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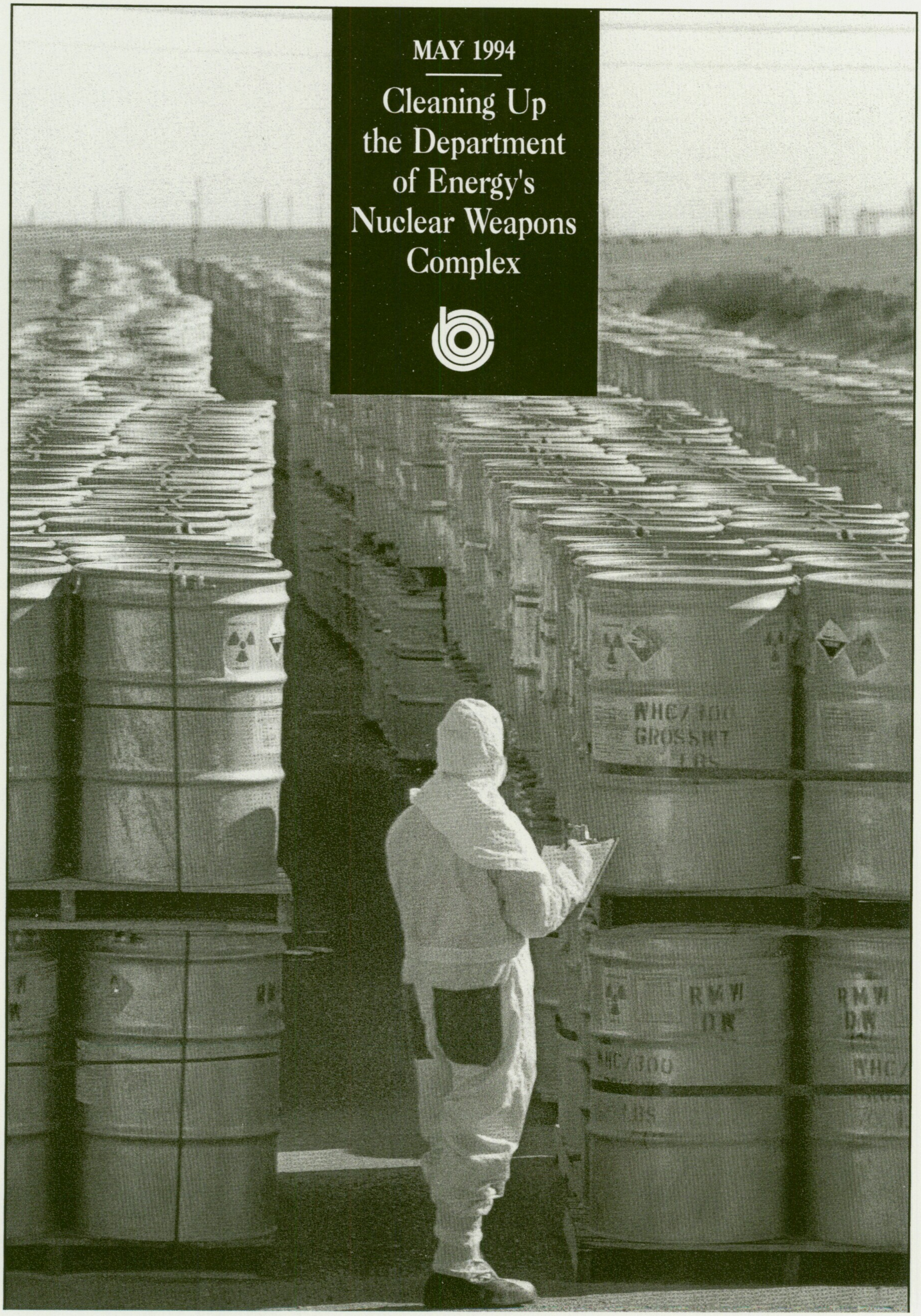
Cleaning Up the Department of Energy's Nuclear Weapons Complex



CLEANING UP THE DEPARTMENT OF ENERGY'S NUCLEAR WEAPONS COMPLEX

The Congress of the United States
Congressional Budget Office

NOTES

Unless otherwise indicated, all years referred to in this report are fiscal years.

Numbers in the text and tables may not add to totals because of rounding.

Cover photo shows drums of low-level radioactive waste stored on an asphalt pad in a trench at the Hanford nuclear facility in Richland, Washington. (Photo courtesy of the Department of Energy.)

Preface

The Department of Energy faces daunting challenges as it attempts to correct the environmental problems that exist throughout its nuclear complex. As DOE's budget for its Environmental Restoration and Waste Management program has grown, so has Congressional concern about how DOE intends to carry out its cleanup plan. This study, which was requested by the Chairman of the Department of Energy Defense Nuclear Facilities Panel of the House Committee on Armed Services (now known as the Military Application of Nuclear Energy Panel), examines the key issues that bear on the potential costs of DOE's cleanup program. In keeping with the Congressional Budget Office's (CBO's) mandate to provide objective analysis, this study makes no recommendations.

Elizabeth Pinkston of CBO's Natural Resources and Commerce Division and Frances M. Lussier of the National Security Division wrote the study under the general supervision of Robert Hale, Jan Paul Acton, Neil Singer, and Roger Hitchner. Elizabeth Pinkston was the primary author of Chapters 1, 2, and 3 and Appendixes A and B. Frances Lussier was the primary author of Chapter 4 and Appendixes C and D.

The authors would like to thank Perry Beider, Wayne Glass, Elizabeth Chambers, Douglas Elmendorf, and Kim Cawley of CBO for their valuable assistance. The study also benefited from the contributions of many people outside CBO. Paul Portney, Jonathan Gledhill, Mark Holt, Peter Johnson, and John Morrall made helpful comments on the draft. Though space constraints do not permit naming all of the DOE staff and contractors who responded to numerous requests for information, the authors would especially like to thank Eli Bronstein, Robert Muller, and Beverly Heffernan, who provided many updates to budgetary data. (The assistance of external participants implies no responsibility for the final product, which rests solely with CBO.)

Sherry Snyder edited the report, and Christian Spoor provided editorial assistance. Judith Cromwell, Gwen Coleman, and Donna Wood typed numerous drafts. Kathryn Quattrone, with the assistance of Regina Washington and Martina Wojak-Piotrow, prepared the study for publication.

Robert D. Reischauer
Director

May 1994

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Summary

A half century ago, the United States initiated a massive effort, cloaked in secrecy, that produced the most powerful nuclear arsenal in the world. Fifty years later, much of the production capacity is no longer needed, but a legacy remains in the form of vast quantities of nuclear and other types of hazardous waste. As the demands for production of nuclear weapons decrease, the Department of Energy (DOE), which now manages both the production of nuclear weapons and the cleanup effort, will increasingly turn its attention to the problem of cleaning up its complex.

DOE's Cleanup Program

The nuclear complex of the Department of Energy consists of 15 major facilities or installations spread over 12 states. Today that complex holds in storage over 100 million gallons of highly radioactive waste, 66 million gallons of waste contaminated with plutonium, and even larger volumes of waste with lower levels of radioactivity. In addition, radioactive and other hazardous substances have contaminated soil and groundwater at DOE's installations. Although some of DOE's environmental problems involve conventional contaminants that are common to many cleanup tasks, the vast majority of its pollutants contain some level of radioactivity and so pose challenges unique to DOE. The department has committed itself to meeting all applicable legal requirements by the year 2019.

In 1989, DOE created the Office of Environmental Restoration and Waste Management (EM), which has primary responsibility for cleanup activities. Since its inception, the office has experienced rapid budget increases. Its budget has risen from $1.6 billion in 1989 to more than $6 billion in 1994, exceeding the funding for the production and maintenance of nuclear weapons for that year. Funding devoted to the cleanup program is projected to continue to increase, rising to more than $7 billion by 2000, based on the Administration's out-year targets.

How much the cleanup program will ultimately cost taxpayers is unknown. In 1988, DOE estimated that the cost would be between $66 billion and $110 billion, but estimates keep rising. In 1993, DOE officials suggested the cost could range from $400 billion to $1 trillion. But no one can make an estimate with any degree of confidence until the Congress and regulators clarify the ultimate goals of the program, which include reducing health and safety risks to humans and mitigating damage to the environment. The goals may also include restoring sites to make them available for other uses--industrial, commercial, residential, or recreational. Setting goals and priorities will help determine the specific steps DOE must take to achieve them, which will permit more accurate cost estimates. In turn, such estimates can help set priorities among the various cleanup options.

Factors Contributing to the Growth of the Cleanup Program

Several factors have contributed to the rapid growth of the EM program. As the need to produce nuclear weapons has decreased, responsibility for some DOE facilities and programs for managing associated waste have been transferred from the production program to the EM program. Another factor is the increasing number of regulations that govern how DOE operates. Until the 1980s, DOE maintained that the Atomic Energy Act, which it administered, took precedence over other environmental and safety laws and regulations. Now, however, the department concedes that it must accommodate many legal constraints established outside DOE. It must comply with national laws governing environmental impact statements and cleanup plans, and it is also subject to state environmental laws and related requirements. Finally, many specific requirements are set forth in agreements between DOE, the Environmental Protection Agency, and state regulatory authorities. Many of these agreements contain schedules and timetables for the start and finish of cleanup activities at DOE's various sites.

Budget Constraints

While DOE's cleanup responsibilities have increased, the size of the budget function for national security, which includes the bulk of DOE's cleanup budget, continues to decrease in real terms in the aftermath of the Cold War. Although DOE has received most of the cleanup funds it has requested from the Congress, that situation could change. Indeed, in 1994 the Congress appropriated approximately $300 million less than DOE requested for its cleanup program. To accommodate budgets that may no longer rise as rapidly as in the past, the department may have to revise the priorities for its EM program and seek more efficient means of carrying it out.

Establishing Goals and Priorities for the Cleanup Program

Policymakers need to establish realistic goals and objectives for the cleanup effort. Returning all DOE sites to a pristine state by 2019 is clearly not realistic, given the presence of such contaminants as long-lived radioactive materials and substances that persist in groundwater.

There is general agreement that DOE should promptly eliminate imminent hazards to the public, and DOE is moving to do so. For the remainder of the program, however, the Congress and DOE need to decide what to do and when to do it. They must grapple with the question of whether DOE should attempt to minimize all risks to human health and the environment, regardless of cost, or whether some amount of risk is acceptable. Moreover, they must recognize that eliminating some risks will inevitably increase others. For instance, transporting hazardous wastes for disposal entails the risk of a catastrophic accident. Policymakers also need to determine the ultimate use of each site and how quickly to restore it to an alternative use.

Understanding Risks

To make informed decisions, DOE will need better information about the risks posed by the hazardous substances within its complex. Polls suggest that the public perceives hazardous waste sites to be extremely dangerous. The negative publicity associated with Love Canal and Times Beach, for example, help explain that concern. But two recent reports published by the Environmental Protection Agency (EPA) suggest that hazardous waste sites rank considerably lower in risk than many other environmental problems. In one report, experts within EPA attempted to assess the relative risks of a number of environmental problems, such as hazardous waste sites, air pollutants, discharges of contaminants into drinking water, and exposure of workers to chemicals. These technical and policy experts ranked the problems in terms of four categories of risk: cancer risks, noncancer health risks, ecological damage, and risk to economic welfare. In none of the four categories did hazardous waste sites such as those within the DOE complex rank among the worst problems. The second report, by EPA's Science Advisory Board, identified some important shortcomings in the first report but did not dispute its relative rankings of health risks.

These studies raise questions about how much of the limited public funds available for environmental cleanup should be devoted to hazardous waste sites such as DOE's. Both of the EPA studies emphasize, however, that their results are not conclusive, because information about risks is limited. Better information is clearly needed so that policymakers can make informed decisions about how to allocate resources for cleanup activities. For example, it would be helpful to have more definitive studies regarding the long-term effects of substances found at DOE installations on the health of the public and the environment. DOE also needs to have a better idea of which hazardous substances are found at its installations and whether or not they are migrating off-site. To this end, DOE has initiated an effort to evaluate the information available about risks to human health and the environment and to fill the gaps in knowledge in order to develop a comprehensive strategy for reducing risks. The National Academy of Sciences is assisting with this effort.

Only after such information is available can DOE show that it is making the appropriate choices based on scientific evidence and so continue to win both Congressional and public support for its cleanup program. This problem is not unique to DOE; the Environmental Protection Agency and the Department of Defense need similar information, and any efforts to gather that information should therefore be collaborative.

Estimating Costs

To establish priorities among cleanup projects by comparing benefits and costs, DOE must have reliable estimates of the cost of those efforts. The accuracy of such estimates depends, however, on understanding the difficulty of cleanup efforts, and cleaning up some DOE sites involves highly complex problems with which DOE has little previous experience.

The department's ability to estimate costs should improve as it gains more information concerning the extent of the cleanup problem it faces. As DOE performs more assessments of the contaminants at its installations, it will have a better idea of the scope and seriousness of the cleanup task. Also, as DOE gains more experience with initiating and completing specific tasks associated with the cleanup, it will have more cost data on which to base subsequent cost analyses. Finally, DOE has undertaken some initiatives to improve its ability to estimate costs. They include a benchmarking initiative to identify causes of cost growth in DOE cleanup projects, and a performance tracking system designed to monitor the cost of projects over time.

Weighing Benefits and Costs

With more information about costs and risks, DOE can decide how to allocate funds among the various cleanup tasks. For each site requiring cleanup, DOE can employ benefit-cost analysis to help determine whether remediation is needed immediately, can be delayed, or can be avoided. The analysis should look at several factors: the cost; the benefit in terms of reduced risk to workers, the public, and the environment; and alternative uses of land and facilities that are not currently available to the public. The department could thus identify and proceed with those tasks that, for each dollar spent, provide the greatest benefit in terms of these criteria.

