are technically feasible, at all sites that pose significant threats to human health **and** the environment (unless privately or State-funded cleanups offering comparable protection have taken place), These cleanups would draw on the institution building that occurred during the first phase. Spending large sums before specific cleanup goals are set and before permanent cleanup technologies are available leads to a false sense of security, a potential for inconsistent cleanups nationwide, and makes little environmental or economic sense.

Federal support could contribute in five areas. Such efforts take time, but cost little relative to Superfund's total costs and could result in more environmental protection at lower costs. The five areas are:

1. *Intensify Federal efforts to obtain more information on health and environmental effects and develop specific national cleanup goals,* Without this effort, selecting technologies, estimating costs, and evaluating public and private cleanups will be difficult and contentious. Cleanup goals could employ site classification based on locally decided site use, in combination with other information such as risk assessment, cost-benefit analysis, and existing environmental standards.
2. *Provide substantially more support for developing and demonstrating innovative, permanent cleanup technologies for a variety of problems,* The immediate costs for cleanups based on waste containment and redisposal omit much: monitoring, operation and maintenance, and the costs of future cleanups, especially for groundwater. Also, they are highly uncertain and can add greatly to total costs. For some geological settings, like the Stringfellow site in California, containment does not work. Permanent remedies, which destroy, detoxify, or otherwise treat wastes will be necessary to any cost-effective, long-term Superfund program; many innovative approaches exist, but they face substantial barriers to demonstration and use, such as the absence of protocols to evaluate their effectiveness.
3. *Provide increased support for EPA and perhaps the States so they can improve technical oversight of contractors and thus ensure quality cleanups,*
4. *Provide Federal support for technical training programs,* An expanded national cleanup effort could increase the need for certain technical specialists fivefold by 1995; shortages of experienced technical personnel such as hydrogeologists have already been noticed.
5. *Improve the Superfund program, and public confidence in it, by supporting public participation in decisionmaking about initial responses and remedial cleanups and providing technical assistance to communities.* Improved public participation could address the intrinsic tension between the desires of communities to obtain fast, effective, and complete cleanups at their sites and the limitations and goals of a national program.

OTA has considered only one use of Superfund, the remedial cleanup of hazardous waste sites that are "uncontrolled" because actual or potential releases of hazardous substances into the environment must be managed. A number of other applications exist and could increase in the future (e. g., leaking underground storage tanks, pesticide contamination areas, and transportation accidents). There is little doubt about the need to clean up sites that now get placed on the NPL, but additional sites are likely to require clean up. OTA's estimate of additional waste sites include: 5,000 sites from the more than 600,000 open and closed solid waste facilities, such as sanitary and municipal landfills, which can release toxic substances to groundwater; 2,000 from an improved site identification and selection process; and 1,000 from hazardous waste management facilities operating with ineffective groundwater protection standards.

A much larger Superfund program would likely mean that more reliance would have to be placed on general tax revenues or some other broadly based tax. Along with continued use of the tax on chemical and petroleum feedstocks, a tax on hazardous wastes could raise significant sums, but this latter tax would generate significant revenue only in the near-term, if less hazardous waste is generated over time. If such "waste-end" taxes, already adopted by 20 States, were made simple to administer, they would aid in reducing the generation of hazardous waste and the use of land disposal and, hence, the creation of still more Superfund sites.

Finally, OTA has stressed estimating future national needs, without making specific assumptions about non-Federal spending. Other research has assumed significant cost recovery of Superfund expenditures through enforcement actions and a fairly high level of privately and State-funded cleanups. Such assumptions often are not made clear, tend to be quite optimistic, and lead to "adjusted" costs for Superfund that could prove to be substantially low. Cost recovery to date has amounted to about 1 percent of Superfund spending, but EPA assumes cost recoveries of 47 percent for removals and 30 percent for remedial actions. To date, about $300 million has been committed by responsible parties for cleanups, an amount commensurate to what EPA has spent. EPA assumes that 40 to 60 percent of sites will be cleaned by responsible parties. Current obstacles to private cleanups, such as uncertain future liabilities, could discourage private spending. Continued, substantial spending by the private sector on cleanups is desirable and incentives (or the removal of barriers) may be necessary. However, clear cleanup goals and technical oversight are still essential to assure that effective cleanups are performed. Furthermore, it is not necessarily correct to assume that current policies on required matching funds from States will remain, as significant concerns exist about the willingness of some States to provide these funds.

BACKGROUND

Proved releases of hazardous substances have occurred from uncontrolled sites throughout the Nation. Groundwater and surface waters have been contaminated, drinking water supplies have been lost, and people have been evacuated or, in some cases, permanently relocated. There have been some fires and explosions. Most sites must be strictly off limits to unprotected people. Across the Nation, from Love Canal in New York, to Times Beach in Missouri, to the Stringfellow Acid Pits in California, people are worried about acute and chronic threats to their health, loss of natural resources, and sharp declines in the value of their homes and property,

After Federal legislation was enacted to manage newly generated hazardous wastes, it became apparent that a separate Federal program was needed to tackle the cleanup of uncontrolled waste sites. The Resource Conservation and Recovery Act (RCRA) of 1976 was followed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980. CERCLA established the Superfund program to handle emergencies at uncontrolled sites, to clean up the sites, and to deal with several other related problems.

At the very beginning of Superfund, the full scope of the uncontrolled site problem was unclear. Several releases of hazardous substances into the environment had been documented, and limited and often anecdotal evidence of adverse health and environmental impacts had been gathered. But unambiguous, comprehensive, and scientific understanding of the effects, particularly of the long-term effects, of such releases was lacking. For these reasons, Congress limited the Superfund program. The Environmental Protection Agency was directed to establish an NPL of at least 400 sites which needed remedial cleanup;[2] considerable flexibility was allowed to respond to emergencies. In addition, Congress directed the Department of Health and Human Services to gather data on health impacts from uncontrolled sites. Although in 1980 and earlier some people thought the evidence showed that a very large program would be necessary, many uncertainties and the new, highly technical challenge of performing large numbers of cleanups, caused Congress to limit the program to $1.6 billion over 5 years.

Now, as we approach the end of the initial Superfund program, Congress and the Nation have the benefit of more information about uncontrolled sites and can learn much from the early experiences of the program. This study concentrates on what can be learned from the results of the initial program; but it must be stressed that the Superfund program has made progress, especially considering that the program was created as a fast public policy response to a newly recognized and highly complex, technical, and diverse set of problems.

Much uncertainty about health and environmental effects remains. But EPA and the States have obtained more information about the number and kinds of uncontrolled sites, and they have studied the nature of releases from the sites. Thus, EPA has expanded the NPL to 538 sites, has proposed several hundred more, and has estimated an eventual NPL of some 2,000 sites.

Responses to emergencies, such as transportation accidents, have been swift and effective in dealing with immediate threats. However, although responses at many sites have been limited, they usually consist of moving the waste to land disposal sites (which themselves may become Superfund candidates] or leaving the waste in the ground. Sites that pose threats only to the environment have received little attention. In a number of cases, even expensive "cleanups" quickly proved to be ineffective because hazardous substances continued to be released. The public has started to demand permanently effective cleanups; that is, cleanups which minimize the likelihood of future actions for the same sites or wastes. This usually means treatment of wastes and contaminated materials. But little progress has been made toward permanent cleanups, particularly for the expensive, difficult, new, and uncertain task of cleaning up contaminated groundwater. Moreover, detailed goals for permanent cleanups remain unclear, and without them it is difficult to select cost-effective cleanup technologies and evaluate their effectiveness, Finally, how much private parties and the States can or will contribute has not been settled. At first, it was generally thought that Superfund would deal only with the Nation's worst sites, especially those without identifiable responsible parties. Now, however, some believe that Superfund must move beyond this early limitation to address many more sites if national environmental protection goals are to be met expeditiously,

Congress faces a number of complex issues and policy trade-offs in its debate on the new Superfund program. Evidence on the number of sites and the extent of pollution is clearer, but much of the uncertainty about health and environmental effects remains unresolved. How should risk assessment techniques be used? Can cleanup goals be established more quickly? Moreover, a multibillion dollar pro-

[2] To qualify for remedial cleanup, a site must be placed on the NPL. EPA's Hazard Ranking System is used to obtain a numerical rating for sites; currently sites receiving a score of 28.5 or above qualify, plus each State may designate one priority site for inclusion. However, non-NPL sites may receive emergency attention and some limited, low-cost initial response.

gram raises questions about impacts on the Federal budget and the national economy, Experts disagree on how much money Superfund needs and have different opinions on how the money should be raised. Deciding how many sites need cleanup, how to clean them up, how much money to make available, and other policy judgments will determine how long the national cleanup program will last. A consensus has not yet emerged on many issues, including how long the public is willing to wait for permanent cleanup.

Lastly, performance of the Superfund program to date raises questions about institutional capabilities for an expanded program. How should Superfund operate, in terms of decisions regarding what sites get selected and acted upon, and in what order? Many people viewed the Superfund as lasting 5 or 10 years. Therefore, relatively little emphasis has been placed on work important for a long-term program, such as research, development, and demonstration of innovative, permanent cleanup technologies, and building up an adequate supply of technical personnel.

The principal goals of this study are: 1) to understand future Superfund needs and how permanent cleanups can be accomplished in a cost-effective manner for diverse types of sites, 2) to describe the interactions among the components of the complex Superfund system, and 3) to analyze the consequences of pursuing different strategies for implementing the program. A number of policy options are presented for congressional consideration.

THE KEY POLICY OPTION: CONSIDERING A NEW STRATEGY FOR THE SYSTEM

The initial Superfund program was viewed as temporary and was assembled quickly to deal with a technically complex and unique environmental threat defined in a preliminary way, Its strategy was oriented to taking limited responses at the *worst* sites, to addressing, for the most part, *immediate* threats to human health, and to gathering information on the extent of the national problem and its solution.

In identifying the following key policy option for congressional consideration, OTA recognizes that *as an initial Federal effort the Superfund program has been effective in limited ways*. To be considered now is the evolutionary development, restructuring, and improvement of the Superfund program. The opportunity is to move from a program that generally considered immediately threatening sites on a case-by-case basis to a comprehensive approach for effective control of all NPL sites, whether 2,000, 5,000, 10,000, or more. This reappraisal] of the program is possible because of the experiences, both positive and negative, with the initial program and because of recent data on the magnitude of the national uncontrolled site problem and information about the potential solutions, In order to devise a more cost-effective risk management strategy, it is useful to: 1) recognize how large the uncontrolled site problem is nationally, and 2] evaluate the long-term economic and environmental *performance* of the program rather than just the *numbers* of actions taken.

If OTA is correct in its assessment of future cleanup needs, then *it is technically and economically impossible to permanently clean up all uncontrolled waste sites in the near term*, But how can the Superfund program equitably address public demands for an effective, timely, national cleanup program when there are constraints involving budget, technology, and technical personnel? OTA has analyzed the long-term aspects of different strategies for implementing Superfund. This has been done by using a systems analysis of major interrelated variables of the program to examine how they affect certain outcomes such as program cost and duration.

The complexity of the Superfund system confronts policy makers with difficult decisions and trade-offs. For example, yielding to pressures to increase and speed cleanup actions, both by Superfund and private parties, can be counterproductive if such actions are impermanent and have a high probability of leading to substantial future costs. But perhaps the most difficult issue is the choice of either staying with the basic structure of the current program (on the assumption that it will improve substantially in response to lessons learned from early experiences), or restructuring the program to achieve greater environmental protection and cost effectiveness. OTA's analysis has found that if a new strategy is to be considered, the following two-part strategy appears advantageous.

A Superfund program that tackles a very large number of sites over several decades could be based on two parts that overlap to some degree in time, but differ in their focus and priorities.