The Hanford Example. In late 1992, DOE released an analysis of the alternatives for disposing of eight surplus reactors at the Hanford site in Washington State. That analysis is subject to many substantial uncertainties about costs and risks, but it illustrates the effects of choices related to the cleanup program.

The department considered several options: maintaining the reactors in place indefinitely and monitoring them to ensure safety; removing them immediately for disposal at another Hanford location; and removing them to the disposal location after 75 years. It also considered whether to move the reactor blocks intact or to dismantle them first.

DOE anticipated that the cost of removing the reactors would be about the same regardless of whether it was done now or many years later. In the time leading up to removal, DOE would incur maintenance costs, but they would be relatively small. When future costs are discounted, however, the savings from delaying removal of the reactors are substantial.

How delay would affect risks is somewhat more complicated. Removing the reactors immediately would entail additional exposure of workers to higher levels of radioactive material; delaying removal would lower that risk by allowing some of the radioactive material to decay. Leaving the reactors in place indefinitely, however, could expose the population to the potential risks of radioactive contamination. But even if the buildings fell into disrepair or were abandoned, DOE estimated that just 20 additional cancer deaths would result over a period of 10,000 years. To put that figure in perspective, an estimated 400,000 people will die from cancer in 1994 in the United States. Weighing all these factors, DOE opted for one-piece removal of the reactors after a period of 75 years.

Similar Choices Elsewhere. Benefit-cost analyses are not available for most DOE cleanup sites. In many cases, DOE does not yet know the nature and extent of contamination at its facilities, nor does it have sufficient information to make reliable projections of risks or costs. Nonetheless, the type of analysis performed for the Hanford reactors is a useful tool for establishing priorities among the department's cleanup tasks.

Involving Citizens in Setting Priorities

Weighing the benefits and costs of options for cleaning up the DOE nuclear complex requires the involvement of citizens affected by the cleanup, including taxpayers, workers at the facilities, neighbors whose environment is affected, and concerned members of the public at large. They can help evaluate the benefits of various cleanup options by indicating how much they value them. Their preferences about risks and land use are key factors in making trade-offs. For instance, some communities may consider it more important to clean up a facility to a standard acceptable for industrial use--and make it available for manufacturing jobs--than to remove every trace of contamination. Others may place greater value on restoring the environment to its pristine condition. Incorporating such preferences into a benefit-cost analysis can guide decisions about setting priorities and determining the level of cleanup to be done.

DOE has stepped up efforts to increase public involvement in establishing cleanup policies. It is participating in an endeavor known as the Keystone process that attempts to improve communication between citizens and the federal agencies responsible for cleaning up hazardous waste sites. Among other things, this effort provides a forum for discussing priorities under constrained budgets.

Improving the Efficiency of DOE's Cleanup Program

While DOE gathers information and performs the analyses necessary to set priorities, it must also continue to manage its ongoing cleanup efforts. Several policy changes might make those efforts more efficient.

Place Greater Emphasis on Technology Development

Current methods of cleaning up contaminants, which usually involve digging up soil or pumping out water, are time consuming and costly, particularly for pollutants that have found their way into the groundwater. To develop techniques for characterizing and cleaning up sites more quickly and cheaply, DOE established the Technology Development program. In its budget request for fiscal year 1995, DOE has allocated 7 percent--$426 million--to that effort.

It may be appropriate, however, to invest even more funds in efforts to develop cheaper means of cleanup. DOE should add funds only for promising technology programs--those for which the present value of the cost savings and other benefits associated with the new technology exceed the cost to develop it. DOE and other organizations have identified some programs that may meet this test. Candidates include research into methods to clean up heavy metals and techniques for removing from the soil or groundwater those dense organic compounds that are not soluble in water.

New technologies may be able to make the cleanup effort cheaper in the long run. DOE claims that using new rather than current technologies could reduce the costs of some cleanup activities by as much as 80 percent. During the entire cleanup process, savings for the whole complex could approach $100 billion from a total cost that could be as high as $1 trillion. These estimates are, of course, subject to great uncertainty, but their size suggests that new technologies could have major effects on costs.

How much additional funding for technology development might be appropriate? A definitive answer would require a detailed analysis of candidate projects, which is beyond the scope of this study. But DOE and the Congress have both established 10 percent of the total cleanup budget as the goal for funding technology development. To meet that goal at the budget levels proposed by the Administration, DOE would have to add $200 million to its funding for technology development in 1995 and increasing amounts each year, with $250 million more needed in 2000. Since many of DOE's cleanup problems are similar to problems confronted by the Environmental Protection Agency and the Department of Defense, some of the additional funds might be directed to agencies other than DOE.

Regardless of which agency controls the money, the personnel to carry out added development efforts could come from a variety of places, including DOE's national laboratories and other research organizations whose defense funding is declining. Any added funds provided under this option, however, should be spent on research. Of the funds requested for technology development for 1995, about 40 percent are earmarked for programs not directly involved in research and development. If development funds are increased, the Congress could direct that all added funds be spent only on promising projects for technology development rather than on increases in administrative or support costs.

Before adding funds for technology development, the Congress may also want to direct that DOE implement a new management system to improve tracking of the costs and schedules of cleanup projects. The new system might be patterned after one now in place in the Department of Defense to track major weapons programs. For each major weapon system, the Defense Department's system establishes four milestones, each with its own costs and deadlines. Periodic reports compare progress against those goals. DOE could establish a similar system for major cleanup projects. Its milestones might start with the designation of a new cleanup site and extend until remedial work begins.

Delay Technically Difficult Characterizations and Remediations

While DOE develops new technologies to perform cleanup tasks more cheaply, the department could delay projects that are costly and time consuming to accomplish with current technology. Delaying these projects would save money in the short term and, if more efficient technology became available, could also reduce long-term costs.

Through a detailed analysis of the Environmental Restoration program's five-year plans, the Congressional Budget Office (CBO) determined that DOE could spend as much as 30 percent of its budget, on average, for environmental restoration activities over the next six years on projects that may be difficult to accomplish with current technology. These projects include characterizing very large sites or buried waste, cleaning up contaminated groundwater, remediating soil contaminated with radioactive substances or heavy metals, and decontaminating and decommissioning surplus buildings.

Delaying these technically difficult projects until more efficient technologies are available could reduce costs substantially, but CBO cannot examine each of these projects in detail to determine which can be performed at reasonable cost with today's technology. To illustrate the budgetary effect of delaying some projects, CBO examined the impact of reducing funding for all of the difficult projects by 50 percent over the next six years. The resulting savings would increase from $270 million in 1995 to $300 million in 2000. The savings could be returned to the Treasury, or they could be used to offset the added cost of increased investment in technology development.

DOE is proceeding with some of these difficult tasks, even in the absence of techniques to accomplish them efficiently, because it is bound by many agreements concerning the conduct of its cleanup program. Most of these agreements contain schedules and deadlines that determine when DOE must begin cleaning up certain sites. Delaying some projects, as envisioned in this option, would result in the breach of some of these agreements. But many agreements were signed in the early stages of the cleanup, before DOE knew the extent and type of contamination it faced. The Environmental Protection Agency, the states, and other parties to the agreements therefore might be amenable to renegotiating them if they felt that DOE was making a good-faith effort to find better ways to address mutual problems. Indeed, a recent renegotiation of the agreement governing cleanup of Hanford delayed treatment of highly radioactive waste stored in tanks by 10 years. DOE conceded that it could not meet the deadlines established in the original 1989 agreement. Through renegotiation with the EPA and state regulators, DOE established a new set of priorities and deadlines acceptable to all parties to the agreement.

Reduce Funding for Administration, Support, and Management

DOE may also need to improve the efficiency of its cleanup efforts. Since 1989, the department's Office of Environmental Restoration and Waste Management has received about $23 billion from the Congress to spend on the cleanup program. DOE has been severely criticized because of the small amount of visible cleanup that has been accomplished. Some of the slow start reflects the difficulty associated with beginning a new operation and the need to devote substantial sums to assess the nature and extent of cleanup problems. But DOE may also be devoting too much of its budget to administration and support, thus limiting the funds available for actual cleanup work.

Several reviews of DOE's costs for cleanup activities have concluded that EM devotes a large proportion of its funds to administrative and support functions. Three reviews, one by the Army Corps of Engineers and two performed under contract to DOE, have found that contractors charged the EM program project overhead rates of 20 percent to 28 percent. These rates were higher than those charged to private industry or other government agencies--in some cases by as much as a factor of 4 and 2, respectively. CBO and the Corps also found that roughly 20 percent more of EM's funds were being used to provide programwide support (such as program direction) and installationwide activities (such as security and utilities). All told, at least 40 percent of EM's funds are devoted to administrative and support activities, a level that many reviewers have considered excessive.

One of the analyses requested by DOE recommended a 7 percent reduction in the EM budget to reduce spending for project overhead, and the Corps recommended a 25 percent overall cut. If administrative costs were cut by 25 percent, the total EM budget would be reduced by 10 percent, a reduction that is toward the lower end of the range recommended by the two reviews. A reduction of this magnitude would yield savings of $630 million in 1995. Annual savings would increase to $710 million in 2000, based on the Administration's out-year targets for EM spending. The funds freed up by reducing funds devoted to administration and support could be used either to reduce the deficit or to accelerate cleanup activities.

Various studies and the Assistant Secretary for EM, Thomas Grumbly, have suggested ways to achieve such savings. One suggestion is to increase the number of DOE personnel in order to provide better oversight of DOE's large number of contractors. In the EM program alone, more than 49,000 contractor personnel are engaged in cleanup, overseen by fewer than 1,800 DOE personnel. Grumbly has proposed adding 400 DOE personnel to monitor contractors and perform some functions that are contracted out but would be more appropriately performed by government staff. He predicted that increased oversight would save $360 million in 1995.

Another means of reducing administrative spending, particularly for contractor overhead, is through contract reform. Such reform would involve changes in DOE's contracts with the firms that manage its installations. Particularly with respect to contracts for environmental work, Grumbly recommends limiting the time period covered by the contracts, issuing separate environmental contracts at those installations where production is ongoing, and making individual contracts for some functions such as security or road maintenance. Grumbly is also actively pursuing this approach and predicts savings of 10 percent to 20 percent in EM spending on contracts--which represents the vast majority of EM spending--over the next four years as a result of increased oversight and contract reform combined.

Safely Maintain DOE's Surplus Facilities

The end of the Cold War and the restrictions on strategic arms that have resulted from international treaties have made much of DOE's nuclear weapons complex unnecessary. DOE could declare as many as 7,000 of its facilities surplus in the next 30 years, leading to their eventual decontamination and decommissioning. In the meantime, the EM program is responsible for the security and maintenance of an increasing number of surplus facilities.

In a recent report, the General Accounting Office concluded that the EM program faces problems concerning maintenance, safety, and costs for the disposition of its surplus facilities. Since maintaining inactive facilities is not a high priority among EM's tasks, DOE's inactive facilities are deteriorating physically. Repair projects for surplus buildings are often deferred in favor of higher-priority work elsewhere. As a consequence, conditions at such buildings have violated regulations established by DOE and the Occupational Safety and Health Administration and have resulted in accidents among workers.

Furthermore, DOE has engaged in some practices that can increase the cost and dangers associated with cleaning up inactive facilities. Incomplete or substandard work performed during the shutdown process can lead to unanticipated problems or accidents during subsequent decontamination and decommissioning. Inadequate shutdown procedures can also affect the cost of cleanup projects. For example, because equipment was not cleaned when the plutonium fuel facility at Savannah River was put on standby in 1983, it is now so badly deteriorated that it can no longer be used to remove the plutonium that remains in the facility. As a result, DOE has estimated that an additional $115 million will be needed to decontaminate and decommission the facility. Had the facility initially been cleaned adequately, subsequent higher cleanup costs could have been avoided.

In general, the cost to maintain surplus facilities awaiting cleanup is substantial and could grow because of problems of the sort just noted. Increasing near-term funding designed to attain safe shutdown status at surplus facilities, thereby reducing annual security and maintenance costs, could produce long-term savings in the DOE budget.

Conclusion

DOE's cleanup program must address a problem created and, for the most part, ignored over the past 50 years. It must do so during a period in which funding for all federal programs, including environmental cleanup, is becoming increasingly tight. Better understanding of risks and costs, brought together by benefit-cost analyses, would be the best means of establishing priorities for allocating scarce cleanup funds. DOE may also be able to improve the efficiency of its cleanup efforts by policies such as investing more heavily in technology development, delaying technically difficult projects, and cutting overhead costs. New management systems may also be necessary to permit DOE and the Congress to track the performance of cleanup projects.

Chapter One

Overview of DOE's Environmental Problems

The Department of Energy (DOE) presides over a vast complex of facilities with massive environmental problems. These problems have accumulated over the past 50 years as a by-product of producing nuclear weapons. From the inception of the Manhattan Project in 1942 through the 1980s, DOE and its predecessor agencies focused on developing, producing, and testing nuclear weapons. Protecting environmental safety and health took a back seat to that primary mission. In recent years, however, concerns about environmental contamination have mounted. At the same time, the end of the Cold War has diminished the perceived urgency of maintaining ambitious production goals. Together these factors have led to a shift in emphasis from production to environmental cleanup.

The nuclear weapons complex consists of 15 major facilities and a dozen or so smaller facilities at which production, research, and testing have occurred over the past five decades. In addition, DOE is responsible for environmental cleanup at thousands of sites formerly used in the weapons program and sites where uranium was processed. Altogether DOE must contend with more than 100 million gallons of highly radioactive waste, 66 million gallons of waste contaminated with plutonium, and larger volumes of low-level radioactive waste. It also must deal with huge volumes of other toxic materials, including heavy metals, chemicals used as solvents, acids, and other materials that are difficult and costly to clean up.[1]

Six of DOE's 15 major facilities--Hanford, Savannah River, Oak Ridge, Fernald, Idaho National Engineering Laboratory, and Rocky Flats--account for more than 60 percent of the budget of DOE's environmental cleanup program. Hanford alone is responsible for nearly a quarter of the budget. The major facilities are shown on the map in Figure 1 and are profiled in Appendix A.