Part I: In the near term, for perhaps up to 15 years, the strategy would focus on: a) early identification and assessment of potential NPL sites, b) initial responses to reduce near-term threats at all NPL sites and prevent sites from getting worse, c) permanent remedial cleanups for some especially threatening sites, and d) developing institutional capabilities for a long-term program.

A substantially larger Superfund program would be needed to carry out these efforts. Initial responses to accomplish the most cost-effective and significant reduction of risks and to prevent sites from getting worse might cost about $1 million for most sites. This is three times the current cost of immediate removal actions and about 10 percent of currently projected remedial cleanup costs. Case studies by OTA and others reveal that both immediate removals and remedial cleanups are ineffective for their intended purposes. Under the two-part strategy, initial responses would emphasize covering sites and temporarily storing wastes and contaminated materials to reduce groundwater contamination and, where technically and economically feasible, excavating wastes to minimize releases into the environment.

Part II: Over the longer term, the strategy would call for more extensive site studies and focus on permanent cleanups, when they are technically feasible, at all sites that pose significant threats to human health and the environment (unless privately or State-funded cleanups offering comparable protection have taken place). These cleanups would draw on the institution building that occurred during the first phase. Spending large sums before specific cleanup goals are set and before permanent cleanup technologies are available leads to a false sense of security, a potential for inconsistent cleanups nationwide, and makes little environmental or economic sense.

Under the current program, cleanups have tended to be both costly and impermanent, and thus likely to lead to substantial future spending for the same sites or wastes. However, in some cases the ad hoc nature of the current program has resulted in use of the two-part strategy, such as cases where large amounts of contaminated soil have been removed for temporary storage. Moreover, cleanups have not progressed rapidly, and many sites have received little attention, although the pace is picking up. For example, 30 percent of the current 538 NPL sites are receiving some form of cleanup attention.

Having few permanent cleanups in the first part of the two-part strategy makes sense for several basic reasons, and it does not represent a slowdown in cleanups which are as thorough and permanent as possible for critical sites. First, it is both technically and economically impossible to permanently clean up all sites—even for an NPL of 2,000 sites—in the near term, certainly not within 20 years. Cost-effective permanent cleanup technologies have not been developed for some problems, particularly for the extremely difficult (and possibly intransigent) problem of decontaminating entire aquifers. It will take time to demonstrate the effectiveness and costs for innovative technologies. There is also too little information on most sites to decide about permanent cleanup, particularly when there are no detailed national cleanup goals. Furthermore, there are not enough people with experience in this area to implement a large permanent cleanup effort.

In the two-part strategy, initial responses would not be designed for long-term effectiveness; they would probably be impermanent and, thus, in almost all cases permanent cleanups would have to follow. Their purpose is to quickly and *sharply* reduce exposure to hazardous substances at NPL sites without simply transferring the threat somewhere else. Initial responses can be thought of as a subset of the interim, impermanent approaches now being used and described as "cleanups. " The public, however, must be assured that initial responses can be environmentally effective both to deal with immediate risks and the critical need to stop sites from getting worse. When there are continuing releases of hazardous substances into the air, land, and water, the difficulty and costs of cleanup increase drastically. Both in terms of environmental protection and economics, the most important thing to do is to quickly reduce risk once a site has been found to present significant hazards. It is quite possible to know that a site poses significant risk even though it is not possible to know *precisely* what the risk is, how to eliminate it, or what constitutes an eventual safe level of permanent cleanup. For initial responses it is necessary to think not solely in terms of "cleanup," but also in terms of isolation, stabilization, and recontrol of the site.

Relatively low-cost initial responses could include pumping to contain plumes of contamination in aquifers, covers to keep out water, excavation of buried wastes or removal of wastes from surface impoundments for above ground *temporary* storage, and environmental monitoring. However, in contrast to current immediate removals and interim ''cleanups, ' wastes would not be moved to operating land disposal sites and reliance on the use of underground material barriers to prevent migration of wastes offsite would be limited to special conditions. Substantial long-term economic benefits would result from avoiding costly "cleanups" based on containment and land disposal, which, despite their high initial expense, also require major future spending.

In contrast to the present program's use of immediate removal actions, which do not necessarily include actual removal of materials from the site, the initial responses defined here place great emphasis on reducing present and future exposures to hazardous substances under the assumption that no further action may take place for some years. For example, if the site is exposed to water intrusion, partially draining or building berms around a surface impoundment containing liquid waste is unlikely to be effective because of the potential for repeated overflows. Nor will removing some surface waste and contaminated soil be effective at a landfill exposed to rain if other contaminants can reach groundwater. Waste removal and excavation, temporary storage, and surface capping can be more effective. As with the current program, there will be sites where it will be necessary to take actions such as supplying alternate water and relocating residents, rather than or in addition to tackling the site itself.

In examining the costs of a variety of technical actions, OTA finds that effective initial responses might average about $1 million for most sites; at some sites where there is extensive groundwater problems initial responses would cost substantially more. The current program spends an average of about $300,000 for immediate removals and estimates about $10 million for remedial cleanups, neither of which meets their intended purpose very well (i. e., sites often get worse, exposures may continue, and problems often persist). In other words, by spending more money initially it is possible to receive more benefits per unit cost. This is consistent with the fact that in addressing environmental problems, substantial benefits are generally achieved with the first response although more work may have to be done to reach the ultimate or permanent solution.

In the near term, say 5 years, the two-part strategy would result in a Superfund program substantially larger than the present one. The two-part strategy would lead to a different distribution and type of spending, not to decreased or level spending. While spending under the two-part strategy would be focused, in large part, on taking many initial responses, there would also be spending for expensive permanent cleanups at some high priority sites, and (as discussed in chapter 2) significant spending for several efforts aimed at strengthening institutional capabilities (e.g., expanding the information base for establishing cleanup goals, development and demonstration of innovative cleanup technologies, training programs for critical technical specialists, and increased funding for EPA and States to expand technical oversight). With the two-part strategy, much more money is spent on efforts to ensure that future spending on cleanups produces cost-effective results. If Superfund is a short-term program, such investments are not likely to be made. The current program has not addressed these kinds of investments.

Furthermore, if the current program were simply expanded, many expensive and time-consuming Remedial Investigation/Feasibility Studies ($800,000 is the average figure used by EPA) as well as a number of expensive but impermanent cleanups would need to be done. With the two-part strategy, more money is spent on initial responses and less money is spent on studies to select permanent cleanups and/or expensive cleanups (which are often done in stages).

To decide which sites should eventually receive permanent cleanups, we will need much more sophisticated methods than are now being used. For example, EPA's recent ground-water protection strategy uses a classification system for aquifers to set priorities. As discussed later, some sort of classification approach may be useful to establish cleanup goals and priorities in an objective, orderly fashion; these might include classification for restoration, rehabitation, and reuse of NPL sites. Without well-defined cleanup goals it is not possible to know if a permanent cleanup technology exists for every site that needs permanent cleanup, or even to know how to decide which sites need permanent cleanup.

Concluding that a much larger Superfund program is necessary is not the same as quickly implementing the program. Moreover, if the Superfund program is viewed as a short-term effort, then large sums of money will probably be spent ineffectively and future generations will pay repeatedly *for* cleaning up wastes *that should have been rendered harmless years earlier, or that should have been safely managed until they could, if possible, be treated.*

From a policy perspective, substantial costs and risks could result if the number of sites on the NPL is *underestimated.* Thus, another important objective of the strategy's initial period is to resolve uncertainties about future needs. This issue cannot be delayed without encountering high costs. Many festering sites may go unattended, spreading contamination and getting worse. Should impermanent "cleanups" continue at many sites, they and the sites receiving cleanup wastes could also get worse, eventually requiring more expensive work and large amounts of drinking water might become contaminated. The resulting "environmental deficit" could come due eventually and the Nation would face thousands of sites requiring cleanup; few cost-effective, permanent cleanup technologies; not enough technical specialists; little time to control sites to prevent great damage to public health and the environment; and costs so great that they might be impossible to meet. *In other words, a planning mistake now based on an underestimate of the national cleanup problem could result in an environmental crisis years or decades from now.* Therefore, this study emphasizes the importance of greatly reducing the uncertainty about future needs as soon as possible.

Policy Options: More specifically, Congress may wish to consider the following legislative options for CERCLA: 1) a policy statement on the long-term nature of the program, 2) a policy statement on the explicit strategy to be pursued so Congress can evaluate the program's performance, and 3) a redefinition of the types of responses to NPL sites and their intended purpose.

CLEANUP OF HOW MANY SITES, AND AT WHAT COSTS?

Most assessments have underestimated the number of uncontrolled sites that may require Superfund action. OTA's work indicates that 10,000 sites (only considering waste sites) is a more realistic figure for planning purposes than EPA's projection of about 2,000 sites. Even OTA's figure may prove conservative, but the main goal here is not determining the precise number of future NPL sites. Rather it is important to consider the confidence policymakers can have in current estimates. OTA does not dispute the need to clean the sites already qualifying for placement on the NPL. But many sites not now listed on or considered for the NPL may also require cleanup.

At least 5,000 of the 621,000 operating and closed solid *waste* facilities may require cleanup (see table l-l). Hazardous substances often leak from these facilities and contaminate groundwater; at least 20 percent of current NPL sites were solid waste facilities. About 1,000 operating *hazardous waste* facilities may require cleanup, chiefly because of problems with RCRA groundwater protection standards that regulate about 2,000 of these land-based facilities (see table 1-2). Finally, OTA estimates that an improved site identification and selection process would add some 2,000 sites now listed in EPA's inventory of uncontrolled sites to the 2,000 projected by EPA for the NPL. Important changes include: recognizing environmental as well as human health threats, using national guidelines to evaluate sites, increasing emphasis on site identification, and removing the arbitrary cutoff score for placement on the NPL. These changes will qualify more sites that pose threats to public health or the environment for cleanup,

Table 1-1 .—Summary Data on Solid Waste Facilities

Percent of uncontrolled sites that are solid waste facilities:	
Of 1,389 sites with actual or presumed problems of releases of hazardous substances	180/0
Of *550* sites on National Priority List	20°/0
Two most prevalent effects at problem solid waste sites:	
Leachate migration, groundwater pollution: at 89°/0 of sites	
Drinking water contamination: at 49°/0 of sites	
Mean size of problem solid wastes sites	67.4 acres
Median hazard ranking score:[a]	
Solid waste sites on the NPL	40.8
All NPL sites	42.2
Estimates for national number of solid waste sites:	
Operating sanitary, municipal landfills	14,000
Closed sanitary, municipal landfills	42,000
Operating industrial landfills	75,000
Closed industrial landfills	150,000
Operating surface impoundments	170,000
Closed surface impoundments	170,000
Total	621,000
Estimate of need for future cleanup:	
Low: 5°/0 landfills, 1°/0 impoundments likely to release toxic substances	17,400
High: 10°/0 landfills, 2°/0 impoundments likely to release toxic substances	34,800
Conservative figure used for cleanup by Superfund	**5,000**

[a]28.5 required for placement on National Priorities List; current highest site score IS 756

SOURCE Office of Technology Assessment

OTA's estimates are only semi-quantitative, but an effort has been made to be conservative, especially in view of the uncertainties of cleanup actions by States and responsible parties. Furthermore, there is no reason to conclude that the additional sites pose substantially smaller or more easily managed risks than EPA's 2,000. OTA's projection of an NPL with 10,000 sites is consistent with the results of a survey conducted by State officials which indicated a need to clean up about 8,000 sites.[4]

[3]Solid waste facilities are governed by Subtitle D of the Resource Conservation and Recovery Act (RCRA) regulatory program, There are a number of sources of hazardous substances in these facilities, including some household wastes and industrial wastes not regulated as hazardous waste by RCRA or the States. Concerning the latter, a forthcoming report by the Congressional Budget Office estimates that in 1983 over 26 million metric tons of hazardous waste were disposed of in sanitary landfills nationwide. A study for EPA has found that hazardous wastes not so defined by RCRA are being disposed of in surface impoundments. (M. Ghassemmi, et al, "Assessment of Hazardous Waste Surface Impoundment Technology—Case Studies and Perspectives of Expert s," May 1984.)