Although all of the weapons facilities present cleanup challenges, they differ in ways that may affect goals, methods, and timetables of cleanup efforts. Some facilities are near population centers where releases of toxic materials might pose imminent hazards to public health; other facilities are remote and present less near-term risk. Yet the latter may still impose long-term effects on human health and the environment. Soil and drainage conditions vary, leading to differences in how toxic releases might migrate into the groundwater and ultimately to supplies of drinking water. All of these factors affect both the costs and benefits of cleanup.

The potential cost to the federal government of cleaning up the nuclear weapons production facilities is large, and the cost estimates keep rising. No one knows what the ultimate cost will be, in part because the dimensions of the problem are still not clear. One estimate widely cited is $160 billion over the next 30 years--assuming technological breakthroughs to reduce the costs of dealing with radioactive wastes. Recently, however, the head of the cleanup program has referred to that effort as "our trillion-dollar program."[2]

1. A thorough description of the nuclear facilities and their environmental problems is contained in Office of Technology Assessment, *Complex Cleanup* (February 1991).

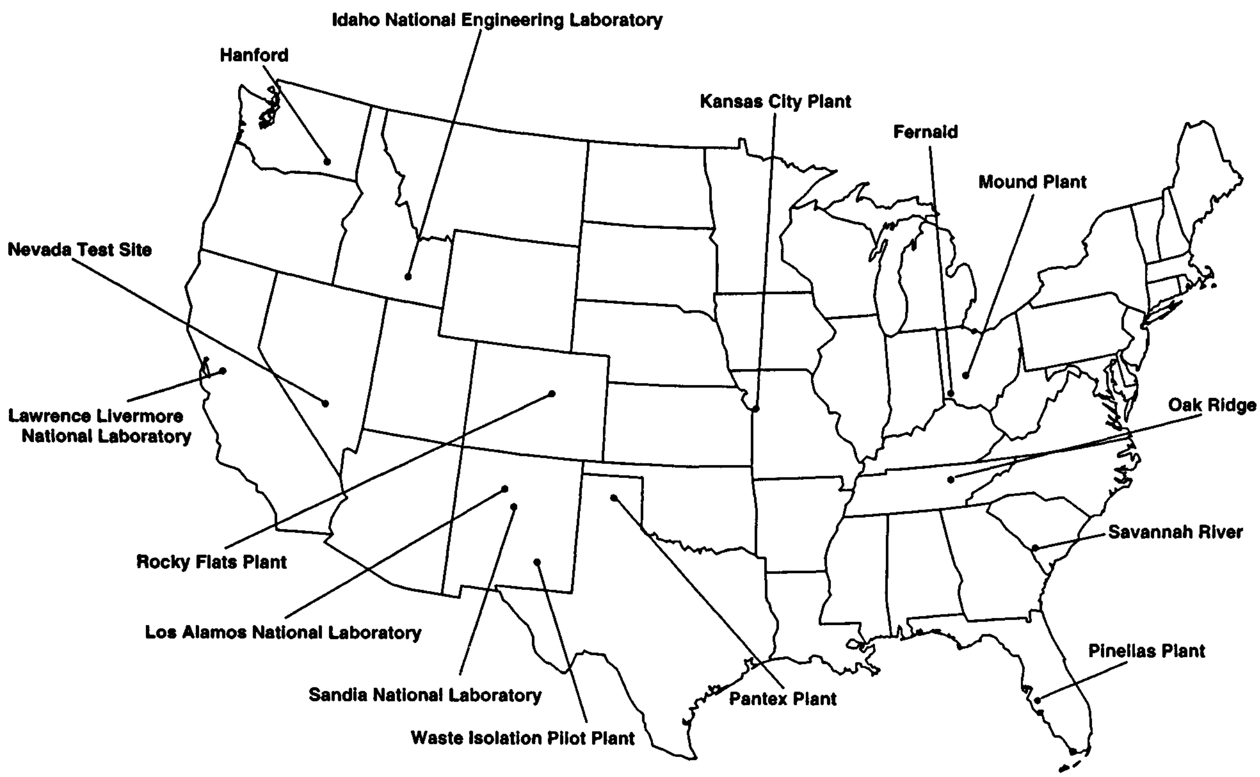
2. Thomas Grumbly, Assistant Secretary of Energy for Environmental Restoration and Waste Management, as quoted in *Inside Energy/with Federal Lands* (newsletter published by McGraw-Hill, Inc., New York, July 19, 1993), p. 10.

People do not even agree on what is meant by "cleanup": some argue that the term should refer only to environmental restoration of sites that are no longer in use; others would have it include such activities as managing wastes currently being generated and developing technologies to promote environmental goals. This study adopts the broader definition, which encompasses all the activities of DOE's Office of Environmental Restoration and Waste Management--the office charged with the prodigious task of planning and managing environmental policies for the weapons complex and for some nondefense nuclear facilities.

The Office of Environmental Restoration and Waste Management spent $13.8 billion from 1990 through 1993. Most of this money has been used for managing waste streams associated with ongoing operations. At inactive waste sites designated for cleanup, most of the work to date has been to characterize the contaminants and assess what remedial work is needed.

The relatively small amount of visible results has led to complaints that DOE is wasting money. DOE may have promised too much early in the program, before realizing the extent and complexity of its contamination problems. The department also may have been overly optimistic about technological breakthroughs to aid in assessing and cleaning up waste sites and overly ambitious in agreeing to meet certain goals and schedules. A reassessment of program objectives and priorities could result in a redirection of resources to achieve greater environmental benefits.

Figure 1.
Department of Energy's Weapons Complex



SOURCE: Congressional Budget Office.

The cost of DOE's cleanup program largely depends on the ultimate goals. One goal is reducing health and safety risks to humans and damage to the environment. Another is restoring land and making it available for other uses, which could range from industrial or commercial to residential or recreational. The choice of the ultimate goal will affect the type and extent of cleanup at individual sites, as well as the cost and schedule of the entire cleanup program.

The Department of Energy has expressed a commitment to cleaning up the nuclear facilities by the year 2019.[3] That entails bringing operating facilities into compliance with all applicable laws and regulations and cleaning up the contamination at inactive sites. With current technologies, however, the cost of such a complete cleanup would be extremely high. It may be appropriate to invest in developing better technologies, and wait until they are available, before undertaking some cleanup efforts. Even if improved technology can reduce costs, which is not guaranteed, the cost of a complete cleanup program may be judged unacceptable when competing demands for resources are considered. A more limited program of remediation could free up resources to provide greater benefits elsewhere.

Institutional Factors and Constraints Affecting Cleanup Policies

In addition to budgetary limitations, the Department of Energy faces a number of constraints that affect its cleanup policies. Three factors are particularly influential: nuclear weapons policies, legal requirements, and public opinion.

3. Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1994-1998*, vol. 1 (January 1993), p. I-9.

Nuclear Weapons Policies

Questions about the role of nuclear arms in national security policy in the aftermath of the Cold War lead to uncertainty about the future mission of some of the nuclear weapons facilities, which in turn complicates the task of setting policies for environmental restoration. Reduced reliance on nuclear weapons has prompted DOE to terminate production at some facilities. Fernald, where uranium was processed, was the first facility to be turned over entirely to environmental restoration. Production has also ceased at Hanford and Rocky Flats. At some facilities, production has been halted temporarily but may resume, depending on plans for the strategic arsenal.

Some facilities are likely to remain in production for some time, although the size of the production area may shrink if output is reduced. If DOE decides to consolidate production at a few facilities and close the rest, however, then production could occur on a relatively large scale at those sites. DOE is developing a programmatic environmental impact statement that addresses these issues and plans to issue a draft of the statement early in 1995. Whether a facility is actively producing weapons makes a difference in carrying out environmental restoration. Cleanup is more complicated at active production sites for a variety of reasons, including the need to keep production and cleanup activities from interfering with each other and the need for greater security in production areas.

Legal Constraints

Current cleanup plans call for meeting all federal and state environmental laws, regulations, and requirements by 2019. DOE can make some changes in cleanup plans unilaterally, but most changes would require approval by the Congress, the Environmental Protection Agency (EPA), or state regulators. The department must comply with a host of federal environmental laws and regulations and must adhere to terms of agreements negotiated with states. It is also constrained by authorization and appropriation legislation.

The major federal environmental laws governing cleanup of DOE's nuclear facilities are the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, the law that set up Superfund) and the Resource Conservation and Recovery Act (RCRA). These laws establish requirements and procedures for dealing with hazardous wastes. CERCLA focuses on cleaning up inactive sites, and RCRA imposes "cradle-to-grave" requirements for tracking and properly dealing with hazardous materials throughout all stages of production. DOE must also comply with the National Environmental Policy Act, which sets forth requirements for analyzing the likely impact of any activity that would significantly affect the environment, as well as the Clean Air Act, the Clean Water Act, the Atomic Energy Act, and numerous other environmental statutes.

DOE is also subject to state environmental laws and related requirements. The Federal Facility Compliance Act of 1992, for example, clarified the states' authority over disposal of solid or hazardous waste by federal facilities. Many specific requirements, including interim milestones for accomplishing certain objectives, are set forth in agreements between DOE, the Environmental Protection Agency, and state regulatory authorities. These agreements are commonly referred to as triparty agreements.

The department considers complying with triparty agreements to be one of its highest priorities. Analysis of data made available by DOE indicates that about 54 percent of the 1994 budget for environmental restoration and waste management is for activities required by such agreements. The percentage driven by these agreements differs substantially among facilities, ranging from 3 percent at the Nevada Test Site to 89 percent at Savannah River. At five facilities--Savannah River, Rocky Flats, Hanford, Oak Ridge, and Fernald--more than 70 percent of funding is attributed to meeting interagency agreements.[4]

The Congress has become increasingly concerned about the amount of funding required for DOE to meet its legal obligations. It has directed the department to review compliance agreements and to submit a report to the Committees on Appropriations by June 30, 1995. The report is to evaluate the risks to the public health and safety posed by the conditions at weapons complex facilities that requirements in the compliance agreements address.[5]

Triparty agreements typically have been based on the best information available at the time they were signed--information about types of contaminants, potential risks, expected cleanup capabilities and resources, and so on. In many cases, however, this information was quite limited. Parties to the agreements could only make educated guesses about potential hazards and risks, and their estimates of abilities to handle difficult cleanup problems were optimistic. In some instances, the estimates of risks may have been pessimistic, and further investigation may reduce concern about adverse effects on public health.

Moreover, in the time since some agreements were signed, the mission of the facility has changed. At Rocky Flats, for instance, the agreement was negotiated when the plant was still producing plutonium components of weapons; now that the facility has been turned over to environmental restoration, a different set of cleanup options is available. Some local citizens have suggested a reordering of priorities--for example, placing more emphasis on restoring buildings to make them usable by other employers than on cleaning up all the outside areas.

As time has passed and DOE has gained a greater appreciation of the overwhelming size, complexity, and potential costs of the cleanup problem, some facets of the triparty agreements have come to be viewed as unrealistic and even counterproductive. For example, some agreements require removing and treating certain contaminants by fixed dates, but assumptions about the timely availability of treat-

4. These findings should be treated with caution because the data set from which they were derived has not been verified. Some obvious errors throw into doubt the reliability of the data. They appear to be the best data available, however. DOE is attempting to gather better data on the role of legal requirements. For purposes of this analysis, Oak Ridge includes the K-25 Site, the Y-12 Plant, Oak Ridge National Laboratory, and administrative spending at Oak Ridge; it excludes off-site facilities managed by the Oak Ridge field office.

5. U.S. House of Representatives, *Making Appropriations for Energy and Water Development for the Fiscal Year Ending September 30, 1994, and for Other Purposes*, Conference Report 103-305, to accompany H.R. 2445 (October 22, 1993), p. 94.

ment technologies and disposal facilities have proved wrong. As a result, DOE would like to renegotiate those milestones and requirements.

In January 1994, DOE reached agreement with EPA and the Washington State Department of Ecology to revise the triparty agreement at Hanford. The regulators allowed DOE to slip some of its milestones in return for a commitment to act more aggressively on the most pressing safety problem--the storage tanks containing a mixture of radioactive and hazardous wastes. The new agreement reflected not only revised views about the relative seriousness of different waste problems but also a realization that new technologies for treating wastes were more elusive than originally anticipated.

Because each facility is unique, the Hanford renegotiation may or may not serve as a useful model for others. Still, as additional information becomes available, the parties to other agreements may find that they too could gain by revising the agreements. For example, new information may lead the parties to conclude that some problems they initially thought to be most serious are less grave than others, and vice versa. In addition, the initial agreements relied on assessments of when remedial technologies would be available. But treatment methods have not always emerged as anticipated. Reordering priorities to deal first with problems for which treatment technologies are available, safe, and effective--and postponing work on problems for which no treatment exists--may benefit all parties. The troublesome issue of what to do about a serious problem for which no remedy is known remains.

Renegotiating an agreement also provides an opportunity to explore the question of the eventual use of the land. Resolution of this issue will have a bearing on the appropriate remedy as well as the speed of restoration. If the local community is eager for DOE to make a facility available for industrial use, it may be willing to accept somewhat lower cleanup standards than if the land was designated for residential use. Cleanup might be expedited at facilities that could be put to commercial use. Some of DOE's facilities are so large that a variety of future land uses may be appropriate for different sites at those facilities.

DOE faces formidable obstacles to getting EPA and the states to renegotiate triparty agreements. In the typical case in which DOE has made commitments it cannot keep, it is hard pressed to find something to offer in return for forbearance. Moreover, the department suffers from a serious credibility problem. One legacy of the secrecy in which DOE conducted business over several decades was a culture of not being held accountable to outsiders for meeting health, safety, and environmental commitments. Although current management is trying to change this, shaking a reputation formed over many years is not easy.

Public Opinion

The triparty agreements responded in part to growing public concerns about what hazards might lurk at DOE facilities. DOE's nuclear weapons program had been cloaked in secrecy since its inception during World War II, leaving neighboring communities in the dark about potential environmental risks. The high level of secrecy shielded DOE from the public scrutiny that might have forced it to keep environmental problems from getting out of control. The department itself has acknowledged that "the secretive, unresponsive nature of DOE during the weapons production years of the Cold War [has] undermined the public trust and created long-term suspicion of DOE operations."[6] Moreover, its credibility suffered as more information about environmental problems became available to the public.

Two factors converged in the late 1980s to increase public interest and involvement in environmental remediation. DOE began to lift the veil of secrecy at the nuclear facilities, and a few well-publicized events--spills, releases, exposures of workers--alarmed citizens (especially those in neighboring areas, but also many environmental activists) about risks to health and safety. DOE recognizes that its credibility suffers when it withholds vital information about its environmental and safety problems, and it has stepped up efforts to inform the public.

6. Department of Energy, "Perspective on DOE's Environmental Restoration Program," Section III of briefing materials for Benchmarking for Cost Improvement Initiative (June 1993), p. 4.

In addition to environmental concerns, many communities fear loss of jobs as neighboring nuclear facilities are shut down. In the short run, employment may actually increase at plants as they shift from production to environmental cleanup. Over the longer term, however, unless facilities can be cleaned up enough to be safe for other uses, the local economic base may be severely weakened. Neighbors of several facilities want DOE to speed up the decontamination of buildings to make them available for employers who can use the skills of displaced workers.

Factors Affecting Cleanup Decisions

What should DOE do about remedying the environmental problems it has sown? The answer is not at all clear, and the possible responses are numerous. At a minimum, DOE could focus on ensuring that no significant amounts of contaminants migrate into drinking water or otherwise pose imminent threats to human health. At the other extreme, DOE could attempt to restore all sites to their original pristine condition. In between lie such options as cleaning sites up to a level acceptable for industrial or commercial use.

Underlying the laws requiring DOE to clean up its facilities is the premise that the nuclear weapons facilities pose risks to public health and the environment and that these risks should be eliminated as rapidly as possible. As suggested in Chapter 3, however, the DOE sites probably encompass a wide range of risks. Some sites may pose substantial, imminent threats; others may be relatively benign, at least compared with other environmental risks. The state of knowledge about potential risks is limited, and until environmental and health assessments of DOE's nuclear weapons facilities are completed, one can only make informed guesses about the extent of those risks. More information is needed about the nature and extent of contamination, whether and how contaminants are migrating into the air or groundwater, and how they affect the health of people exposed to them.

A better understanding of the risks would permit informed debate among the public and policymakers about how much risk is acceptable. Eliminating all risks is not only very costly but also virtually impossible, since reducing one risk often entails increasing another. Identifying the trade-offs between risks and costs can help policymakers set appropriate goals and priorities for the cleanup program.

Debate on acceptable risk should consider not only ultimate cleanup levels but also how soon those levels should be reached. DOE could adhere as closely as possible to the schedules set forth in agreements with EPA and the states. Alternatively, it could seek permission to delay cleanup at sites where existing technologies are ineffective and costly, while moving forward with "easier" cleanups and with the development of technologies to solve the harder problems. If its budget becomes tighter, DOE, in consultation with regulators, stakeholders (people who work at or live near nuclear weapons facilities, taxpayers, and others with an interest in cleanup), and the Congress, will have to decide which activities to defer.

Short of a fundamental reexamination of the goals and scheduling of the cleanup program, DOE could take several measures to make the existing program more effective. These measures, discussed in Chapter 4, include stepping up efforts to develop new technologies that would make cleanup safer, cheaper, and more effective, and cutting administrative and overhead costs. Attention to these measures and to the fundamental objectives of the program could bring about significant improvements in benefits per dollar spent.

Chapter Two

DOE's Cleanup Program

The United States has produced nuclear weapons for the past 50 years, and for most of that time environmental activities have been subsumed under production activities. But as the extent of environmental problems became clearer and as public concerns mounted, Department of Energy officials decided in 1989 to form a separate office with primary responsibility for environmental cleanup. The Office of Environmental Restoration and Waste Management (EM) assumed environmental responsibilities that previously had been handled within the Offices of Defense Programs, Nuclear Energy, and Energy Research.

The environmental cleanup program is the largest and fastest-growing part of DOE's budget, having risen from $1.6 billion in 1989 to nearly $5.9 billion in 1994 (see Table 1).[1] Over this period, the Congress has appropriated more than $23 billion for environmental restoration and waste management. DOE runs the largest environmental cleanup program in the federal government, surpassing funding for the Environmental Protection Agency's Superfund program and the cleanup of installations run by the Department of Defense.

Some of the growth of EM's budget is not new funding but rather reflects a shift in responsibilities to EM from other DOE offices, primarily the Office of Defense Programs, which runs the nuclear weapons production program. Before EM was formed, that office managed all activities at the weapons facilities, including production, security, and environmental and safety activities. It continues to handle operations and maintenance responsibilities as long as environmental management activities are a relatively small part of a facility's work, but as the mission of a facility shifts to environmental restora-

Table 1.
Appropriations for Environmental Restoration and Waste Management, 1989-1994 (In millions of dollars)

Year	Appropriation
1989	1,580[a]
1990	2,274
1991	3,600
1992	4,308
1993	5,520
1994	5,888[b]

SOURCE: Congressional Budget Office using data from the Department of Energy, Office of Environmental Restoration and Waste Management.

a. Budget authority.

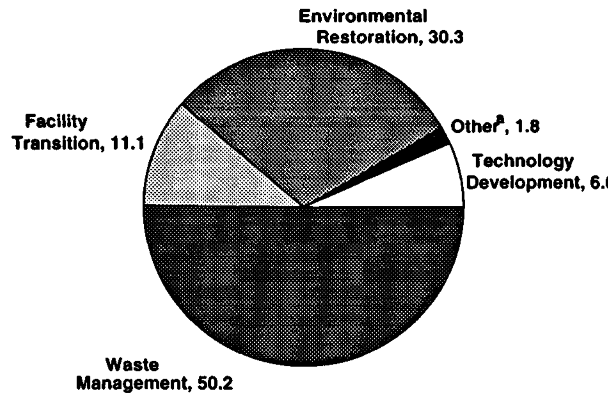
b. Excludes funding for the Uranium Enrichment Decontamination and Decommissioning program.

1. The budget data throughout this chapter exclude the new Uranium Enrichment Decontamination and Decommissioning program, whose 1994 appropriation is $286.3 million, in order to facilitate comparisons with spending in earlier years. This program is separate from the cleanup at the weapons complex. The total also excludes the use of balances from prior years.

tion and waste management, EM picks up these managerial and administrative functions--and a corresponding budget. This shift makes it difficult to track the growth of funding for DOE's cleanup efforts on a consistent basis.[2]

The $5.9 billion budget for 1994 includes $707 million, or 12 percent of the total, for cleaning up DOE's facilities involving civilian uses of nuclear energy. Over the years, the defense component has been by far the larger share, accounting for between 85 percent and 90 percent of the budget each year since EM's inception. Although this study is primarily concerned with the cleanup of defense facilities, the budgetary data included in the following description of the program reflect the nondefense part as well.

Figure 2.
Department of Energy's 1994 Budget for Environmental Management, by Program (In percent)



SOURCE: Congressional Budget Office.

a. Includes Transportation Management and Program Direction.

Program Components

The Office of Environmental Restoration and Waste Management is divided into several functional programs. They include Environmental Restoration, Waste Management, Technology Development, Facility Transition and Management, Transportation Management, and Program Direction.

The program most closely associated with environmental cleanup is Environmental Restoration, whose 1994 budget is $1.8 billion, accounting for 30.3 percent of the EM total (see Figure 2).[3] Its mission of cleaning up inactive facilities and sites employs two main types of activities: remedial actions and decontamination and decommissioning (D&D). Remedial actions generally deal with contaminated soil and groundwater, and D&D applies to buildings, tanks, and structures. DOE and its regulators have defined about 3,700 sites subject to remedial action and about 500 contaminated structures that require D&D. (Each major weapons production facility has numerous contaminated sites. A site is essentially a discrete, well-defined unit at which cleanup activity can be self-contained.) In addition, DOE is responsible for cleanup at more than 5,000 properties in the Uranium Mill Tailings Remedial Action Project and the Formerly Utilized Sites Remedial Action Program.[4] Environmental Restoration is the EM program that will be affected the most by decisions about the ultimate goals and objectives of DOE's environmental cleanup mission.

Although restoring the environment is perhaps the ultimate goal of EM, it is not its largest program. That position belongs to the Waste Management program, whose budget of $3.0 billion ac-

2. Some people disagree about whether spending on the DOE cleanup program should be categorized as environmental spending or as national security spending. These categories are not mutually exclusive, however, and DOE cleanup belongs in both. The total life-cycle cost of nuclear weapons includes the cost of disposing properly of the products and by-products. In this respect, DOE cleanup is attributable to spending on national security. But the current objectives and the demands on current resources are environmental.

3. This is the amount specified for environmental restoration in U.S. House of Representatives, *Making Appropriations for Energy and Water Development for the Fiscal Year Ending September 30, 1994, and for Other Purposes*, Conference Report 103-305, to accompany H.R. 2445 (October 22, 1993). The legislation called for a general reduction of $280 million but did not specify from which EM programs it should be taken.

4. Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1993-1997* (August 1991), pp. 210-211.

counts for 50.2 percent of EM's total in 1994. Waste Management is responsible for treating, storing, and disposing of wastes from ongoing production as well as from environmental restoration activities. It also constructs new treatment, storage, and disposal facilities and performs cleanup actions required to bring DOE facilities into compliance with all applicable laws and regulations as soon as possible. These "corrective activities" account for only $26.5 million, less than 1 percent of the 1994 budget for waste management.

Since the inception of the EM program, about 60 percent of the budget has been for waste management and 30 percent for environmental restoration, with the remainder split among the other programs described below. The lines between the two major activities sometimes blur because some waste management activities are attributable to environmental restoration. For example, when wastes are generated as a consequence of environmental restoration, they generally are turned over to the Waste Management program for treatment, storage, and disposal.

Technology Development, with a budget of $397.5 million, accounts for 6.6 percent of EM's budget in 1994. The program is charged with the important mission of developing technologies for safer, more effective, and less costly cleanup (see Chapter 4).

The Facility Transition and Management program was established as a separate function in 1993 with the purpose of planning and implementing the transfer of surplus facilities from defense production to the cleanup program. Its budget rose sharply, from $17.9 million (0.3 percent of the EM budget) in 1993 to $671.8 million (11.1 percent) in 1994. The growth in this program stems primarily from the reclassification of some activities that would have come under Waste Management but are now assigned to Facility Transition and Management.

The remaining 1.8 percent of EM's budget is for Program Direction and Transportation Management. These functions are handled primarily out of DOE headquarters.

Outlook for Spending

As DOE began its environmental cleanup efforts, it attempted to estimate total costs through completion of the program. In 1988, the department estimated it would cost $66 billion to $110 billion to clean up the entire complex.[5] In 1992, the General Accounting Office reported an estimate of $160 billion and said costs could be much higher unless technological breakthroughs were made.[6] At a June 1993 workshop, a DOE official acknowledged that an estimate of $400 billion was not unrealistic.[7] This statement was followed in July by the Assistant Secretary's reference (cited in Chapter 1) to a $1 trillion program.

Perhaps because of the uncertainties about ultimate goals, DOE has stopped publishing estimates of total cleanup costs. Most experts now recognize that uncertainties about requirements, tasks, and technologies make any overall cost estimate unreliable. Thus, nobody knows the potential federal liabilities.

Estimating spending over the next few years is somewhat more tractable because it will be driven primarily by budget constraints. DOE has not published detailed information about its plans but has released budget targets by program. The department assumes that budgets for the EM program will grow about 2 percent annually, from the requested level of $6.0 billion in 1995 to $6.8 billion in 2000 (excluding the Uranium Enrichment Decontamination and Decommissioning program). Spending over the six-year period from 1995 through 2000 would total $38.8 billion (see Table 2), and program shares would remain about the same as in 1994 (see Figure 2).

5. Department of Energy, *Environmental Safety and Health Report for the DOE Defense Complex* (July 1, 1988), p. 35.

6. General Accounting Office, *Cleanup Technology: Better Management for DOE's Technology Development Program*, GAO/RCED-92-145 (April 1992), p. 1. These estimates were not discounted.

7. Department of Energy's Benchmarking for Cost Improvement Kickoff Meeting, Washington, D.C., June 22-23, 1993.

Table 2.
Spending Targets for Environmental Restoration and Waste Management, 1995-2000 (In millions of dollars)

Year	Target Spending Level
1995	5,979[a]
1996	6,315
1997	6,439
1998	6,565
1999	6,694
2000	6,826
Total	38,817

SOURCE: Congressional Budget Office using data from the Department of Energy, Office of Environmental Restoration and Waste Management.

NOTE: Excludes funding for the Uranium Enrichment Decontamination and Decommissioning program.

a. Budget request.

Targets for 1995 through 2000 are also available by field office. Data for field offices that manage environmental cleanup at more than one facility do not show how much each facility would receive. Still, the data provide a general picture of the field offices' spending plans.

The Richland field office, which manages Hanford, would receive $9.6 billion for the 1995-2000 period. That amount represents 24.7 percent of the total, substantially more than any other field office. Richland manages only the Hanford facility, so all of its funding would go toward cleaning up Hanford. Savannah River would receive $4.4 billion, and Albuquerque, Rocky Flats, Oak Ridge, and Idaho would each get about $4 billion over the six-year period.