[4]The survey, funded by EPA, was conducted of its members by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO). With responses from 44 of its members, a report issued in December 1983 presented the following

Table 1-2.—Summary of Problems With RCRA Groundwater Protection Standards Governing Operating Hazardous Waste Facilities[a]

- Interim Status Facilities: Groundwater protection standards for these facilities are less stringent than for new facilities, and most of them already are, or are likely to become leaking sites.
- **Fixing Leaks:** With confirmed groundwater contamination there are no requirements that a facility be closed until the leak is found and corrected, nor to even find or stop the leak.
- RCRA **Coverage Limited to 30 Years: New** facilities must be designed not to leak for 30 years after closure during which time the operator must maintain the facility, but later when leaks are more likely CERCLA becomes responsible.
- **Contaminants Which Are Regulated:** Because CERCLA regulates more substances than RCRA, and detection levels for other substances are set lower by CERCLA than by RCRA standards, a permitted but leaking RCRA facility can become an uncontrolled site under CERCLA.
- Tolerance Levels of Contaminants: Acceptable levels of groundwater contaminants are not based on health effects, and using detection limits of analytical techniques may not be protective of human health.
- **Geological** Standards: There are difficulties in predicting groundwater movement or the rapid movement of contamination in some geological environments which make early detection and correction uncertain at some sites. However, RCRA has no facility siting standards to restrict hazardous waste sites to geologically suitable locations.
- **Groundwater Monitoring:** Technical complexity and site specificity make it difficult for government rules to set the conditions for effective groundwater monitoring.
- **Monitoring in the Vadose Zone:** Although the technology exists, RCRA standards do not require monitoring in the land between the facility and underground water; hence, an opportunity to gain an early warning of leaks is lost.
- **Test for Statistical Significance:** Tests required by RCRA keep the probability of falsely detecting contamination low at the expense of high probability that contamination might go undetected.
- **Corrective Action Delays:** Complex RCRA procedures can lead to delays of several years, increase cleanup costs, and increase the chances of CERCLA financing of cleanup.
- **Compliance Monitoring and Corrective Action:** Technology does not necessarily exist to meet the RCRA standards for taking corrective action, nor in all cases for compliance monitoring, required after contamination is found.

[a]Because of these problems, OTA has estimated that 50 percent of these facilities may require cleanup by Superfund

SOURCE Office of Technology Assessment,

findings: "At least 7,113 sites nationwide require some form of remediation. These figures understate the extent of the nation's uncontrolled hazardous waste site problems because they do not take into account the states not responding to our questionnaire. Our members' judgments on the number of sites needing response were significantly greater than the number of sites now on the NPL. " When EPA used the survey for its CERCLA 301 (a)(l)(E) study on State participation given to Congress in December 1984, the following statement appeared: "The most important observation . . . is that states' estimate that over 7,000 sites require response (sic), although the scope of response for these sites is likely to be less than for sites listed on the National Priorities List. " The latter observation did not appear in the original report which also indicated that only about 10 percent of known sites had been scored to evaluate eligibility for placement on the NPL. The States' estimate of Superfund sites was not used by EPA in its CERCLA 301 (a)(l)(C) study on future Superfund needs also issued in December 1984. The usefulness of ASTSWMO data has been shown by the fact that the States were the basis for the 1983 estimate by OTA of hazardous waste generation in the United States of about 250 million metric tons annually, a figure over six times greater than the then current EPA estimate, The figure of about 250 million metric tons annually was later verified by EPA and will be substantiated shortly by the Congressional Budget Office.

The principal reasons why EPA's projection of a 2,000 site NPL differs so substantially from OTA's estimate of 10,000 are summarized in table 1-3. (Note that EPA considered several categories of sites that OTA ignored, such as mining waste sites and leaking underground storage tanks.) EPA has stated that a full examination of the problem of future sites could lead to a situation where the costs "would overwhelm" the Superfund program. But OTA's point is that by acknowledging the full extent of future needs, rather than underestimating them, effective planning could prevent a crisis.

For planning purposes, an NPL with 10,000 sites implies a need for a much larger Super-

Table 1.3.—Factors in EPA's Examination[a] of Potential NPL Sites That Lead to a Low Projection

Site category: Factor

Solid waste facilities:
- Surface impoundments are not included, even though all types now account for one-third of NPL sites, and they are recognized as a major problem in EPA's Groundwater Protection Strategy
- No accounting for closed industrial landfills
- The basis for saying that there are only twice as many closed municipal landfills as open ones is not given

Hazardous waste facilities:
- ***No*** accounting for the more stringent 1984 amendments to RCRA and effect on number of failures of companies
- No consideration of the sites created due to failure of EPA's RCRA groundwater protection standards as acknowledged in EPA's Interim Status Ground-Water Monitoring Implementation Study

Site selection process:
- Limited considerate ion of current site selection process and potential changes in it

[a]U.S Environmental Protection Agency, "Extent of the Hazardous Release problem and Future Funding Needs—CERCLA Section 301(a)(l)(C) Study, " December 19s4.

SOURCE: Office of Technology Assessment.

fund than previously contemplated, easily $100 billion or more over some decades. A better estimate of future Superfund needs could be made if more were known about the extent of environmental contamination. For example, it is unclear how many sites will require groundwater cleanup, which is the most costly type of cleanup. Nor is it yet clear how advanced technology might reduce the costs of permanently effective cleanups and provide solutions that do not now exist. For example, although it is sometimes possible to pump and treat contaminated groundwater at considerable cost and time, it is not clear that an aquifer, once contaminated, can be restored to a drinkable condition.[5]

[5]See U.S. Congress, Office of Technology Assessment, *Protecting the Nation Groundwater From Contamination*, OTA-0-233 (Washington, DC: U.S. Government Printing Office, October 1984).

In addition, it is difficult to estimate how much money will be recovered from responsible parties and will be spent by industry and the States for cleanups (for non-NPL sites and for their share for NPL sites). A number of States have not yet earmarked enough money to provide their expected share of cleanup costs. OTA has stressed estimating future national Superfund needs, without making specific assumptions about non-Federal spending on the problem. Other estimates of future Superfund needs often make explicit assumptions (leading to "adjusted costs" for Superfund) even though they are highly speculative. Table 1-4 is a brief summary of several recent estimates of future national unadjusted cleanup costs and program lengths.

COSTS AND STRATEGIES

OTA has considered the implication of two primary strategies (see chapter 3) on the costs and duration of a program that must deal with about 10,000 sites. The variable used by OTA in its modeling of these strategies called the "impermanence factor" describes in an average, statistical sense the extent to which interim actions result in unforeseen future costs. It is an attempt to examine the consequences of currently employing cleanup technologies that are less than totally effective in the long term. The impermanence factor can be interpreted in several ways, and the particular interpretation does not affect the results of this simple model. One simple way to think of the impermanence factor is that it is the ratio, averaged over all sites, of the costs of successive interim actions at the same site or on the same wastes. That is, for example, for an impermanence factor of 0.5, 100 first interim actions will result at some time in 100 second actions at one-half the cost, which in turn result in 100 third actions at one-quarter the cost of the first action, and so on. Other more complicated interpretations of the impermanence factor are possible; these incorporate continuous operating and maintenance costs in addition to the probability and/or cost of discrete repeated actions.

Increasing impermanence factors signify increasing environmental risks and damages, High impermanence factors indicate the use of cleanups that are on average ineffective and lead to future spending. Later in this chapter, when the results of several case studies are given, it is seen that an impermanence factor greater than 1 for a specific site is possible. Experience to date with cleanups indicates that rather high impermanence factors are likely with the widespread use of containment and land disposal for cleanups because these methods are known not to be permanently effective.[6] Continuing operating and maintenance costs can also account for a high impermanence factor.

[6]See U.S. Congress, Office of Technology Assessment, *Technologies and Management Strategies for Hazardous Waste Control*, OTA-M-196 (Washington, DC: U.S. Government Printing Office, March 1983).

Table 1-4.—Current Estimates for Cleaning Up Uncontrolled Hazardous Waste Sites

	EPA (1 984)'	EPA (1983)[2]	GA0[3]	Department of Commerce'	ASTSWMO[5]	CMA[6]	National Audubon Society[7]
Total costs (unadjusted) billion)	$10.0 -33.3	$10.3-20.6	**$5.6-33.8**	**$10.5**	**$14.6-42.7**	NA	$29-92
Number of sites requiring cleanup	1,500-2,200	1,400-2,200 23-56°/0 require groundwater cleanup	1,270-2,546 23-56°/0 require groundwater cleanup	546 NPL 1250 non-NPL 41 municipal	7,113 (43 States surveyed); 1,500 most serious sites	1,000 (27 States surveyed) 3,681 (potential)	2,200-7,000 56°/0 require groundwater cleanup
Projected years to clean sites.	NA	14 for 1,800 sites	NA	10-15	16-23 if constrained by personnel; 28-90 if constrained financially	NA	26-84

SOURCES
(1) U S Environmental Protectlon Agency, "Extent of Hazardous Release Problem and Future Funding Needs, " CERCLA Sectlon 301(a)(l)(C) Study, " December 1984
(2) U.S Environmental Protection Agency, Superfund Task Force Preliminary Assessment, December 1983.
(3) U.S General Accounting Office, *EPA "s Preliminary Estimates of Future* Hazardous Waste *Cleanup Are Uncertain,* GAO/RCED-84-152, May 7, 1964.
(4) U.S Department of Commerce, "Estimated Costs and Expenditures for Cleanup of the Nation's Uncontrolled Hazardous Sites" (draft), Feb 22, 19334
(5) Association of State and Territorial Solid Waste Management Officials, "State Cleanup Programs for Hazardous Substance Sites and Spills, " Dec. 21, 1963
(6) Arthur D Little, Inc , Report to the Chemical Manufacturers' Association, "An Analysis of the Number of Inactive Hazardous Sites That Will Use Superfund,'' July 1963.
(7) National Audubon Society, Testimony of Leslie Dach Before the House Subcommittee on Commerce, Transportation, and Tourism, Mar. 1, 1964

Two strategies are modeled: an interim strategy (which simulates the approach of the current EPA program) and a two-part strategy. Both strategies are described and compared in table 1-5 and figures 1-1 and 1-2. The impermanence factor is used in interim strategy; but for the two-part strategy, it is simply assumed that 90 percent of the initial cleanups will have to be followed by a permanent cleanup during the second part of the program. The total adjusted cost and duration of the program depends on a number of assumptions, such as the average cost of site cleanup; the important assumptions are summarized in the table. The program duration and costs shown in table 1-5 and figure 1-1 do not represent what will happen in the future, but only what might happen under certain conditions and policy decisions. If a program duration of more than about 50 years is unacceptable, then under most conditions (i.e., levels of "impermanence" as discussed above) a two-part strategy offers both cost and time advantages over an interim strategy. The results are similar for the other computer-simulated scenarios described chapter 3, including those with a smaller NPL.

Table *1-5.*— Illustrative Scenarios for Two Different Cleanup Strategies

Scenario 1: Interim Strategy	Scenario II: Two-Part Strategy
Brief description:	
Cleanups result in repeated future costs.	Initial response (at most one per site) over first 15 years (Part l). After 15 years, for 90 percent of sites, permanent cleanups, with no future costs (Part II}.
System assumptions:	
• In Scenario 1, future costs depend on the impermanence factor and the average interim cleanup cost, In Scenario II, future costs of initial actions depend on the cost of permanent cleanup, which is taken at 900/0 of sites, • Total number of sites requiring cleanups = 10,546[a] • 20°/0 of sites require groundwater (gw) cleanup. • Initial period (5 yr) budget = $5 billion; growth @ 100% for each of next three periods then @ 20°/0 each successive period. [b]	
Scenario assumptions:	
Average interim cleanup costs: $6M per site $12M per site, with gw cleanup	Average initial response costs: $1M per site $3M per site, with gw cleanup Average permanent cleanup costs: $24M per site $60M per site, with gw cleanup
• Breakeven program cost at $313 billion, breakeven program length is 45 years. • On the basis of program cost alone; the interim strategy is chosen if its average impermanence factor is less than 0.73, • On the basis of program length alone, the interim strategy is chosen if its average impermanence factor is less than 0.25, • Overall, when the average impermanence factor is less than 0,25, the Interim Strategy is preferred; when it is greater than 0.73, the two-part strategy is preferred; for values in between, reduced program length can be obtained with the two-part strategy at a cost above that the interim strategy.	

[a] Initially 546 sites; 200 new sites per year for years 1-5; 800 new Sites Per year for years 6.10 and 1,000 new sites per year for years 11-15
[b] Budgets and total costs reflect total spending by all parties, not lust by the Superfund program
[c] Time to initiate 9000 of work Times are given for future costs incurred over 30 years

SOURCE Office of Technology Assessment

However, to the extent that the interim strategy modeled by OTA approximates the current program, there are conditions under which the current program could be viewed in a positive manner. Much depends on the values for the average impermanence factor for the remedial cleanup technologies now being used. As discussed above, there are several reasons why OTA believes that the average impermanence factor is likely to be high, at least 0.5 to 0.7. If this is the case, then a two-part strategy offers time and probably cost advantages over the current program (i.e., the interim strategy). If the average impermanence factor were to be low, say about 0.1 or 0,2 (i.e., remedial cleanups which had a low probability of leading to unforeseen future costs), then a decision to continue with the current program would not lead to undesirable consequences. Adoption of a two-part strategy would still be a valid option to consider because of the opportunities it affords for institution building, for quickly addressing most sites through initial responses, and because the medium-cost, low impermanence actions of the interim strategy could then be appropriate for part two. If, however, the current program continued and it became clear that the average impermanence factor was high, then much money and time could be wasted. The *conclusion of OTA's*

Figure 1-1 .—Program Length v. Impermanence Factor (Scenario 1USG)

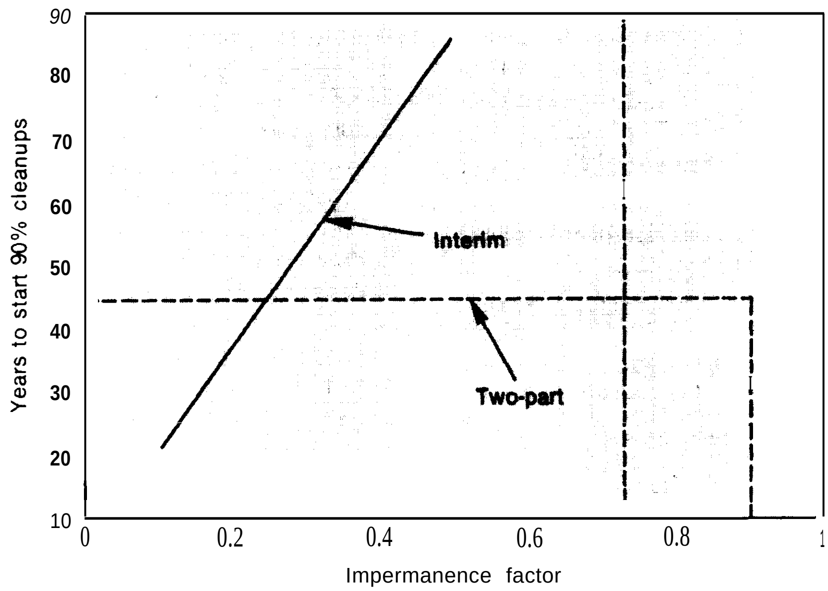
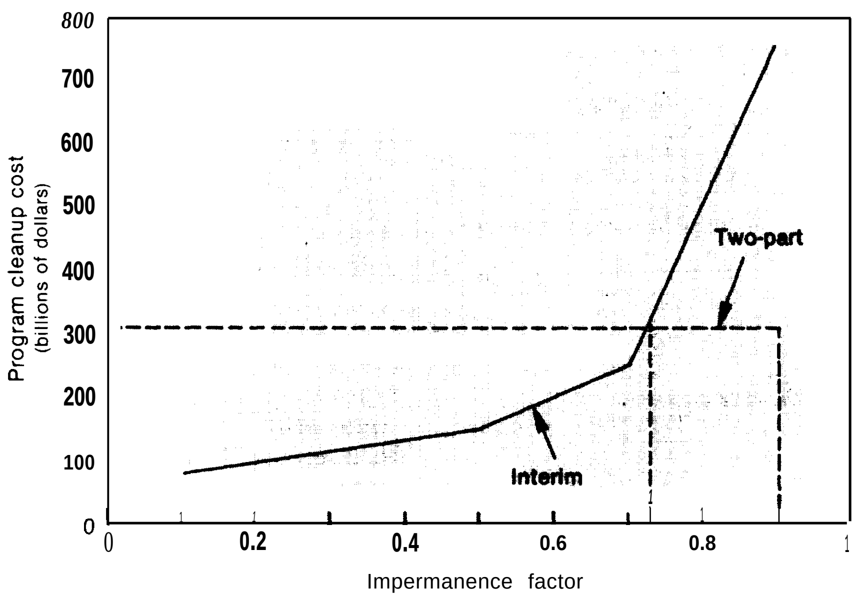


Figure I-2.—Program Cost v. Impermanence Factor (Scenario 1USG)*



"See also table 1-5 and "Costs and Strategies" section One simple way to think of the Impermanence factor is that it is the ratio, averaged over all sites, of the costs of successive interim actions at the same site or on the same wastes *analysis is that, in the face of important uncertainties, the two-part strategy is less risky and more "fail-safe" in the sense that proceeding with it is less likely to result in ineffective spending.*

policy Options: Congress may wish to consider including in CERCLA a statement on what strategy the program is to pursue. More specifically, Congress may wish to consider directing EPA to: 1) examine the potential cleanup problems of RCRA Subtitle D solid waste facilities and to strengthen and hasten the development of Federal regulations for: a) the monitoring of a broad range of hazardous substances at both open and closed sites, and b) the future operation of open and new solid waste sites; 2) reexamine its RCRA Subtitle C regulatory program for hazardous waste land disposal facilities, particularly the groundwater protection standards, from the perspective of minimizing the creation of future uncontrolled sites; and 3) redesign its system of identifying, assessing, and ranking sites for the NPL to reduce the likelihood of excluding sites that merit cleanup. Congress may also wish to reexamine the policy requiring matching funds from States, particularly the 50 percent match for State and municipally owned and operated facilities. Already, the 10 percent State matching requirement for private sites presents an obstacle to cleaning up some sites. The unwillingness, but not necessarily the inability, of many States to provide their matching requirement might slow the national cleanup as much as or more than almost any factor.

RESOLVING THE "HOW CLEAN IS CLEAN?" ISSUE

Identifying and quantifying risks to health and the environment for the extremely broad range of conditions, chemicals, and threats at uncontrolled hazardous waste sites pose formidable problems, Risk management will have to proceed even though there is no quick way to determine the precise levels of cleanup. For example, quantitative risk *assessments* cannot be performed for most cases, except at considerable cost and time, as the necessary technical data do not now exist.

The paucity of documented, unambiguous findings of adverse health and environmental effects caused by uncontrolled sites does not mean that such effects have not occurred or will not occur. Nor is it inconsistent to say that enough information exists to know that a site presents significant risk to warrant action, but not enough to know *precisely* what the level of cleanup should be. Much better understanding is needed of adverse health effects from uncontrolled sites, and the work required by Congress is proceeding slowly. However, society must understand that multiple exposures to toxic chemicals at home, in the workplace, and in the general environment make it difficult to attribute causality to any one source of exposure,

A detailed framework for determining and achieving cleanup goals that are nationally consistent in themselves or in the *process* used to reach them, effective in protecting human health and the environment, and appropriate for site-specific conditions does not yet exist. While there are a number of approaches to establishing cleanup goals, none are simple or easily administered. OTA has examined the current ad hoc, highly flexible, and nonspecific approach and six others. It finds that the current approach is not satisfactory and that more explicit attention is warranted for this issue at the highest policy levels. *Without clear and well-supported cleanup goals the selection of cleanup technologies and the ultimate evaluation of cleanup performance will remain contentious.*

Two approaches to establish cleanup levels are not practicable technically or *economically;* they are: 1) requiring sites to be restored to pristine or background levels, and 2) using best available technology. A third approach, the use of existing environmental standards or criteria for particular chemicals, will cover only a small fraction of the broad range of the health threats at uncontrolled sites and does not address all environmental problems. However, this approach can be used to some extent. Two other approaches, risk assessments and cost-benefit analyses, present many difficulties and uncertainties but also offer ways to establish cleanup levels.

One approach has been found to offer a policy framework for moving more forcefully toward clear cleanup goals: it is to use information and decisions about restoration, rehabitability, and reuse of the site to establish cleanup levels. In particular, it appears worthwhile to examine in more detail how classifying sites according to their future use and other site conditions can be used to select the process to set cleanup levels, as well as determine how the site is managed more generally. For example, the use of costly risk assessments could be limited to high-priority sites where reuse and rehabitation is certain. Cost-benefit analyses could be used for sites where future use may be limited or where risk management options other than site cleanup (e.g., relocation of residents) is practicable. For some sites where exposures are small and reuse not an issue, use of existing standards may be sufficient. Since this approach relates to land use, it is clear that local communities would have to be involved in decisions.

It is also necessary to address the extent of action needed in initial responses. Generic standards that consider both immediate reduction of exposures to hazardous substances and the prevention of further deterioration while the site is awaiting remedial cleanup would be useful.

Policy Options: For risk management purposes, Congress could consider a Superfund policy that: 1) first establishes environmentally effective cleanup goals for a site, then 2) determines the cost-effective site response, and lastly 3) implements the fund-balancing provision of the statute by considering how a site cleanup or risk management decision affects actions taken at other sites. Congress may also wish to consider two more specific options: 1) having EPA develop an implementation plan that establishes cleanup levels on the basis of a classification of sites according to their future use and other site conditions, and 2) designating a well-funded, high-priority interagency program (e.g., EPA, Department of Health and Human Services, Department of the Interior) whose purpose is to more expeditiously and comprehensively deal with the problem of obtaining more complete information on the health and environmental effects of toxic wastes.

DO WE HAVE AND USE EFFECTIVE CLEANUP TECHNOLOGIES?