DOE headquarters accounts for $5.8 billion (14.9 percent) of target funding. Some of that money will be distributed to the field offices as DOE determines which ones have the most pressing needs.

Accomplishments of the Program

What has the Office of Environmental Restoration and Waste Management accomplished since its creation five years ago? Some critics complain that the results are scant. For example, in its report on the 1994 appropriation bill for energy and water development, the House Committee on Appropriations expressed concern about the increasing costs of the program and the apparent lack of significant progress in cleaning up contaminated sites. The committee warned DOE not to expect unlimited funding for the EM program, especially if DOE is unable to show concrete results from the investment to date.[8] Defenders of the cleanup program respond that it has had to overcome resistance to change from a culture in which environmental, health, and safety factors were subordinated to weapons production to one in which they are the central mission.

Assessing the Cleanup Program

The EM program has faced the growing pains common to a new and rapidly growing organization. As the budget has spiraled upward, the structure of the organization has changed, with new program offices being formed. Decentralized operations at the facilities that produce weapons and reliance on contractors to run the facilities--legacies of the weapons production program--have hampered attempts by headquarters to establish and coordinate effective cleanup policies. Although decentralized decision-making can offer many advantages, differences in standard operating procedures among the facilities have made it difficult for headquarters to obtain cost

8. House Committee on Appropriations, *Energy and Water Development Appropriations Bill, 1994*, Report 103-135, to accompany H.R. 2445 (June 17, 1993), p. 111.

and budgeting information on a consistent basis. That makes it exceedingly difficult to decide how to allocate resources to best advantage throughout the complex.

Some of the accomplishments of the EM program are, by their very nature, hard to recognize. The bulk of EM spending has been on waste management activities, many of which are not visible unless something goes wrong. An accidental release of hazardous substances is noticed, but the successful control of wastes on a daily basis is not.

Likewise, successes in the Technology Development program may receive little public attention. Innovations that cut costs or enhance the safety of workers are critical to the success of cleanup efforts but do not directly result in a cleaner environment. Even where innovations yield more thorough remediation, the results may not be evident for many years to come. The inability to show immediate success may lead DOE to underinvest in technology development, a problem that is discussed further in Chapter 4.

Environmental Restoration Activities

The program that most people associate with cleanup is environmental restoration. Environmental restoration is a popular activity because it promises results that people can see and enjoy. Many people fear the potential consequences for their health and the environment from toxic wastes, especially radioactive materials. They also recognize that DOE's nuclear facilities will be off-limits to other uses until they are cleaned up. Accomplishments in the Environmental Restoration program, therefore, are what many people look for in assessing the success of DOE's overall cleanup efforts.

The legal requirements governing environmental cleanup may explain in part why accomplishments seem elusive. Much of DOE's Environmental Restoration program comes under the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund), although federal and state regulatory agencies have given primary jurisdiction to the Resource Conservation and Recovery Act at some DOE sites. Both statutes impose specific procedural and substantive requirements on polluters; the triparty agreements among DOE, EPA, and state regulators generally include the completion of these requirements as milestones.

Before remedial actions or decontamination and decommissioning can begin at a site, DOE must study it to see what contaminants are present and what kind of treatment or disposal is appropriate. At sites on Superfund's National Priorities List, this stage is known as the remedial investigation/feasibility study. These studies have accounted for the bulk of spending in the ER program and will probably continue to consume a substantial amount of resources for the foreseeable future.[9] Data supporting DOE's budget request for 1994 indicate that about 53 percent of the funding for environmental restoration would be spent for studies, about 35 percent for cleanup, and the rest to support a variety of management functions, including oversight of compliance, program direction, and landlord responsibilities.[10] Inadequate records of past manufacturing and disposal processes increase the cost of studies and the length of time they take.

After DOE completes the remedial investigation/feasibility study, the Environmental Protection Agency prepares a record of decision, which sets forth what DOE must do to clean up a site. Only a few DOE sites have reached the record-of-decision stage. That has two implications for the department as it tries to respond to criticisms of the cleanup program. First, it means that DOE has relatively few tangible results, such as decontaminated buildings or restored sites, to show for the money spent on environmental restoration. Second, it means that DOE does not have a clear idea about the magnitude of the problem nor the extent of remediation that will be required at individual sites.

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9. DOE's August 1991 five-year plan was the last to identify assessment and cleanup separately. At that time, assessment spending was projected to be about equal to cleanup spending in 1993 and only slightly less through 1997.

10. The data did not contain an explicit categorization. Categories were inferred from the description of the activity; many included the term "assessment" or "cleanup" in the title. For a small number of activities, accounting for less than 1 percent of the budget, the category could not be inferred from the information available.

The often-heard criticism that the environmental cleanup program is being studied to death is not unique to DOE. The Environmental Protection Agency has come under similar attack and has launched an effort to accelerate cleanup at sites where the appropriate remedy seems clear.[11] DOE has begun to explore interim remedies at such sites, but for many of them it has too little information about the scope of the problem to determine the best approach for remediation. Achieving the right balance--conducting the assessment that is needed but no more--is more easily said than done.

Perhaps the brightest spot in DOE's cleanup record is the Uranium Mill Tailings Remedial Action Project (UMTRAP), although the growth of its costs has exceeded estimates.[12] This project was authorized by the Uranium Mill Tailings Radiation Control Act of 1978, well before the EM office was established. The act directed DOE to stabilize and control uranium mill tailings at 24 designated sites and about 5,000 properties near those sites in 10 states and on two Indian tribal lands.[13]

UMTRAP has completed surface remediation at 20 sites and plans to complete remedial action on all surface sites by the end of 1998.[14] It still faces the challenging task of cleaning up the groundwater. But DOE is confident that it can meet regulatory requirements for groundwater in a timely, cost-effective manner. The success of this program cannot serve as a model for DOE's other cleanup programs, however, because UMTRAP's sites do not have the vexing problems of the larger, more complicated weapons facilities.

11. For example, at wood-treating sites on the Superfund list, EPA has proposed dispensing with detailed assessments and instead proceeding with the usual remedy--burning soil to break down organic contaminants.

12. Uranium mill tailings are the sandy wastes that result from processing ore to extract uranium.

13. Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1994-1998*, vol. 2, *Installation Summaries* (January 1993), p. II-68.

14. Ibid., p. II-71.

Initiatives for Managing the Environmental Cleanup Program

The Department of Energy has instituted several efforts to help manage the environmental restoration and waste management activities. It has published a series of five-year plans that provide blueprints for the near term, established a program for controlling costs and improving cost estimates, and stepped up efforts to track progress.

Five-Year Plans

Soon after the Office of Environmental Restoration and Waste Management was established in 1989, DOE published the first of a series of five-year plans that set forth objectives, timetables, and budgets. In addition to serving as management tools, the plans provide a perspective on the growth and evolution of the program, especially the rise and fall of projections for budgetary growth.

The first plan envisioned spending $19.2 billion over the five years it covered, 1991 through 1995. One year later, the 1992-1996 plan called for spending $31.6 billion.

The 1993-1997 plan, published in August 1991, contained two scenarios for budgetary growth. The first, called the preliminary unvalidated case, envisioned spending of $40.7 billion over the five-year period. This was the amount DOE estimated it would need to comply with all legal requirements. The second scenario, called the validated target level, assumed growth of about 10 percent a year--an amount DOE thought possible within overall constraints on the federal budget. Spending in that case would total $28.8 billion over the five years.

The 1994-1998 plan projected budgetary growth of between 5 percent and 10 percent a year, yielding total spending of about $35.5 billion over five years.[15] It is not clear whether DOE will publish a plan for the 1995-1999 period; it may instead skip to the 1996-2000 period since it has already made preliminary projections for 2000.[16] As noted earlier, these projections assume growth of about 2 percent annually and spending of about $32.8 billion over five years.

Although overall budget constraints are set from the top down, the specifics of the five-year plans depend on estimates made from the bottom up. DOE divides cleanup tasks into basic units called activity data sheets (ADSs). Each sheet shows the cost estimates, regulatory requirements, milestones, and other useful information for each year in the five-year plan. ADSs should provide an effective way to track growth in costs, schedule slippages, and other developments over time and, indeed, they are the building blocks of DOE's Progress Tracking System (discussed below).

The usefulness of the ADSs has been limited, however, because DOE has continually changed the scope of work contained in individual sheets. For example, for each of the principal sites needing environmental restoration at Rocky Flats, the 1993-1997 plan contained two ADSs--one for assessment and one for cleanup--but the 1994-1998 plan collapsed them into one ADS per site, covering both activities. That change is easy to track, but other changes involved folding several ADSs into one or splitting one ADS into two or more, thereby making it virtually impossible to track progress. Overall, roughly 2,000 ADSs in the 1993-1997 plan were consolidated into 850 in the 1994-1998 plan.

Some realignment is inevitable in a relatively new program. Undoubtedly some of the consolidations have resulted in more logical groupings of tasks. But continual change thwarts efforts to identify the factors that cause costs to grow and schedules to slip, and to analyze how to facilitate progress in cleaning up the environment.

15. This plan, published on January 19, 1993, was somewhat sketchy because it was completed during the Presidential transition, when policy changes appeared likely.

16. Alternatively, the department may abandon five-year plans in favor of other managerial tools and reporting mechanisms, such as the progress report required by the National Defense Authorization Act for Fiscal Year 1994.

Improving Cost Control and Cost Estimates

Rapidly escalating costs are a perennial problem for large-scale programs, and DOE's cleanup effort is no exception. Two independent reviews by analysts outside the EM office--DOE's Independent Cost Estimating (ICE) team and an interagency group led by the Office of Management and Budget (OMB) and the Army Corps of Engineers--underscored the problems of estimating and controlling costs.[17]

Team members visited DOE's field offices and reviewed a large sample of activity data sheets. The OMB/Corps analysts found that DOE had overestimated direct program costs for about 12 percent of ADSs and that the estimates contained relatively high overhead and contingency costs. For a sample of ADSs, the OMB/Corps group found that DOE had estimated overhead costs to be 139 percent higher than for comparable Corps projects; the ICE team found an estimated $350 million of seemingly excessive overhead costs and $450 million in excessive contingency costs.[18] These findings are discussed in greater detail in Chapter 4.

In response to the independent cost reviews, DOE has launched a "Benchmarking for Cost Improvement" initiative.[19] This project will gather and examine detailed information about costs in an attempt to make cost estimates more reliable and to keep costs under firmer control. If successful, this

17. Interagency Review Group, *Interagency Review of the Department of Energy Environmental Restoration and Waste Management Program*, Final Report (April 29, 1992); Army Corps of Engineers, *Supplemental Report on Cost Estimates* (Report to the Associate Director for Natural Resources, Energy and Science, Office of Management and Budget, April 29, 1992); and Gilbert/Commonwealth, Inc., *Independent Cost Estimate for the Environmental Restoration and Waste Management Five Year Plan, Fiscal Years 1993-1997* (Reading, Pa.: Gilbert/Commonwealth, Inc., November 1991).

18. Interagency Review Group, *Interagency Review*, p. iii.

19. Department of Energy, Office of Environmental Restoration and Waste Management, *Benchmarking for Cost Improvement: Final Report* (September 1993).

effort will provide useful information about which factors drive costs and are responsible for cost increases at the site or project level.

Perhaps as important as the numerical findings of the independent reviews is the more general conclusion that DOE needs to improve its procedures for estimating costs. Whether improvements in cost estimating by themselves can hold the line on future increases in program costs is debatable, but improvements can certainly help to illuminate the trade-offs involved in developing alternative program plans.

Experience at DOE and Superfund sites can serve as a guide for estimating costs of many common remedial activities.[20] The problems at some DOE sites are so difficult, however, that there is little experience to draw on.

At many sites known to be contaminated, the exact nature, extent, and even types of contaminants are unknown. In many cases, experts must conduct extensive and costly studies before they can determine the kinds of measures needed to correct the problem. The hazardous and radioactive nature of the contaminants may require special methods and technologies with which DOE has insufficient experience to estimate costs with confidence. The cleanup may require special training and equipment, and contractors may insist on being indemnified against responsibility for future cleanup costs.[21] Moreover, the legal requirements concerning the extent and type of cleanup are subject to change. In short, cost estimates made before a site has been analyzed and cleanup requirements have been determined must be viewed as highly uncertain and subject to substantial change. Appendix B describes DOE's process of estimating costs at a site.

Estimating the costs of cleaning up the entire nuclear weapons complex will continue to present challenges for some time. Even though estimates of the costs of cleaning up each site (or other manageable unit of observation, such as the ADS) can be made with increasing confidence, aggregating and coordinating them poses additional problems. For example, experience might suggest that excavating, storing, treating, and disposing of contaminated soil would cost a certain amount per ton. But if vast quantities of contaminated soil from numerous sites are excavated at once, they may overwhelm the capacity of storage, treatment, and disposal facilities. DOE's demands for environmental cleanup services may account for such a large share of the total market that they would create shortages and bottlenecks that would drive up costs and also cause delays.

As increasing numbers of site assessments are completed, DOE will have a firmer grasp of the magnitude of the cleanup actions that lie ahead. And as DOE gains experience with remedial actions, it will be able to refine its estimates of cleanup costs. But cost estimates depend fundamentally on the cleanup standards DOE is required to meet.

Progress Tracking System

DOE has been hampered in its ability to estimate costs and show accomplishments--and to understand why some cleanup projects appear to be more successful than others--by the lack of a comprehensive system for tracking performance. To fill that need, it has been developing the Progress Tracking System (PTS). DOE implemented an initial version of the PTS in October 1991, but that version could perform only a few functions and was not easy to update. The PTS has been under continual development in an attempt to make it the robust management information system needed to ensure managerial and financial control of EM's programs.