The problems with using containment and land disposal approaches to cleanup have already been discussed. These technologies are not likely to be effective over the many decades corresponding to the lifetimes of some toxic chemicals of concern. Even though they may be proven technologies for their original applications in construction engineering, they are not proven for long-term effectiveness in containing hazardous wastes. Nor are their immediate costs indicative of the likely total long-term costs, including monitoring, operation and maintenance, and the costs of future cleanup actions, especially for cleaning up contaminated groundwater. Table 1-6 projects future uses of conventional containment technologies. Table 1-7 gives similar projections for conventional treatment technologies; these existing technologies that can permanently clean up sites are underused. These projections are

Table I-6.—Future Use of Containment Technologies

Technique	Applicability	Effectiveness	Confidence	Capital cost	Cap/O&M	Projected level of use
Barriers:						
Slurry wall	**2**	1	**2**	**2**	1	**Extensive**
Grout curtain	**2-3**	1	**2**	**2-3**	1	**Limited**
Vibrating beam	**2**	1	**2-3**	**2-3**	1	**Moderate**
Sheet pile	3	1-2	2	2-3	1	Nil-Limited
Block displacement	3	1	4	3	1	Nil
Hydraulic controls (wells)	2	1,3	1	1	3	Extensive
Subsurface drains	2	1	2	1	2	Moderate
Runon/runoff controls	1	3	1	1	2	Extensive
Surface seals and caps	1	2,3	2	1	1	Extensive
Solidification, etc.	2	1,3	3-4	2	1	Moderate-Limited

KEY'
Applicability:
1 = Very broadly applicable, little or no site dependency
2 = Broadly applicable; some sites unfavorable
3 = Limited to sites of specific characteristics
Effectiveness
1 = Can produce "leak-tight" containment
2 = Can reduce migration—some leakage likely
3 = Used as supporting technique in conjunction with other elements
Confidence
1 = Well *proven—long-term effectiveness—high*
2 = Well proven—long-term effectiveness—unknown
3 = Limited experience, used in other applications
4 = Developmental; little data
Capital cost for function provided:
1 = Low
2 = Normal
3 = High
Capita/ to *operation and maintenance (O&M) cost* ratio:
1 = Capital higher than O&M
2 = Capital about same as O&M
3 = Capital lower than O&M

SOURCE A D Little, "Evaluation of Available Cleanup Technologies for Uncontrolled Sites, " contractor report prepared for the Office of Technology Assessment, Nov. 15 1984

Table 1-7.—Future Use of Treatment Technologies

Technique	Applicability	Effectiveness	Confidence	Capital cost	Cap/O&M	Secondary disposal	Projected level use of
Biological treatment	Or, 1-2	2	1	1	1-2	3	Moderate
Chemical treatment:							
Neutral ization/precipitation	In, 1	1	1	1	2	4	Moderate-Extensive
Wet air oxidation	Or, 2	2	2	3	1-2	1	Limited
Chlorination	In, 3	1	2	2	2	1	Limited
Ozonation	Or, 3	2	3	3	2-3	2	Nil
Reduction (Cr)	In, 3	1	2	2	2	3	Limited
Physical treatment:							
Carbon adsorption	Or, In, 1	1	1	2	2-3	2-3	Moderate-Extensive
Sedimentation/filtration	Or, In, 1	1	1	1	2-3	4	Moderate-Extensive
Stripping	Or, 2	1	1	1	2	4	Moderate
Flotation	Or, 2	2	1	1	1	4	Limited
Ion exchange	In, 3	1-3	3	3	3	4	Nil
Reverse osmosis	Or, In, 3	1-2	3	3	3	4	Nil
Gas stream controls:							
Thermal oxidation	Or, 1	1	1	3	3	1	Limited-Moderate
Carbon adsorption	Or, 1	1	1	3	2-3	2-3	Limited-Moderate
Incineration							
Onsite	Or, 1	1	2	3	1	3[a]	Limited
Off site	Or, 1	1	1	3	NA	3[a]	Moderate
In situ biodegradation	Or. 3	2	3	2	3	1	Limited

NOTES:
a Must dispose solid residues
b Depends on reactive material used.
KEY
Applicability
Class.
Or = Organic compounds
In = Inorganic compounds
Range
1 = Broadly applicable to compounds in in. dicated class
2 = Moderated applicable" depends on waste composition concentration
3 = Limited to special situations
Effectiveness
1 = Highest levels available
2 = Output may need further treatment; may have pockets untreated (in-situ)
Confidence"
1 = Well proven—easily transferable to site cleanup
2 = Well proven—but not in clean-up settings
3 = Limited experience
4 = Developmental; little data
Capita/ cost *for function provided*
1 = Low
2 = Normal
3 = High
Capital to *operations and maintenance (O&M) cost basis*
1 = Capital higher than O&M
2 = Capital about the same
3 = Capital lower than O&M
Secondary treatment or disposal
1 = None
2 = Minor
3 = Major, but does not require hazardous waste techniques.
4 = Basically a separation process; must be used with subsequent hazardous waste treatment or secure disposal step.

SOURCE A D Little, "Evaluation of Available Cleanup Technologies for Uncontrolled Sites, " contractor report prepared for the Office of Technology Assessment, Nov. 15, 1984 based on OTA's evaluation of how these technologies meet the goals of permanently effective cleanups.

Not enough research, development, and demonstration (RD&D) is devoted to innovative cleanup technologies. Many innovations exist, but few have overcome institutional barriers to their use. A major barrier is the lack of clear criteria developed by EPA for judging their effectiveness for certain types of cleanups. Cleanup technologies should be judged effective according to their ability to destroy, detoxify, or immobilize hazardous wastes and to decontaminate soil and groundwater (although it may not be possible to clean or restore an entire aquifer or even a portion of an aquifer). Summary data on some innovative cleanup technologies are given in table 1-8.

The long-term environmental and economic benefits of permanent cleanups have not been assessed properly or considered when cleanup technologies are being chosen. Considering the large cost of the Superfund program, spending more RD&D money on innovative cleanup technologies could offer considerable economic advantages in the long term. To date, EPA has not made a major commitment to assist the development of innovative technologies. For the first 5 years of Superfund, EPA will have spent no more than about $25 million on cleanup technology RD&D.

Policy Options: Congress may wish to consider establishing a program to fund RD&D of innovative cleanup technologies that offer promise for effective permanent cleanups at lower total costs for a range of uncontrolled site problems. Funding of perhaps $25 million to $50 million annually for some years could lead to substantial economic and environmental benefits when applied to a multibillion dollar program over a number of decades. Removing institutional barriers to the demonstration and use of innovative technologies also can be examined. Such actions could include directing EPA to: 1) reduce the time and cost of obtaining RCRA permits for waste treatment facilities, 2) establish protocols to evaluate new cleanup technologies, 3) make it easier to obtain samples of waste and contaminated materials from uncontrolled sites and transport them to test facilities, 4) streamline the RCRA procedure for delisting harmless residues of waste treatment operations (residues are now *presumed* to be hazardous wastes), and 5) continue to remove the bias in favor of land disposal over waste treatment options in Superfund cleanups, particularly by establishing a procedure for performing cost-effectiveness analyses that more accurately reflect the full, long-term costs of impermanent technologies. There is a particular need to address the problems facing small businesses (e.g., inability to afford demonstration) attempting to enter the cleanup market with new technologies.

ARE SUPERFUND EFFORTS RESULTING IN QUALITY WORK?

In case studies of Superfund cleanups by OTA and others there is evidence of significant problems in the quality of technical work. Federal oversight of contractor work, State efforts, and private cleanups is not adequate. Lack of coordination, redundancy of efforts, delays, and high costs also result from the use of many contractors, sometimes selected more because of cost than technical competence, and from the involvement of a number of Federal and State agencies at each site.

Moreover, a shortage of *experienced* technical experts in several fields may explain a lack of quality performance now and it may cause a major bottleneck in an expanded Superfund program. OTA estimates the demand for technical professionals (primarily, bachelors level) to work on cleanups of uncontrolled sites may rise from the present 3,750 to about 21,000 by 1995 and then stabilize at that level. This projection assumes an increased national cleanup effort of about $4 billion annually from all

Table 1-8.—Summary Data on Some Innovative Cleanup Technologies

	Technology	Development stage	Removal/ destruction capability	Estimated relative costs: Capital	Estimated relative costs: Treatment	System applicability[a]: In situ	System applicability[a]: On-site	System applicability[a]: Off-site	Mobile (M) Transportable (T) Permanent (P)	Primary waste applicability: Class[b]	Primary waste applicability: Form[c]
Gard	Dehalogenation	pilot	medium	low	low	N	Y	Y	M,I	[illegible]	L,SL
Zerpol	Chemical reaction	pilot	?	?	?	N	Y	N	T	I	GW,L
Bend Research	Coupled transport	pilot	medium	low	low	N	Y	P	M,T	I	GW,L
DeVoe-Holbein	Metal extraction	pilot	medium	low	low	N	Y	N	M,T	I	GW,L
MODAR	Supercritical water	pilot	high	medium	medium-high	N	Y	Y	P,T	O	GW,L
Zimpro	Wet air oxidation	full	low-medium	medium	low	N	P	Y	P,T	O	GW,L
Methods Eng.	Submerged reactor	pilot	?	medium	low	N	P	Y	P	O	GW,L
IT Corp.	Wet oxidization	bench	low-medium	?	medium-high	N	P	Y	P	O	L
Huber .	Adv. elec. reactor	pilot	high	high	medium-high	N	Y	Y	T	O	S,L
Thagard	Fluid wall reactor	pilot	high	?	?	N	Y	Y	T	O	S,SL
Pyrolysis	Plasma arc	pilot	high	medium	high	N	Y	N	M,T	O	L
Westinghouse .	Plasma arc	pilot	high	high	high	N	Y	N	M,T	O	L
Lockheed	Microwave plasma	bench	medium-high	?	?	N	P	Y	P	O	L
RoTech	Rotary kiln	pilot	high	medium	low-medium	N	Y	Y	M,T	O	S,SL,L,S
Midland-Ross	Rotary pyrolytic	full	?	high	medium	N	P[d]	Y	P,T	O	SL,L
Waste-Tech . . .	Fluidized bed incin.	pilot	medium	medium	?	N	P[d]	Y	P	O	SL,L,S
G.A. Tech. . . .	Circulating bed	pilot	medium-high	medium	?	N	Y	Y	M,T	O	S,SL,L
Rockwell	Molten salt	pilot	high	medium	high	N	N	Y	P	O	L,SL
Sandpiper	Segas process	pilot	?	medium	medium	N	Y	Y	T,P	O	L
Detox	Biotechnology	pilot	medium	?	low	Y	Y	N	T	O	GW,S,SL,L
GDS	Bio. degradation	full	medium	low	low	P	Y	N	T	O	GW,L
SBR	Batch reactor	pilot	medium	?	?	N	Y	Y	P,T	O	GW,L
Univ. Gottingen	Bio. degradation	research	high	?	?	P	P	P	T	O	SL,L
Battelle Pacific	Vitrification	pilot	na	?	low	Y	P	N	T	O	S,SL
Lopat/K-20 . . .	Chemical treatment	pilot/full	high	low	low	Y	Y	Y	T	[illegible]	S,SL,L
NMT/Fujibeton	Chemical treatment	pilot/full	high	low	low	Y	Y	Y	T	[illegible]	S,SL,L

NOTES: ? = data not available; na = not applicable
[a]Yes—Y, No—N, P—Perhaps, with further testing. Pretreatment may be required
[b]Class
O = organics I = inorganics

[c]Form
GW = groundwater (dilute aqueous); S = soils/solids (low concer ration);
L = liquids (concentrated); SL = sludges/solids (concentrated)
[d]For large sites; i.e., high volume of waste to be treated.

SOURCE: Office of Technology Assessment.

sources. Current educational programs may not be able to prepare sufficient numbers of some professionals, particularly hydrogeologists, and perhaps toxicologists, geologists, civil engineers, and some types of chemists. But a more critical problem is that the already strong demand for people with a masters degree and 3 to 5 years of experience may increase and not be met for the next decade.

Policy Options: If the Superfund program is to be a long-term one, the Congress may wish to consider: 1) funding various expanded training and educational programs, perhaps $5 million to $10 million annually for some years; 2) providing funding for EPA to build up its in-house professional staff in disciplines appropriate for cleanup work and oversight, perhaps increased funds of $25 million to $50 million annually; 3) making direct grants to the States for their staff development, perhaps $25 million to $50 million annually for some years; and 4) directing EPA to reexamine: a) how it selects and uses contractors, particularly with respect to its emphasis on the cost of proposals rather than technical qualifications; and b) how it involves government agencies at Superfund sites.