As its name suggests, the system is designed to track EM's progress toward meeting its cleanup objectives. The PTS reports information about costs, schedules, and technical performance and eventually

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20. For a discussion of estimates of the costs of cleaning up Superfund sites, see Congressional Budget Office, *The Total Costs of Cleaning Up Nonfederal Superfund Sites* (January 1994).

21. Under the Comprehensive Environmental Response, Compensation, and Liability Act, liability for cleaning up a Superfund site is strict, joint, and several. Any company that has owned or operated a site or disposed of wastes on it is potentially responsible for the entire cost of cleaning it up, even if that company contributed only a small fraction of the environmental problem. Section 107(d) of CERCLA provides protection from liability to a contractor engaged in cleanup, except for damages resulting from the contractor's negligence, but some contractors have expressed concerns nonetheless.

should enable DOE managers and others to monitor progress, identify projects that are experiencing problems meeting cost and schedule objectives, and take steps to get such projects back on track.

In September 1993, an independent panel of experts in the management and control of large-scale programs found that the PTS had made substantial progress and "has the potential to be the premier DOE-wide reporting system."[22] The panel made a number of recommendations for improving the system. On the accuracy and timeliness of the data, the panel made the following observation:

> Quality of data should be one of the most important objectives of the PTS. This establishes the credibility necessary for management use of the system and its reports. Quality and accuracy of the data begins with the inputs of baseline budgets, schedules (milestones), and actual cost and schedule data . . . . The field organizations must feel that PTS is an extension of their reporting system and therefore data input and its accuracy is their full responsibility and they are being held accountable for its validity . . . . Correct data at the time of input can add much to the credibility of PTS.[23]

Among its other recommendations, the panel suggested that the PTS be linked more closely to other financial and budget reporting systems at DOE. It also commented that, at present, the PTS is on a current year basis, which does not permit looking forward or reviewing historical trends--capabilities that would provide valuable information for developing cleanup plans. The panel also suggested measures that would enhance technical capabilities, reduce the time and cost of entering data into the system, and make the system easier to use.

The PTS is able to track differences between budgeted cost, work performed, and actual costs. This information is reported on the activity data sheet and presented in an overall summary. The system is not yet able to maintain a history of changes to the budgets and schedules, however. It can report a variance between the most recent budget and actual spending, but it cannot show how much the budget has increased or decreased over the history of the project. Maintaining a baseline history would help analysts track changes in costs--both for individual projects and for the program as a whole--and would better identify factors that increase costs or cause schedules to slip.

Identifying changes in the scope of a project or changes in its management history is difficult within the present Progress Tracking System. DOE is considering incorporating a mechanism for recording and managing such changes, including a formal system of review and approval. The Department of Defense (DoD) uses this kind of approach in managing acquisitions of major weapon systems. Even though requirements, quantities, and other characteristics of a new weapon system may change over time, there are decision points throughout the acquisition process at which estimates of cost and schedule are made. DoD's Selected Acquisition Reports provide a way of tracking deviations from plans and attributing them to such factors as changes in quantities, changes in requirements, and inflation. This kind of information would be very useful for DOE's cleanup program because it would help to identify the factors that drive up costs and delay cleanup.

The Progress Tracking System is a promising addition to DOE's data bank. Pulling together massive amounts of data, ensuring their reliability, and making them readily available and understandable to disparate users is a challenging task, but continuing to upgrade and improve the system appears well worth the effort.

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22. *Assessing the U.S. Department of Energy Progress Tracking System*, Report by the Review Panel (September 24, 1993), p. 1-1.

23. Ibid., pp. 5-10 and 5-11.

Chapter Three

Strategic Policy Issues for DOE's Cleanup Program

Decisions about a series of broad policy issues could dramatically change the shape and cost of the Department of Energy's program to clean up the nuclear weapons facilities. Reexamining the goals and objectives of the program could result in a refocusing of cleanup efforts. The basic questions are what to do and when to do it. Should DOE try to eliminate all risks to human health and the environment, or is some risk acceptable? What should be done with the facilities--restore them for industrial, commercial, or residential use, or for recreation or other purposes? How fast can and should cleanup occur? Given the enormous cost of cleaning up the facilities and limited budgets for that purpose, what can DOE do to achieve the greatest benefits per dollar spent on cleanup?

Answers to these questions will affect the type, extent, and pace of cleanup. Given budgetary constraints, stretching out the cleanup program beyond the 30 years initially envisioned appears inevitable. DOE and its regulators will have to decide which objectives, types of problems, or sites to focus on first.

Information about risk to human health and the environment at DOE's nuclear weapons facilities is scant. Yet understanding these risks is crucial to making decisions about what remedial actions should be undertaken immediately, what should be done in the near future, and what would be desirable, if not essential, over the longer term. The discussion below suggests a need for substantial additional effort to identify and characterize risks from environmental contamination.

Intertwined with the goal of reducing risk are decisions about eventual land use at DOE sites. At some, there is little choice. Sites where long-lived radioactive wastes have been disposed of will be off-limits to other uses permanently. Such sites could be fenced off permanently or until technologies are developed to allow detoxification. Plutonium, for example, remains hazardous for more than 25,000 years. Other areas also could be fenced off, at least until their value for alternative use becomes high enough to justify remediation. Still other sites might be made available for industrial use without cleaning them up to as high a standard as sites opened up for general use, provided that all the necessary precautions are taken to protect workers. Decisions about eventual land use will depend on both technical and economic feasibility as well as public preferences.

Efforts to reduce health, safety, and environmental risks and to restore lands to other uses will occur within the constraints of the federal budget. As discussed in Chapter 2, reliable estimates of cleanup costs are difficult to make but will inevitably be part of the process of determining goals and setting priorities. This chapter discusses the use of benefit-cost analysis as a way of determining which cleanup projects would offer the greatest benefits per dollar spent. It concludes with an example illustrating the trade-offs.

Background

In 1989, DOE announced the goal of completing environmental cleanup at the nuclear weapons facilities within 30 years. More recently the department has expressed the goal in terms of meeting all applicable legal requirements by 2019. Returning all DOE sites to a pristine state by 2019 is clearly not realistic, given the presence of such contaminants as long-lived radioactive materials and substances that persist in groundwater. Meeting legal requirements is also a challenge, especially where technologies are inadequate to achieve the prescribed level of cleanliness. Moreover, legal requirements may change over time, requiring DOE to meet increasingly strict standards.

Most people would agree that imminent hazards to the public should be eliminated promptly. DOE's program for corrective activities is intended to remedy such hazards. At Hanford, for example, one of DOE's top priorities is a storage tank containing a witches' brew of hazardous wastes that periodically releases hydrogen gas in concentrated amounts, raising fears of an explosion.[1] Much of the environmental contamination at DOE facilities, however, does not appear to pose an imminent danger to the public. No one really knows the risks at the nuclear weapons facilities, but no strong evidence has been presented of imminent dangers that DOE is not attempting to resolve. Rather, there is a broad range of potential risks. For example, contaminants in the soil may be migrating toward underground aquifers, but at such a slow pace that reaching them would take many years.

Still other potential problems may pose fewer hazards if cleanup is delayed. Hanford's surplus reactors, for instance, contain a number of radioactive materials that decay over time. If DOE postponed decontaminating and decommissioning these reactors for 75 years, half of the cobalt 60 would decay, significantly reducing potential exposure to workers.

Should DOE aim to eliminate all potential risks? Or to reduce them to some level that weighs costs against risks and is acceptable to the general public? Reaching consensus on this matter may be impossible, but informed debate could contribute to a generally acceptable result.

Many people perceive hazardous waste sites to be extremely dangerous. Such well-publicized contaminated sites as Love Canal and Times Beach have raised public consciousness about hazardous wastes. Polls conducted by the Roper Organization in 1988 and 1990 reported high levels of public concern about Superfund and other hazardous waste sites.[2] This concern has been reflected in legislation authorizing environmental cleanup--in particular the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation, and Liability Act--and in appropriations.[3] Public perceptions have also been a driving force in the development of the cleanup agreements that DOE has signed with the Environmental Protection Agency and state agencies.

Reaching a consensus about the goals of environmental cleanup at DOE's nuclear weapons complex can be facilitated by discussion and debate that includes all interested parties. As the following sections suggest, however, experts, policymakers, and the general public all need more information than is now available to make informed judgments about goals and priorities.

Understanding Risks

How dangerous are DOE's nuclear weapons facilities? How much of a threat do they pose to health, safety, and the environment? How do risks from hazardous waste sites compare with risks associated with other environmental problems? The answers to these questions can help shape DOE's plans for cleaning up the hazardous waste sites.

1. In July 1993, workers installed a pump intended to agitate the liquid waste in the tank. They think the agitation will reduce pressure inside the tank by preventing the buildup of hydrogen and other gases. See *Inside Energy/with Federal Lands* (newsletter published by McGraw-Hill, Inc., New York, July 12, 1993), p. 6.

2. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, "Environmental Problem Area Profiles" (July 20, 1991), pp. 7, 16.

3. In addition to DOE's program, the Department of Defense has a large and growing budget for cleaning up hazardous wastes, and the Superfund program now accounts for about one-quarter of EPA's budget.

The lack of comprehensive measures of risks from contamination at its facilities has hampered DOE's planning efforts. It has some information that was collected at various sites and by various offices within DOE, but the information has not been coordinated into a unified framework that would facilitate comparisons. As noted in Chapter 1, the Congress has directed DOE to evaluate risks to health and safety and to report on how they are to be addressed under the agreements DOE has entered into with the Environmental Protection Agency and state regulators. DOE has been directed to estimate risks based on the best scientific information available; it has not been asked to undertake the massive task of performing exhaustive formal risk assessments.[4]

In response, DOE has launched a risk management program whose objective is to bring together what is known about risks, identify the gaps in knowledge, and seek to fill them. (See Box 1 for a discussion of risk assessment and risk management.) To assist with this effort, DOE has asked the National Research Council of the National Academy of Sciences (NAS) to form a committee of experts to review DOE's risk management. NAS sponsored a workshop on November 3-4, 1993, for the committee to hear the views of facility managers, regulators, and stakeholders, and it issued a report on January 4, 1994.[5]

DOE says it has acted to remove all of the imminent threats that it knows about. The department recognizes that all sites do not pose equal threats to public health, safety, and the environment. For example, "a small, 'wet' site in a populated area may have the potential for higher risk due to the proximity of the community and the migration of contaminants than . . . contamination in the middle of a larger, 'dry' site that is far from populated areas."[6] However, at the NAS workshop on risks, DOE's Assistant Secretary for Environmental Restoration and Waste Management acknowledged that the department had not yet identified the risks.

Until detailed investigations of each site have been completed, one can only draw inferences about potential risks on the basis of information from more general studies. Information about risks at hazardous waste sites in general may have important implications for DOE's problems.

Preliminary Assessments by ATSDR

The Agency for Toxic Substances and Disease Registry (ATSDR) has begun to assess public health risks associated with DOE facilities.[7] It has completed a preliminary survey of 19 DOE sites and has categorized them by potential public health risks.[8] The rankings are preliminary but will aid ATSDR in developing plans for in-depth studies of potential public health problems. Over the next several years, ATSDR will compile and analyze data on exposure to hazardous substances at DOE sites. It will then assess current and likely future impacts on human health from the release of hazardous substances into the environment.

In ATSDR's initial screening, only Hanford was included in the highest potential risk category, defined as "sites where exposure is known to be occurring or has occurred at levels of contamination that might cause acute health effects."[9] Fernald, Los

4. U.S. House of Representatives, *Making Appropriations for Energy and Water Development for the Fiscal Year Ending September 30, 1994, and for Other Purposes*, Conference Report 103-305, to accompany H.R. 2445 (October 22, 1993), pp. 94-95.

5. National Research Council, *Building Consensus Through Risk Assessment and Management of the Department of Energy's Environmental Remediation Program* (Washington, D.C.: National Academy Press, 1994).

6. Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1994-1998*, vol. 1 (January 1993), p. v.

7. Section 104(i) of CERCLA created the ATSDR within the Public Health Service to study health effects of toxic substances.

8. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Division of Health Assessment and Consultation, Federal Programs Branch, *Health Assessment Activities at Department of Energy National Priorities List Sites for FY 1992* (November 1992). The sites include 16 DOE sites on the National Priorities List (NPL), one proposed for the NPL, one jointly listed as a DOE/Army site, and one for which ATSDR received a petition for assessment.

9. Ibid., p. 9. ATSDR considered Hanford areas 100, 200, 300, and 1100 separately; it put the 100, 200, and 300 areas in the highest risk category.

Box 1.
Risk Assessment and Risk Management

Risk assessment and risk management are commonly confused. Indeed, the terms were sometimes used interchangeably at the risk-management workshop convened by the National Academy of Sciences on November 3-4, 1993. Risk assessment generally includes the development and analysis of scientific information; it is an input--but not the only input--to risk-management decisions. Risk management consists of actions that are intended to alter the likelihood of certain events or outcomes.

A risk assessment is based on detailed scientific analysis. It involves identifying substances that may be hazardous to human health and determining their effects on health. In many cases, the latter entails exposing laboratory animals to very large doses of the substance, measuring the effects, and then interpreting the implications of smaller exposures for humans. A risk assessment may estimate the number of people who might be exposed to a harmful substance and the length and type of exposure. The product of a risk assessment is usually a measure of additional risk, such as one additional cancer case over 20 years among 10,000 people living within a given distance of the hazard.

But in many respects, risk assessment is an art, not a science. The assessor rarely has complete information about every aspect; the art includes a judgment about what can safely be left out of detailed analysis. Lacking sufficient information about key elements of the analysis, the assessor may have to make numerous assumptions in order to proceed. How uncertainty about the assumptions is handled can have an impact on the results. Stating clearly these assumptions can enhance the credibility of a risk assessment and can facilitate testing the sensitivity of the results.

People not trained in science may be able to provide information that would improve the reliability and the credibility of risk assessments by augmenting the work of scientists. For instance, a risk assessment may assume that a certain number of people live within a certain radius of a contaminated site for a certain number of years. But the local community may disagree with the assumptions and present evidence that many people live there for longer than assumed, or that the community is growing and more people are moving into the area where they might be exposed to contaminants. A risk assessment should be presented in such a way that these alternative assumptions can be factored in, to see what their effect is on the resulting estimate of risk.

Risk assessments also may make assumptions about the amounts of various foods people eat. If some ethnic groups consume much larger amounts of fish, in which contaminants bioaccumulate, relative to other sources of protein, the potential risk may be underestimated.

Managing risk involves combining the results of risk assessments and many other factors to determine an appropriate set of actions. These other factors may include competing demands on the resources available to reduce risks, the availability of technological remedies, and comparisons with other risks. For example, one might want to compare the risks existing at a site with the risks of remediation. The latter particularly affect workers--those engaged at the site in current activities (for example, monitoring or maintenance) and those who would perform cleanup tasks. Digging up contaminants that have been contained poses additional risks, as does transporting them to storage and disposal facilities. Transporting contaminants off-site may be especially hazardous, since DOE cannot control safety on the highways or railroads.

Managing risks involves a number of thorny issues. Among them are:

- How to compare risks that are voluntary (skydiving) with those that are involuntary (living in an area with poor air quality);
- How to factor in effects on the most susceptible members of the exposed population when those effects greatly exceed the effects on the average person;
- How to account for large differences in expected exposure (for example, if most people living near a hazard stay there only a few years but some spend a lifetime there);
- How to deal with risks that are very large but affect only a small number of people living near a site;
- How to treat risks that affect various age groups or other population groups differently; and
- How to compare scientific studies whose results differ (for example, somehow "average" the results, place the greatest weight on the most pessimistic, take what the majority of "experts" conclude, and so on).

There are no easy answers in evaluating and managing risks. But the presence of subjectivity does not mean that risk assessments are not useful nor that consensus about managing risks is unattainable. If estimated risks from different environmental problems vary by orders of magnitude, for example, it may be clear which ones to pursue first. Where risks appear high in some studies but not in others, additional research may be an important element of risk management. And public debate on the most difficult issues that involve individual and societal values can provide useful information for officials as they set policies for managing risks.

Alamos National Laboratory, Oak Ridge, and Hanford's 1100 area were included in the second highest risk category, defined as sites where exposure is probable, chronic health effects are possible, and/or residents have alleged that health effects have occurred. Rocky Flats and Savannah River were put in the third category--sites for which there is limited information and where available information indicates exposure is occurring or has occurred --but will be subject to additional review. Idaho National Engineering Laboratory was put in a fourth category of sites for which limited information indicates that exposure is not occurring. ATSDR surveyed other DOE sites as well, but the sites listed above are the ones with the most environmental cleanup activity.

ATSDR emphasizes that its categorization is preliminary and may change as additional information becomes available. The categories do not represent conclusions about public health risks.

EPA Studies of Risks

The Environmental Protection Agency has published two reports about the risk associated with hazardous waste sites compared with other kinds of environmental problems. The reports are by no means conclusive, nor do they purport to be. They recognize that the state of knowledge about a broad range of environmental risks is still in its infancy.[10] Still, they provide a comprehensive overview of the relative risks of various environmental problems, in the judgment of experts. The reports discuss in detail the importance of understanding how different environmental threats--such as pesticide residues in food, automobile emissions, and leaking drums of hazardous wastes--pose risks to human health, human welfare, and ecology.[11]

The EPA reports reach the surprising conclusion--at least in view of common perceptions--that hazardous waste sites rank considerably lower in risk than many other environmental problems. Although the DOE facilities may have special problems that would make them rank higher than other hazardous waste sites, the EPA studies indicate that other types of environmental problems pose greater risks to health and safety than do waste sites in general.[12]

The first report, *Unfinished Business*, contains assessments by EPA experts of risks associated with a variety of environmental problems.[13] The report drew on the expertise of health scientists, engineers, economists, and other specialists in environmental programs administered by EPA. The experts formed four groups, each focusing on one of four major categories of risks: cancer risks, noncancer health risks, ecological risks, and welfare risks. Each group of experts compared risks across the full range of environmental programs--clean air, clean water, toxic substances, pesticides, radiation, solid wastes, hazardous substances, and so on--and ranked risks from environmental problems as relatively high, medium, or low.[14]

Because most of DOE's environmental cleanup involves hazardous waste sites--active and inactive--the experts' rankings are useful in providing a sense of the relative threat that each site poses to public health and the environment. The rankings are by no means conclusive, however. Additional specific

10. Risk assessment is a complicated undertaking, involving an understanding of a variety of disciplines, including toxicology, epidemiology, and statistics. For a summary of issues surrounding risk assessment, see the Carnegie Commission on Science, Technology, and Government, *Risk and the Environment: Improving Regulatory Decision Making* (New York: Carnegie Commission, June 1993), especially pp. 76-78.

11. EPA included in "welfare effects" such effects as damage to property and groundwater supplies, aesthetic losses, and loss of recreational benefits.

12. A motivation for the EPA studies was to help set priorities in environmental policy. DOE is more constrained than EPA, having to adhere to EPA rules, triparty agreements, and laws and regulations set by other regulatory agencies.

13. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, *Unfinished Business: A Comparative Assessment of Environmental Problems* (February 1987). As the title suggests, the risks addressed by EPA are those remaining; many potential risks have already been removed or abated through controls in place under existing laws and regulations.

14. The groups took slightly different approaches in structuring their ranking systems. The experts assessing cancer risks and welfare risks ranked the environmental problems separately and then grouped them into clusters of relatively high, medium, and low risks. The experts assessing noncancer health risks and ecological risks presented their findings in clusters reflecting degree of relative risk but did not rank individual environmental problems separately.

information about risks at individual sites would be required to establish a more definitive ranking.

Cancer Risks. EPA's experts on cancer risks ranked inactive hazardous waste sites eighth highest of the 29 environmental problems studied, and active sites 13th. These individual rankings put hazardous waste sites in the second riskiest group of cancer-risk problems. The experts considered inactive hazardous waste sites to be less of a threat than the exposure of workers to chemicals, indoor radon, pesticide residues on foods, indoor air pollutants other than radon, exposure of consumers to chemicals, hazardous and toxic air pollutants, and depletion of stratospheric ozone.[15]

Noncancer Health Risks. EPA's experts on noncancer risks to human health rated both active and inactive hazardous waste sites relatively low on the risk scale.[16] A major reason for the low ranking is that despite the moderate toxicity of substances at hazardous waste sites, relatively few people are exposed, and exposures are generally by indirect routes and low in concentration. These characteristics contrast with problems rated as a higher risk, such as air pollutants, pesticides, and discharges to sources of drinking water and water habitats of edible fish and shellfish.[17] Exposure of a small number of people, of course, does not mean that a hazard can be ignored. It may have a bearing, however, on the best way to reduce or eliminate a risk. Even though lack of hard scientific data led the work group on noncancer health risks to rely heavily on professional judgment, there was a surprising amount of consensus about the rankings.

Although the experts did not consider the health risks at hazardous waste sites to be high, they noted that if hazardous substances at these sites are not contained--if they seep into groundwater, for instance, or pollute the air--the risks may be much higher. Risks also may be high for workers at the sites. These factors may raise the relative threat to health at some DOE facilities.

Ecological Risks. The ecology experts considered risks of damage to entire ecological systems, to geographical regions, and to the biosphere itself. They ranked active hazardous waste sites in the lowest of six risk groups, and inactive hazardous waste sites in the second lowest group.[18] The primary reason given for the relatively low ranking is that environmental problems caused by hazardous waste sites generally are highly localized. Moreover, even the local environmental impacts typically are low. The experts noted, however, that the rankings of ecological risks of Superfund sites must be considered tentative because they are based on relatively little data.[19]

Welfare Risks. EPA's experts on welfare risks considered how environmental problems reduce the value of a variety of goods, services, and activities. They reported two types of risks: to community drinking water supplies, and to property values of nearby residences. Examples of welfare effects include damage to property by air and water pollutants, diminished enjoyment of natural resources because of pollution, and lower yields from farming and fishing. Of the 23 environmental problems ranked, inactive hazardous waste sites were ranked ninth, and active hazardous waste sites were ranked 11th. Like the ecological risk group, the welfare risk group downgraded the risks of waste sites because "most of their effects are localized, and most waste sites are located away from areas of high population density."[20]

15. Environmental Protection Agency, *Unfinished Business*, Appendix I, "Report of the Cancer Risk Work Group," Table 1, pp. 4-10.

16. Ibid., Appendix II, "Report of the Non-Cancer Risk Work Group," Table 2-1, p. 2-2. Because of uncertainties and lack of data, the noncancer work group did not numerically rank each type of environmental problem (although they used a quantitative scoring system to help in the ranking process). Instead, they used three categories of risk: low, medium, and high.

17. Ibid., p. 2-3. Municipal and industrial nonhazardous waste sites were ranked in the medium-risk category (Table 2-1, p. 2-2). The experts considered them riskier than hazardous waste sites because larger numbers of people were potentially exposed to pollutants, and in the case of industrial sites, exposure concentrations were expected to be higher (Table 2-2, p. 2-7).

18. Ibid., Overview, pp. 48-49.

19. Ibid., Appendix III, "Basis for Ranking Position."

20. Ibid., Appendix IV, "Report of the Welfare Risk Work Group," p. 7-10.

Criticisms and Follow-up to EPA's *Unfinished Business*

EPA's *Unfinished Business* represented a major step in systematically examining risks and comparing different kinds of threats to human safety, health, welfare, and ecology. The EPA Administrator subsequently asked EPA's Science Advisory Board (SAB) to review the report, "to examine strategies for reducing major risks, and to recommend improved methodologies for assessing and comparing risks and risk reduction options in the future."[21] Building on the report's findings that the activities and media regulated by EPA presented substantially different risks, the SAB noted the lack of coordination among environmental laws and programs. It recommended measures to integrate environmental policies so as to make use of risk comparisons in setting priorities among policy actions.

The SAB found several shortcomings in *Unfinished Business*, most of which were attributed to the limited information available about risks and other relevant factors. The SAB also expressed concern that the report defined some environmental problems so broadly as to encompass all gradations of risks--thus making assignment to a single risk group meaningless. The SAB noted that the environmental problems identified in *Unfinished Business* were an amalgamation of noncomparable items, including specific pollutants, sources of pollutants, and types of exposure.

Still, the SAB did not dispute the report's rankings of relative health risks. Instead of reassessing health risks, the SAB's Human Health Subcommittee devoted its efforts to seeking ways of resolving a variety of methodological problems. For example, the subcommittee noted the desirability of developing an aggregate ranking that would combine the relative risks of cancer and noncancer health effects. It also recommended stepped-up efforts to gain information about the health effects of various types and amounts of exposure to various substances.[22] Until better scientific information becomes available, the health subcommittee deemed it "not illogical" to rank as most risky the environmental problem areas with the highest probability of exposing humans to toxic substances--in effect, the problem areas classified as highest risk in *Unfinished Business*.[23]

For nonhealth risks, the SAB's assessment differed somewhat from that of *Unfinished Business*. The SAB's Ecology and Welfare Subcommittee recommended moving active hazardous waste sites up one risk category from the lowest to the second lowest category and moving inactive hazardous waste sites to a medium-risk category. The subcommittee questioned *Unfinished Business*'s assumptions that current regulation is adequate to deal with all potential threats of migration of contaminants from waste sites. It also expressed concern about release of toxic substances from inactive hazardous waste sites and recommended continued monitoring of such sites.[24]

The SAB noted the dichotomy between the public's perceptions of risk and the risk assessments of environmental professionals. Given the nature of the political process, the problems the public perceives to be serious have received greater attention in environmental legislation, regulation, and budgets than have problems deemed serious by experts. This dichotomy probably also applies to the DOE cleanup program: the public appears to be greatly concerned about hazardous wastes, even when they are properly stored and considered by experts to pose relatively little threat to health, safety, or the environment (the limited information available about actual risks at each site, however, precludes a definitive assessment). The SAB recommended improving the public's understanding of environmental risks.

21. Environmental Protection Agency, Science Advisory Board, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*, SAB-EC-90-021 (September 1990), p. ii (cover letter from SAB Chair Raymond Loehr and Co-Chair of Relative Risk Reduction Strategies Committee Jonathan Lash to EPA Administrator William K. Reilly).

22. Ibid., Appendix B, pp. 7-8.

23. Ibid., p. 93.

24. Ibid., Appendix A, pp. 50-53.

Conclusion

Much work remains to be done in assessing health, safety, and environmental risks. Understanding the risks at DOE's nuclear facilities--as well as those from other environmental problems--is essential for directing resources to where they buy the most protection from risks. Responsibility for studying these risks does not necessarily lie with DOE, however. Such agencies as EPA and ATSDR most likely have a comparative advantage in conducting risk assessments because protecting the public from health and environmental risks is central to their missions. The National Academy of Sciences' effort to advise DOE on risk assessment and risk management should make a valuable contribution to understanding risks.

Weighing Benefits and Costs

Risk assessment in its current state has many shortcomings. What role, then, can it play in formulating public policy? Although in some instances the uncertainties are so great that even trying to rank relative risks is fraught with peril, the findings of risk assessments can help inform the debate on how to proceed with hazardous waste sites. Nonetheless, extremely difficult choices remain to be determined by the political process, guided by informed public opinion. How does society value preserving an ecological resource? Is a given reduction in risk of cancer today more valuable than the same reduction in risk 50 years hence? What about one cancer case today versus 10 cases in 100 years?