IS PUBLIC INVOLVEMENT ADEQUATE?

More emphasis is needed to address the legitimate concerns of the public, improve public confidence in the Superfund program, and promote effective public participation in site identification, site assessment, initial responses, cleanups, and long-term monitoring. EPA has concentrated on providing information *to* the public rather than involving the public in decisionmaking. An expanded public role in the Superfund program might reduce delays by dealing with community concerns before substantial actions are taken and by providing useful oversight of activities. Public participation, if given Federal support for obtaining technical assistance, could lead to more effective cleanups for all communities, not just for those who happen to be better organized or fortunate enough to have citizens with political or technical expertise. Concerns about delays caused by more public participation could be addressed by using established methods of arbitration and mediation, for example. Public education is also critical.

policy Options: Congress may wish to consider incorporating in CERCLA a mandate, similar to that in other environmental statutes, for public involvement in decisions that determine which sites are placed on the NPL and the type of cleanups or other actions to be used at Superfund sites. Providing Federal support to aid communities in obtaining technical assistance is also worth consideration.

FINANCING MECHANISMS

Many of the results of this study suggest the need for a considerably larger Superfund program than the present one. A larger Superfund program would need to consider broadly based funding and more extensive use of general tax revenues in contrast to the current emphasis on the tax on chemical and petroleum feedstocks. While this study did not assess the financing question in depth, it did examine the use of a tax on hazardous wastes currently generated (generally referred to as a waste-end tax) to help finance a Superfund program for the near term.

A summary of the three principal sources of funds—feedstock tax, waste-end tax, and general tax revenues—is given in table 1-9. These three sources could generate considerable sums annually. If Superfund is expanded greatly it may prove necessary to rely much more on general tax revenues or some other broadly based tax, as there are limits–perhaps $1 billion to $2 billion annually–to the amount that could be raised with feedstock and waste-end taxes. It should also be noted that this study has examined uncontrolled hazardous waste site cleanups only. Should other major uses of Superfund be mandated by Congress, such as a victim compensation program, long-term Superfund requirements could be far greater than $100 billion.

A waste-end tax could provide funding to complement other sources, but of equal or greater importance, it should be designed to slow the creation of still more uncontrolled waste sites. The tax could be large enough to provide an economic incentive for generators to reduce the amount and degree of hazard of their wastes and to shift management of waste away from land disposal, the chief cause of Superfund sites. Indeed, the greater the future cleanup needs facing the Superfund program, the greater is the need to stop creating still more uncontrolled sites and to stop adding to the mass of hazardous wastes at existing sites. OTA and others have found that 20 States are using waste-end tax systems effectively and without major problems, A Federal waste-end tax could be made simple to administer and could generate from $300 million to $1 billion annually over the next several years, before waste reduction efforts reduce the tax base substantially. It would not be necessary or productive to displace State waste-end taxes, however; a deduction for waste-end taxes paid to States is possible.

Table 1-9.—Summary Comparison of Several Major Financing Schemes

Feedstock tax[a]		Waste-end tax[b]		
Current	Expanded	Low	High	General tax revenues[c]
Fairness:				
Very few companies pay most of the taxes	Improved	Good, many parties pay	Improved if land disposal gets high tax	Parties most directly responsible for problems do not bear burden
Administrability:				
Easy, established	Probably easy	Probably easy on basis of States' experience	Possibly more enforcement necessary	Very easy
Secondary impacts:				
None apparent	Might reduce international competitiveness of some companies	None likely	Provides economic incentive to reduce wastes and shift away from land disposal, thus capacity to raise basic revenue declines	With large amount may have undesirable effect on Federal budget

[a]Based on taxes imposed on chemical and petroleum feedstocks which can be expanded by increasing tax rates and number of materials taxed
[b]Based on taxes on hazardous wastes generated or managed, and may vary according to how wastes are managed and what hazards wastes pose, If the rates are high enough current management decisions may be affected *Low* less than about $10 per dry ton, *high* about $30 to $50 per dry ton
[c]currently a small fraction (12 5 percent) from this source, but much larger amounts could be raised

SOURCE Office of Technology Assessment

CLEANUPS BY RESPONSIBLE PARTIES

To a substantial extent, future Superfund spending depends on how many sites are cleaned up by responsible parties. Although considerable sums have been spent by private parties, the original users and operators of uncontrolled sites are worried that the current program does not facilitate private responses. The most frequently heard concern is that after private cleanup many uncertainties about future liabilities remain. Both in government and the private sector there is interest in providing greater incentives for cleanups by responsible parties. Although various approaches can be considered, including reducing future liabilities, sharing costs, and aiding attempts to use innovative cleanup technologies, sensitivity is needed to two problems addressed in this study. Explicit, environmentally effective cleanup goals are needed whoever does cleanup, and public awareness and effective technical oversight by the Government are important for private cleanups.

OTA is aware that there now exists what might be called a "quiet market" for cleanups. Responsible parties are cleaning up sites, usually on their property, before the sites enter the Superfund system and before public awareness is awakened. Although these cleanups may be done well, there are no *assurances* that these actions (which will often make detection of the sites difficult) are environmentally sound. Interestingly, one positive aspect of this situation is that some new cleanup technologies are being given a chance to prove themselves under field conditions. However, it is not clear that information about positive and negative results is being disseminated.

THE ROLE OF THE STATES

Congress has always envisioned the Superfund program to be a joint Federal-State effort. States could clean up some uncontrolled sites on their own (this has occurred to a limited extent), and States are required by statute to pay for some of the costs undertaken under Superfund. However, there is evidence that a number of States are unwilling to meet their share of cleanup costs, T At the beginning of the Superfund program, States may have faced financial constraints; however, this does not now appear in general to be the case. The effect is that some cleanups have not and will not take place because *some* States are not providing and may not provide future required matching funds, However, it must also be stressed that several States, usually those with many uncontrolled sites, have established means to raise substantial sums for cleanups and do have extensive State programs (e. g., New York, California, New Jersey, and Illinois).

Under Superfund, States are required to pay 10 percent of capital costs (50 percent for publicly owned and operated sites) but all future operating and maintenance (O&M) costs. The selection of the cleanup approach used at sites has been influenced by the availability of State funds. The result is a bias on the part of States for high "up-front" costs, usually meaning more expensive and permanent remedies. But this understandable State preference is counter to EPA's general preference for the use of containment and land disposal, which usually have uncertain and high O&M costs.

[7]For example, a recent study of State efforts to clean up uncontrolled waste sites reached the following conclusions: "States appear less willing to shoulder the financial burden associated with hazardous waste correction actions . . . While state legislatures respond to the hazardous waste problem with policy statements, the allocation of state dollars does not necessarily follow . . . The availability of federal dollars strengthens the [needed response] linkage, the influence of hazardous waste-related industry in state politics depresses it. " (A. O'M. Bowman, "Explaining State Response to the Hazardous Waste Problem," *Hazardous Waste,* vol. 1, No. 3, 1984, pp. 301-308.)

OTA finds little reason to believe that most States could play a stronger role in the Superfund program, particularly if it were to be greatly expanded, However, a small number of States with many NPL sites could do so. On the other hand, questions can be raised as to why some States have not confronted their own current and future needs in cleaning up sites. The slowness of some States to devise ways to raise funds for cleanups may be explained by many factors, including: State priorities that do not give a high rank to this environmental problem; a "wait-and-see" attitude concerning the matching share requirements of Superfund; local obstacles to raising revenues for this purpose; and a perception of an uncertain and still ineffective Federal program.

Another problem is that many States lack technical know-how and people to assume major responsibilities for leading cleanups, or to carry out other aspects of the Superfund program such as site identification, selection, and long-term monitoring. For the most part, States have difficulties obtaining experienced technical professionals, Even with current spending, the demand for such professionals is so great that most States cannot offer competitive salaries.

Policy Options: If OTA is correct in its estimate of much greater future cleanup needs, then Congress may wish to consider two options. First, Congress may wish to accept the trend toward reducing the matching fund requirements for the States (as EPA has done) or it may wish to allow de facto decisions on what sites get cleaned up because of the unwillingness of some States to supply matching funds. Alternatively, Congress may wish to provide incentives for the States to retain or expand their role in the Superfund program. This could be done by providing near-term aid to improve States' technical staffs, arranging for more effective Federal oversight, and directing EPA to establish an information transfer program about cleanup technologies.

SCOPE AND OBJECTIVES OF THE SUPERFUND ASSESSMENT

Congress has decided, and has reaffirmed through oversight, the need for a national Superfund program to clean uncontrolled waste sites. Everyone understands that information on the scope of the problem is imperfect and incomplete. Scientific uncertainty about adverse health effects is substantial and data on environmental contamination are incomplete. But in the absence of an effective and substantial cleanup program, releases of hazardous substances into the environment could cause widespread damage to public health and the environment long before these uncertainties can be resolved.

This Superfund report addresses the problems and issues in implementing and continuing the Superfund cleanup program, not in justifying its fundamental need. The Superfund program has achieved much, especially considering that it was a fast public policy response to a diverse set of newly recognized, highly complex, technical problems. The basic issue at hand, however, is to decide whether it is necessary to change and improve the program so it can achieve its goals and, if so, how to do this in the most economical and efficient way by learning from the experiences of the past 5 years.

OTA has not addressed all the issues surrounding Superfund. As in its earlier study, *Technologies and Management Strategies for Hazardous Waste Control,* a work that was chiefly concerned with the RCRA program, the focus has been placed on those issues with a significant technical content,

Chapter 2 presents *policy options* for congressional consideration. The options are supported by the results and conclusions of the other chapters. Some of these options are

38-745 0 - 85 - 2

broad, while others are specific. Several broad policy issues directly and indirectly related to the Superfund program, such as approaches to financing Superfund and the role of the States in the program are also discussed.

Chapter 3, a systems *analysis,* ties together a number of technical and economic variables of the national cleanup program. Two different strategies are examined for their effects on total program duration and costs under various assumptions and constraints, such as number of sites requiring attention and budget limitations, The strategies make use of an important concept, the "impermanence" of cleanup actions, which assesses currently unforeseen long-term costs following the immediate costs of a cleanup. The difficult choices and tradeoffs facing policy makers are illustrated through the use of scenarios comparing the two strategies.

Chapter 41 addresses the issue of *strategies to achieve cleanup goals* and examines the difficult issue of how to establish cleanup goals that are protective of the environment, nationally consistent, flexible enough to deal with site-specific situations, and administratively feasible and practical. Resolution of this issue affects the selection of cost-effective cleanup technologies, selection of sites for action, and evaluation of cleanup performance.

Chapter 5 considers the *number of sites requiring cleanup* and examines the future needs of Superfund by assessing the extent to which certain types of sites may merit cleanup, This is an area of considerable uncertainty, but one which is fundamental to policy decisions about the nature and size of the national program, The benefits of investment in a stronger institutional infrastructure—such as developing innovative cleanup technologies—increase with increasing size of the NPL.

Chapter 6 discusses *cleanup technologies*. The purpose is to provide a more comprehensive understanding of the capabilities and limitations of existing cleanup technologies, and the problems involved in choosing among them. It also examines the need for, potential benefits of, and problems facing emerging, innovative technologies, and the need for additional or different Federal research, development, and demonstration efforts. A variety of cleanup technologies are necessary to meet environmental protection goals, and meet them in the most cost-effective way.

Chapter 7 examines issues related to *achieving quality work* and assesses current and future problems in achieving timely and effective cleanups at reasonable cost. Three areas are examined: a) the performance to date of the Superfund program; b) EPA's oversight function at cleanups undertaken by EPA, States, and private parties; and c) problems associated with the need for highly specialized technical personnel for site investigations and cleanups.

Chapter 8 considers *public confidence and participation* and examines how the public currently is involved in Superfund cleanup activities. Perhaps more than other Federal environmental programs, Superfund has been shaped by public demands. Yet the formal role of the public in decisionmaking is limited by statute.

SUPERFUND SEEN THROUGH CASE STUDIES

OTA performed several major case studies of Superfund sites to understand the problems confronting the program and better define the issues facing Congress in its deliberations over the extension and possible expansion of the program. It is common to introduce the subject of Superfund with statistics. Such a review usually focuses on numbers of various types of actions, numbers of sites and types of problems at the sites, actual and potential damages to health and the environment, levels of spending, and how these and other factors have changed over time. Such statistics are used throughout this report.

However, to introduce both the general subject and this report, OTA believes it is useful to present summaries of case studies. OTA's engineering case studies, based on in-depth analysis of how each site has been managed, illustrate the difficult and diverse set of challenges facing the national cleanup program. While there is some truth to the proposition that each uncontrolled site is unique, it is also true that sites share some common characteristics that become more obvious as the cleanup program progresses. It is likely, therefore, that these case studies can be instructive in learning how to improve the Superfund program. For example, these studies reveal problems associated with the current approach to establishing cleanup levels, with the quality of cleanup work, and with inadequate technical oversight by the Government.

The *case* study sites were selected because they had received a good deal of response action that could be examined for effectiveness. These sites all had major problems, though not necessarily typical of all Superfund sites.

The Seymour Site

The Seymour Recycling Corp. (SRC) site in Seymour, Indiana, was one of the first major cleanup actions under Superfund. Although land disposal sites are the most common operation requiring cleanup, the Seymour site illustrates how a processing or treatment facility can also create substantial problems. Over a lo-year period SRC established and operated a facility where large amounts of hazardous waste were sent for recycling and treatment. Eventually, authorities discovered that these wastes were not well managed. By 1978 the State of Indiana found it necessary to file a lawsuit to get SRC to clean up an estimated 40,000 drums of waste in various states of decay, leakage, and disarray.

In 1980, after SRC had ceased operations, EPA became involved through the Clean Water Act. Limited containment actions costing less than $1 million were taken, and two companies voluntarily spent slightly more than $1 million to remove their drums and place them in a commercial land disposal facility. EPA estimated that total cleanup costs would be $25 million. Throughout 1980 EPA took legal actions against a number of parties, spent more than $700,000 removing some wastes for incineration, and hired contractors to investigate the groundwater.

In 1981, EPA took the position that Superfund should not be used at SRC because the site did not present an emergency. The State maintained it did not have the resources to cover the 50 percent match ($15 million at that time) required under Superfund for the city-owned site, As a result, EPA pursued an enforcement strategy based on getting responsible private parties, chiefly the generators of the wastes, to pay for cleanup, To some extent, EPA's policy now is to use Superfund to clean up NPL sites first and later try to get responsible parties to pay for the cleanup. Much seems to depend on how urgent the cleanup is deemed and on whether responsible parties are known and financially able to contribute to the costs.

Although the problem of States not being able to pay for their matching requirement still exists, current policy requires the 50 percent match only when the local government also operates the facility. This was not the case at SRC. However, the State might have had difficulty providing even 10 percent of the $30 million required at that time. Currently the State and city face the problem of the operating and maintenance costs of an onsite treatment facility. This facility cleans surface water runoff before the water enters the local sanitary sewer system. The runoff is quite contaminated, revealing that the surface cleanup (described below) left substantial contamination in place.

During 1982 and 1983, two important events took place. EPA reached a settlement with some of the companies that had used the site. Those companies agreed to spend as much as $15 million for a surface cleanup, and EPA agreed to eliminate their responsibility for future subsurface cleanup, The issue of collecting money for groundwater cleanup (estimated at $15 million but quite uncertain), is not resolved; $5 million has been collected from some parties. A major issue raised in this approach is the question of whether it is technically possible and administratively reasonable to make a distinction between surface and subsurface cleanup.

Indeed, the case study has revealed that the negotiated surface cleanup was not technically sound. Although 1 foot of soil was removed, there is no reason to think that all contaminated soil was removed. No testing was done before or after the removal to demonstrate that all contaminated soil was removed. No cleanup goals were set for acceptable levels of residual contamination in the remaining soil. Leaving significantly contaminated soil at the site could worsen groundwater contamination over time. It should be noted that an early estimate judged that 5 feet of soil would need to be removed; removal of only 1 foot reduced removal costs substantially to about $8 million. The surface cleanup was completed in early 1984.

The surface cleanup simply extended the fundamental approach used from the beginning; that is, for the most part, cleanup consisted of removing wastes and contaminated soil from the site and sending them elsewhere for land disposal. The issue of future problems associated with land disposal sites that have received removed wastes has become important, as the problems with the technical soundness of and regulatory control over operating hazardous waste land disposal facilities have become more evident.

During 1982 and 1983, the SRC site was scored to determine its eligibility for placement on the NPL. The site received a relatively high score, in large part because an observed release of hazardous substances into both surface and groundwater was recognized, There are indications that there were problems with the attempts to assess air pollution from the site. The air route for migration of hazardous substances off the site appears to be the most troublesome one for the NPL scoring system.

The scoring of the site, results of various studies, and the need to supply alternate drinking water to some residents suggest that a potentially large, costly groundwater cleanup may be required. It is not clear yet, however, exactly what the extent of groundwater contamination is, what the difficulty and costs might be, what cleanup goals would be used, and what the effect of the surface cleanup has had on the groundwater problem. Nor is it clear if groundwater cleanup will be delayed until responsible parties agree to pay for it or whether Superfund will be used,

Finally, the Seymour site illustrates the concept of impermanent cleanups leading to high future costs (as discussed in chapter 3). About $12 million has been spent thus far at Seymour for initial responses involving site containment and waste removal, surface cleanup involving waste removal, and many studies and investigations, including the ongoing groundwater work. Nevertheless, no permanent cleanup can be said to have occurred. Future actions will be required, including a probable groundwater cleanup, a possible need to remove or treat much contaminated soil, possible cleanup actions at land disposal sites that have received wastes from Seymour, and continuing O&M costs for the water treatment plant. Altogether, future spending for this site is likely to surpass what has already been spent,

The Stringfellow Site

The Stringfellow Acid Pits site near Glen Avon, California, was used as a surface impoundment between 1956 and 1972, during which time over 30 million gallons of a large variety of liquid hazardous wastes were disposed there. The history of investigations and actions at Stringfellow is longer than at most Superfund sites. Much of the work, and many of the misinterpretations of the site hydrogeology, occurred before Superfund was even passed; EPA and Superfund are therefore late arrivals on the Stringfellow stage. However, just because the history is so long, and so much happened so early, this case study is especially rich,

Original geological studies concluded that the site was on impermeable bedrock and that, with the installation of a downstream concrete barrier, there would be no damage of groundwater contamination. Therefore, the canyon site was legally sanctioned as a hazardous waste facility. Subsequent information and events have revealed that the site was quite unsuitable for such a facility, and there have been substantial amounts of surface and groundwater contamination over a period of years. In fact, the site sits over the Chino Basin aquifer, a major source of water for drinking and other uses in an area serving about 500,000 people. Even now, it is not clear whether there is a far more serious groundwater contamination problem than previously recognized, but recent data suggest there is.

Early findings of groundwater contamination in 1972 were wrongly interpreted to be a result of surface water runoff rather than groundwater contamination. The same mistake was made by other consultants in 1977. Undue optimism about the suitability of land disposal sites for hazardous waste disposal is not uncommon, as detailed data on the characteristics of a location are usually lacking. One lesson to be learned from Stringfellow is that problems can arise from having many different consultants, contractors, and government agencies involved with cleanup studies and decisions. The record indicates problems with inadequate oversight of work by qualified government people, problems with redundant activities, and problems associated with conflicts among many local, State, and Federal agencies.

Now there is little doubt about the moving plume of contamination in the groundwater, and it is likely that it will enter the main flow of the Chino Basin sometime in 1985. Downgradient wells 1 mile and more from the site have revealed substantial contamination by toxic chemicals in concentrations sufficient for recertification of a drinking water supply. Alternate drinking water is being supplied to some local residents.

In 1977, the option of total removal of all contaminated liquids and solids from the site was estimated to cost $3.4 million. Two years later, after inaction and heavy rains, this option was still the preferred one, but the estimated cost was four times higher. A State agency, therefore, chose a lower cost option based on containment, which involved removing contaminated liquids and some contaminated soil, onsite neutralization of soil with kiln dust, placement of a clay cap, and installation of monitoring and interceptor wells to deal with groundwater. Both before and after this approach was implemented, large discharges of contaminated water from the site flowed into the downhill area of Glen Avon (800,000 gallons) and 4 million gallons of contaminated water was disposed of at considerable expense in a California land disposal site. This site (BKK in West Covina) is now recognized to be leaking as well and was closed recently to hazardous waste. The Casmalia Resources landfill that now receives 70,000 gallons per day from Stringfellow was fined recently by EPA for inadequately monitoring the groundwater. Thus, Stringfellow illustrates the problem of transferring risk from one community to another when cleanup is based on removal of wastes to land disposal sites.

Already about $15 million has been spent at the site and all concerned acknowledge that no permanent cleanup has been achieved. A permanent cleanup is still being studied by EPA, but its cost could be very high. The State estimates it would cost $65 million. A program for onsite treatment of contaminated groundwater is now underway. But this, too, is not a permanent solution. The OTA case study has concluded that the unfavorable hydrogeology of the site (e. g., fractured bedrock and underground springs) has frustrated all containment attempts to date. Therefore, a commitment is needed to excavate toxic wastes and contaminated soil, and store them onsite until the materials can be treated to render them as harmless as possible. As long as these materials remain in the ground it will be necessary to attempt to extract contaminated water and treat it at considerable O&M costs to the State. Even so, there may well be further spread of contaminated groundwater in the surrounding aquifer as extraction is not likely to be completely effective, It is not clear whether ongoing studies to determine a cost-effective cleanup are adequately considering total removal and treatment of hazardous materials. For about 15 years, dependence on land disposal and containment at the site has not provided either environmental protection or cost effectiveness, but it is still not clear that the cleanup solution preferred originally—total removal of all contaminated liquids and solids—is being seriously considered, since its near-term costs would be quite high.

In all likelihood the eventual cleanup costs for the site will far surpass what it would have cost some years ago to remove materials and even treat them. (The original plan was for removal followed by redisposal in land disposal facilities.) As time continues to pass, cleanup costs are likely to mount, and cleanup may become infeasible if there is widespread contamination of more soil and groundwater. Indeed, actions other than cleanup may have to be considered eventually. As in the previous case, much money has been spent on impermanent "cleanup" of the site with a high probability that much more money will be spent in the future for more permanent cleanup, expensive groundwater monitoring of a large aquifer, and possibly for cleanup of the site that has already received much waste from Stringfellow.

The Sylvester Site

The Sylvester site in Nashua, New Hampshire, was a former sand and gravel pit where hazardous wastes were dumped illegally along with solid wastes for 5 to 10 years through 1979, In addition to large quantities of non-hazardous materials, drums of hazardous waste, bulk materials, and liquids were disposed in a 3-to 4-acre area. Various consultants who have worked on the site used a figure of about 240,000 pounds for the total weight of hazardous waste deposited, based on an estimated 800,000 gallons of dilute liquid wastes, and exclusive of 1,314 drums removed from the site (see below). OTA finds that this figure could be a significant underestimate.

State officials are confident, however, that the figure of 240,000 pounds is substantially correct, based on: 1) affidavits submitted by several potentially responsible parties; 2) records of inspection and surveillance at the dump; and 3) exploratory test pits and borings in the solid materials in the pit above the water level. But the purpose of test pits and borings is to sample the site, not to examine all of it. Based on the number of solid samples, and what they contained, considerable amounts of waste could be present, but undetected, in the volume above the water level; that is, the possibility of a significantly higher figure for total hazardous waste deposited cannot be rejected with confidence on the basis of the sampling of solid material at the site. (Groundwater sampling seems to have well delineated the amount of hazardous materials currently in the groundwater.) State officials have put considerable confidence on the affidavits, inspection, and surveillance, and OTA cannot judge how well placed that confidence is. OTA notes, however, that various documents speak of the site being used for hazardous waste disposal for about 5 years, through late 1979, and agree that the site was used for waste disposal of some sort for 10 years. A legitimate question can be raised about how perfect inspections and surveillance were likely to have been over this long period. For example, such inspections and surveillance did not prevent illegal disposal of hazardous wastes at the site,

This site became eligible for Superfund cleanup because in 1980 a wide variety of hazardous substances were found in groundwater, surface waters, and air. It became clear that a plume of contamination had seeped into a brook which eventually fed into the Merrimack River, a source of drinking water for Lowell, Lawrence, and Methuen, Massachusetts. Several nearby private drinking water wells were also threatened, and air pollution threatened a nearby trailer park.

Early actions included supplying municipal water to replace the private wells, removal of 1,314 drums (roughly 70,000 gallons) that were visible and accessible from the surface for land disposal elsewhere, installation of a security fence and a number of groundwater monitoring wells, and, for about a year, operation of a groundwater interception and recycle system to delay further seepage of leachate into the nearby brook. The latter system has been restarted because of the delay in completing the chosen remedial cleanup and because there is an indication of greater than expected water flow off the site.

The strategy adopted to cleanup the site was to: 1) minimize the amount of water entering and leaving the site through use of a slurry wall around the area and a cap over it, and 2) clean up the contaminated groundwater and contaminated soil through a complex water treatment system. The latter system includes pumping contaminated groundwater downgradient of the site and discharging it upgradient, and treating contaminated water by several techniques to remove a variety of contaminants. On the one hand this strategy was bold and innovative. However, there are several uncertainties with this cleanup approach.

The slurry wall and cap system has been much less effective than anticipated, The design predicted a 95 percent reduction in water flow through the site, A year after installation of the cap and slurry wall system, measurements of the outflow showed only a 39 to 67 percent reduction of the original flow; that is, over five times as much water is flowing through the system as was predicted. A hydrogeological study is underway to evaluate this problem. On the basis of extensive modeling, the hydrogeological contractor believes that the cause of the leaky containment is water flowing under the wall, Some underflow was predicted because the bedrock is fractured, and the contractor and the State officials now think that the bedrock is more highly fractured than originally estimated. Another possible contributing factor is problems with construction during the installation of the wall. A further possibility, which State officials reject based on the hydrogeological modeling, is leakage through the wall because of the degradation of the wall by the contaminants in the water. The possibility of chemical degradation of the slurry wall has come up several times in contractor reports, and a recognized side-benefit of the water treatment systems is that the flows it sets up would protect at least part of the wall from the contaminated water in the site.

The reduced effectiveness of the containment system will not cause major problems if the treatment system removes the contamination to the degree predicted. The design of the treatment system assumes that nearly all contaminants will be flushed out during the relatively brief period (about 2 years) currently planned for treatment. However, to the extent that there is uncertainty about the quantity and particularly the nature of waste that may remain in the soil and in the portion of the site above the water level, there *is* uncertainty about the long-term effectiveness of the groundwater cleanup. The cleanup may succeed in removing contaminants from groundwater in several years, as the operation of the pilot plant indicates, and still leave waste that will leach out over time, recontaminating groundwater. If this should occur, the containment system will not be capable of preventing the new contamination from flowing offsite. Prudence suggests that extensive monitoring of groundwater will be needed at Sylvester for a long time, and that a contingency plan be developed to deal with recontamination should it occur.

The cleanup goals established for the site required a hundredfold reduction in the release of contaminants from the site. The goals were based on: 1) meeting the acceptable lifetime exposure level for inhalation of chloroform, the most serious of the airborne pollutants from the site; and 2) meeting water criteria at the Lowell intake of the Merrimack River, with arsenic as the chemical of greatest concern.

This attempt to set explicit goals was commendable. As EPA and the State recognize, however, the early emphasis on arsenic was misplaced, The background levels of arsenic in the area are very high; the arsenic levels in the Merrimack are about 1,000 nanograms per liter (rig/l), and the contribution of Sylvester to Merrimack of arsenic would be only about 15 rig/l. This contribution is relatively unimportant, and by itself, probably not worth the cost of stringent cleanup. However, there are several other toxic chemicals predicted to exceed water quality criteria at the Lowell intake, and other toxic chemicals at high levels for which criteria have not been formulated; the background levels at Lowell for these are likely to be lower, relative to the Sylvester contribution, than is the case for arsenic. If so, these chemicals are appropriate ones on which to formulate cleanup goals based on water quality. When only the chemicals for which water quality criteria exist are considered, the cleanup goal is similar to that originally proposed on the basis of arsenic.

In the case of Sylvester, it is not yet possible to evaluate the effectiveness of the cleanup strategy. If State officials are correct in their estimate of the nature and quantity of the hazardous waste disposed at Sylvester, the cleanup will be permanent. If not, future costs could raise the total cleanup costs significantly above the currently estimated $13 million,

Other Case Studies on Completed Cleanups

Recently a study was performed on six NPL sites cleaned up under the Superfund program. These six sites had fewer problems than the OTA case study sites, but they too can be instructive.[8] The report questions the widespread impression that the Superfund program has permanently cleaned up six dangerous hazardous waste sites. According to its evaluation, which OTA finds valid, there were thorough cleanups at two of the sites (Chemical Minerals Recovery and Walcott Chemical) which posed only minor hazards. A thorough cleanup was done at the Luminous Processes Site, but some problems remain, including the need for medical testing of former workers exposed to radium. But actions at three sites (Chemical Metals Recovery, Butler Tunnel, and the Gratiot Country Golf Club) have not been permanent cleanups. Surrounding communities still could be exposed to serious hazards, and future cleanups may be necessary.

The Luminous Processes, Inc., facility (Athens, Georgia) was a radioactive watch and clock dial painting operation initially licensed by the Atomic Energy Commission in 1952. The plant used considerable quantities of radium until it was forced to close in 1978 due to repeated violations of Federal and State regulations. The company was also required to decontaminate the facility, which was heavily contaminated with radium-226. Investigation and limited removal of contaminated materials began in 1979. However, most of the cleanup was accomplished with Superfund assistance, This work began in 1982, 3 years after the site was abandoned by Luminous. Overall, the study finds a thorough job was done. About 15,000 cubic feet of radioactive soil was barreled and transported to a low-level radiation facility in Richland, Washington. The building was also cleaned. A slab of concrete was removed from the floor; testing revealed that soils below the building were not contaminated, The study does point out that monitoring and cleanup may have missed contaminated layers below the level of testing (3 feet in most cases). No monitoring of test wells was conducted to detect potential radiation at deeper levels or possible groundwater contamination. Furthermore, the grounds were not surveyed for the possibility of waste burial, a frequent practice at many plants. Also, there has been no medical testing of former employees for radium contamination effects.

The Chemical Minerals Recovery site (Cleveland, Ohio) was a warehouse that had been used for less than 1 year as a temporary storage facility. The warehouse was closed down by judicial order after a fire, It was near collapse, and contained 700 drums of various chemicals, plus another 700 drums outside. Both the company and the property owner refused to clean up the site. EPA approved immediate funding of $205,000 in November 1981. The removal was completed in May 1982. There was little reason to believe that significant amounts of chemicals had been spilled

[8] R. C. Bird, Jr., and M. Podhorzer, "Evaluations of the Six National Priority List Sites Delisted by the Environmental Protection Agency" (Washington, DC: National Campaign Against Toxic Hazards, Oct. 24, 1984).

into the ground or remained below the surface, Cleanup in this case consisted of removal to another land-based facility.

The Walcott Chemical Co. site (Greenville, Mississippi) consisted of two warehouses. Both were in poor condition, but only one was designated as a Superfund site. It became an NPL site because the State chose it as its priority site, not because it scored high enough. The first problem with the site in April 1981 occurred when a fire official filed a fire and explosivity hazard complaint. EPA investigated the site in July 1981 and soon thereafter the property owner cleaned up the site by removing the wastes to a land disposal facility, There was no evidence of spilled materials and in July 1982 the site was judged clean.

The Butler Tunnel (Pittston, Pennsylvania) cleanup dealt with discharges of oily wastes into the Susquehanna River, but not with the remaining wastes and contamination in the tunnel itself. The initial incident occurred in July 1979 prior to the Superfund program. At that time, tens of thousands of gallons of wastes began discharging from the old coal mining tunnel; discharges continued through March 1980. Pollution was detected in the drinking water of Danvers, 60 miles downstream. Federal funding for the response came entirely from funds provided under Section 311 of the Clean Water Act. The original discharge drew a quick and thorough response, EPA and State agencies cleaned up the large spill on the river and took steps to monitor and prevent future damage. Substantial evidence exists, however, to indicate that significant quantities of toxic chemicals still exist in the tunnel, These pose threats to residents living above the tunnel, Cyanide gases in dangerous concentrations have reached the surface through boreholes to the tunnel, which are common in the area and, for the most part, not tested. In June 1980, EPA believed that it had identified the location of the "mother lode" of the wastes in the tunnel, but funding was suspended. Further cleanup was abandoned, In 1983, the State investigated whether dangerous chemicals from sediment contamination may be accumulating in fish, which are caught and eaten, The study has not been made public,

The Gratiot Country Golf Club site (St. Louis, Michigan) was a sanitary landfill; cleanup consisted of relocating the problem. The Velsico Chemical Co. used the 3,5-acre site on the Pine River to dump and burn toxic industrial chemicals between the 1930s and 1970s. In November 1982 Velsico signed a consent agreement with the State and EPA, under which it agreed to spend $38 million to clean up the site and two others across the river. Velsico was to remove soil to a level of 3 feet below where any chemicals were identified through testing. About 68,000 tons of soil were removed to the company's site across the river, where they were placed on a clay liner and under a clay cap. In other words, wastes were land disposed in a sensitive area. In addition, 1.25 million gallons of contaminated water were disposed of in a deep well, raising questions about future leakage. The company was not required to conduct a health effects study, nor was it required to consider the feasibility of removing highly toxic chemicals from river sediments. Even now, for 60 miles downstream, the State warns against fish consumption.

The Chemical Metals Industry site (Baltimore, Maryland) consists of two properties in a commercial and residential section, on both sides of a group of 20 row houses. Initially, there were reported complaints of eye, nose, and throat irritation during spills that occasionally forced residents to leave. There were also burns to children and animals playing in the area, and runoff into one of the neighboring basements. The company never had a permit to handle hazardous materials, and it was shut down in August 1981, EPA investigated the facility, determined that it presented an immediate threat, and that it warranted an immediate removal action. Approximately 1,500 drums of hazardous materials were removed for land disposal, Significant levels of contamination were detected as deep as 15 feet, but less than 1 foot of the contaminated soil was removed for disposal. No action was taken to intercept the migration of chemicals into groundwater, despite evidence of contamination. Although local residences do not use the groundwater, there is a threat of contamination of the Gwynn Falls tributary. It is also likely that toxic gases are escaping into neighboring basements.