If resources to reduce risks were unlimited, setting priorities would not be a problem. But choosing to spend cleanup money to address certain environmental problems has the opportunity cost of not addressing others that may pose bigger risks. How do the threats of DOE's environmental problems compare with others? What criteria could be used to help decide how much should be spent on cleaning up DOE facilities? How can the nation get the maximum benefit for the money spent on environmental cleanup?

Risks and Resources

The amounts of resources the federal government is devoting to environmental problems do not closely parallel the risks as assessed by the experts. For example, EPA's experts considered risks to human health from indoor air pollutants (including radon, asbestos, and other pollutants) to be high; in contrast, a Roper poll found public concern about indoor air pollutants to be low. EPA's budget in 1992 included just $28 million for indoor radon and $32 million for other indoor air pollutants. In comparison, EPA's Superfund budget was more than $1.7 billion, the environmental restoration component of DOE's cleanup budget (the part most like Superfund) was $1.1 billion, and the entire DOE cleanup budget was $4.4 billion.

These numbers do not necessarily indicate that the federal government is spending the wrong amount on these problems; that conclusion would require at least two types of additional information. First is the matter of the appropriate role of the federal government in reducing environmental risks. In some cases, such as radon in homes, the appropriate federal role may be to make people aware of a potential problem but to leave testing and mitigation to the homeowner. For many environmental problems, the federal government requires companies to reduce pollution using their own resources. For the DOE complex, however, the environmental responsibility clearly rests with the federal government.

The other type of additional information needed concerns the benefits to be gained from spending on environmental problems. Ideally, the federal environmental budget would be allocated so as to achieve the greatest benefits per dollar spent.

Risk Trade-offs

If reducing existing risks is a primary goal of environmental cleanup programs, then it also is important to avoid increasing risks when carrying out cleanup activities. Some environmental cleanup actions present their own set of increased risks. In some cases, for example, excavating and burning soil to rid it of contaminants may cause releases of hazardous air pollutants. Transporting wastes from dispersed sites to a central disposal facility carries with it risks of accidental release of hazardous materials.[25] Thus, unless hazardous substances are leaking or otherwise migrating into the environment, it may be safer to leave them where they are. And it may be safer to contain spills or leakages than to take more active measures to remove or destroy pollutants.

Using Benefit-Cost Analysis

Because environmental cleanup places large demands on limited resources, cleanup dollars must be spent as effectively as possible. That can be accomplished by comparing the benefits and costs of alternative plans to see which is likely to yield the largest net benefits.

Benefits of environmental cleanup include reducing risks to human life and health, mitigating harmful effects on plants and animals, improving the quality of the environment, maintaining biodiversity, and so on. Measuring--or even completely identifying--these benefits presents significant challenges because of the many uncertainties about the way hazardous wastes migrate into the environment and affect the health or welfare of humans and other living things. Consequently, attempts to quantify the benefits from reducing exposure to risks should make clear the uncertainties attached to them.

Once benefits have been identified, they must be evaluated; that is, what value do people place on them? Estimating values of benefits is not easy because no active market exists for many types of benefits. Perhaps the most difficult challenge is figuring what value to place on reducing the risk of premature death. One method is to observe what people are willing to pay, or give up, to reduce risks, such as equipping their cars with antilock brakes or installing smoke detectors in their houses. The offering of higher wages to get workers to accept dangerous jobs provides additional evidence about how people value risks.[26] The federal government implicitly places values on risk reduction in the regulations it issues. The estimated cost per premature death averted ranges from $100,000 to more than $5.7 trillion (see Table 3).

Placing a value on natural resources is also difficult. For some lands, private market transactions enable comparisons. For instance, the value of a DOE facility offered for industrial use could be determined by the amount that businesses are paying for comparable facilities. But it is harder to estimate how much people are willing to pay for restoring a site to its pristine condition. Some evidence can be derived from observing how much people are willing to spend on national parks or for recreational resorts. Additional information can be gained from surveys in which people have been asked how much they would be willing to pay for a variety of attributes of environmental quality.[27]

One can sometimes get around the problem of placing a direct value on potential benefits by instead comparing the cost-effectiveness of alternative policies to environmental cleanup. This approach is based on how much can be achieved (in terms of risks reduced, or any other objective) per dollar spent. Alternative policies can then be compared in terms of the benefits they produce. Cost-effectiveness is likely to vary greatly among sites and among the types of waste to be cleaned up.[28]

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25. See, for example, Department of Energy, *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington*, Draft Environmental Impact Statement, DOE/EIS-0119D (March 1989), p. 3.51.

26. Economists have written many books and articles on this subject. For a recent reference, see Kip W. Viscusi, *Fatal Tradeoffs: Public and Private Responsibilities for Risk* (New York: Oxford University Press, 1992).

27. These surveys are known as "contingent valuation" studies in the economics literature. For a more complete discussion, see A. Myrick Freeman III, *The Measurement of Environmental and Resource Values: Theory and Methods* (Washington, D.C.: Resources for the Future, 1993).

28. Cost-effectiveness analysis can also be used to compare options for meeting a narrower set of objectives. Examples include finding the least-cost method of reaching a given regulatory standard or the least-cost method of treating a given volume of waste.

Table 3.
Implicit Costs per Life Saved of Selected Regulations

Regulation	Year Issued	Agency	Cost per Premature Death Averted (Millions of 1990 dollars)
Unvented Space Heater Ban	1980	CPSC	0.1
Trihalomethane Drinking Water Standards	1979	EPA	0.2
Aircraft Floor Emergency Lighting Standard	1984	FAA	0.6
Auto Side Door Support Standards	1970	NHTSA	0.8
Hazard Communication Standard	1983	OSHA	1.6
Standards for Radionuclides in Uranium Mines	1984	EPA	3.4
Benzene Occupational Exposure Limit	1987	OSHA	8.9
Hazardous Waste Listing for Petroleum Refining Sludge	1990	EPA	27.6
Coke Ovens Occupational Exposure Limit	1976	OSHA	63.5
Diethylstilbestrol (DES) Cattlefeed Ban	1979	FDA	124.8
Hazardous Waste Land Disposal Ban	1988	EPA	4,190.4
Hazardous Waste Listing for Wood-Preserving Chemicals	1990	EPA	5,700,000.0

SOURCE: Congressional Budget Office using data from *Budget of the United States Government: Fiscal Year 1992*, Part Two, p. 370, Table C-2. Cost estimates were based on John F. Morrall III, "A Review of the Record," *Regulation*, vol. 10, no. 2 (1986), p. 30.

NOTES: CPSC = Consumer Product Safety Commission; EPA = Environmental Protection Agency; FAA = Federal Aviation Administration; NHTSA = National Highway Traffic Safety Administration; OSHA = Occupational Safety and Health Administration; FDA = Food and Drug Administration.

Example of EPA's Use of Benefit-Cost Analysis

Some of these issues are illustrated in an analysis of a proposed EPA regulation concerning facilities at which wastes are treated, stored, and disposed of (see Box 2). The analysis, called a regulatory impact analysis, identifies the benefits and costs of a proposed rule governing corrective actions at facilities regulated under the Resource Conservation and Recovery Act.[29] The analysis is intended to provide a framework for evaluating the costs and benefits of alternative policy approaches to environmental cleanup at RCRA sites. It points up deficiencies in information about costs and benefits, and it identifies trade-offs facing policymakers.

Although the regulatory impact analysis did not cover the largest DOE facilities, it provides an example of the type of analysis that would be useful in understanding the policy choices and trade-offs at

29. Environmental Protection Agency, Office of Solid Waste, *Draft Regulatory Impact Analysis for the Final Rulemaking on Corrective Action for Solid Waste Management Units: Proposed Methodology for Analysis* (March 1993).

the nuclear weapons complex. As DOE completes assessments of contaminated sites, a better picture of risks and potential risk reductions will appear and will facilitate comprehensive analysis of alternative environmental cleanup activities. As indicated in Chapter 2, DOE is working on improving its ability to estimate costs, although additional information and refinements are needed there as well.

Deciding When to Clean Up

Benefit-cost analysis can help guide policy decisions about both the timing and the extent of cleanup. For each site requiring remediation, DOE will have to decide whether to clean it up immediately, delay cleanup temporarily, or postpone cleanup indefinitely.[30] In each case, DOE must consider several factors: the cost; the reduction in risk to workers, the public, and the environment; and alternative uses of land and facilities that are currently not available to the public.

In terms of reducing risks and restoring land and facilities to alternative uses, immediate remediation would generally produce the greatest benefit. This benefit must be weighed not only against the cost, however, but also against risks--primarily to workers--associated with cleanup and disposal.

Benefits and Costs of Delayed Remediation and Permanent Isolation

Delaying cleanup can reduce the risk of exposure caused by accidental release of radioactive contaminants to cleanup workers, the general public, and the environment by allowing time for the natural decay of radioactive material. For instance, tritium --a common contaminant at DOE installations--decays at the rate of 50 percent every 12 years. Thus, 24 years from now, 75 percent of the contaminating tritium will have decayed to a harmless form of helium; after 36 years, 87 percent will have decayed. Other types of radionuclides decay fairly quickly also and, although not as widespread as tritium, would, at current concentrations, present significant hazards to workers involved in the cleanup. Cobalt 60 and cesium 137, commonly found in reactor cores, are examples of such substances.

Delaying cleanup can also provide time for safer and more effective cleanup technologies to be developed. In addition, cleanup projects that are not affordable in the near term could become so in the future if additional funds become available or if cost-saving technologies are developed.

Delaying remediation has disadvantages, however, especially if it increases the potential for exposing the public to contaminants. Such exposure is particularly likely if the contaminants cannot be completely contained. Delaying cleanup would also require continued limits on the use of contaminated lands or facilities.

Permanently isolating a site, especially one that is particularly difficult to clean up, is a viable option given the remote location of many of DOE's installations. Because of the secrecy of the Manhattan Project, for example, the original sites selected in the 1940s were chosen specifically because they were far away from population centers. Furthermore, to enhance the security of operations, many of the sites on which DOE facilities were built were very large, thereby making it difficult for outsiders to observe them. The same characteristics make it easy to isolate the contaminated sites.

Permanently isolating some sites may be consistent with storage requirements for nuclear waste. For the foreseeable future, the nation will need a location in which to store radioactive materials discarded from its military endeavors. Some of these wastes, though not necessarily highly radioactive, may be rather bulky. Examples of such wastes include discarded housings of nuclear reactors from decommissioned submarines and the sections of submarine hulls that surrounded the reactors. These slightly radioactive components are being stored at Hanford. They probably present little immediate danger to the environment since their low level of contamination is unlikely to spread. Ensuring that

30. Indefinitely postponing remediation need not be construed as license for further contamination of a site. Rather, it could entail storage at an acceptable level of risk, leaving open the option of cleanup if new technologies and less constrained budgets permit.

Box 2.
EPA's Analysis of Hazardous Waste Cleanup

The Environmental Protection Agency (EPA) has recently published a regulatory impact analysis (RIA) that attempts to identify and estimate the benefits and costs of a proposed rule governing corrective actions at facilities regulated under the Resource Conservation and Recovery Act (RCRA).[1] The analysis is intended to provide a framework for evaluating the costs and benefits of alternative policy approaches to environmental cleanup at RCRA sites.

EPA's analysis is useful and relevant to the debate about the Department of Energy's (DOE's) cleanup program. Although it does not estimate the costs and benefits (risk reductions) of complying with the proposed regulation at the most problematic DOE facilities, it sheds light on the kinds of benefits, the magnitudes of costs, and other implications of the proposed rule.[2] Perhaps the most important lessons to be drawn from the RIA are the difficulties of determining costs and benefits and the uncertainties about the estimates.

The analysis estimates the total discounted cost of corrective actions at the sample facilities to be $18.7 billion. These costs occur over a long period; the estimated median time to remediate contaminated groundwater is 115 years for on-site plumes and 90 years for off-site plumes.[3] Most of the costs are associated with removing and treating contaminated soil and groundwater.

The RIA assesses both health and ecological benefits. The expected health benefits over the 128-year modeling period include averting 400 to 13,300 cancer cases and 100 to 12 million cases in which thresholds for noncancer health effects are exceeded. (EPA did not discount the benefits although it did discount the costs.) In addition to unquantified ecological effects, benefits include cleanup of 1.4 million acres contaminated by groundwater and 18 million cubic yards of soil. The large range of cancers averted and the much larger range of noncancer health benefits reflect the difficulties of assessing health risks. By the same token, these ranges suggest that devoting more resources to understanding and evaluating health benefits could produce a large payoff in helping to formulate cleanup priorities.

1. Environmental Protection Agency, Office of Solid Waste, *Draft Regulatory Impact Analysis for the Final Rulemaking on Corrective Action for Solid Waste Management Units: Proposed Methodology for Analysis* (March 1993). The discussion here is not intended to be a comprehensive critique of EPA's analysis, nor an endorsement of its methodology or findings. Rather, it illustrates the type of analysis that can help inform policy decisions and the strengths and shortcomings of the current state of knowledge and estimating techniques.

2. The sample consisted of 359 federal facilities and 5,432 nonfederal facilities. But the RIA excluded seven of the largest DOE facilities--Hanford, Savannah River, Rocky Flats, Idaho National Engineering Laboratory, Fernald, Los Alamos National Laboratory, and the Nevada Test Site. It also excluded two large Department of Defense facilities--Rocky Mountain Arsenal and McClellan Air Force Base. Some parts of DOE's cleanup program fall under the proposed rule, but other parts come under the jurisdiction of the Comprehensive Environmental Response, Compensation, and Liability Act. Most of the same considerations apply, however, regardless of which statute governs.

3. In the context of environmental cleanup, a plume is groundwater contaminated by flowing through a hazardous substance.

the contaminants at such sites are contained may be preferable to attempting to remove and treat them.

Deciding against restoring a particular site also has other advantages. It would probably minimize risks to workers since exposure to contaminants could be limited. In addition, it would avoid the cost of remediation, although those savings would have to be weighed against the costs of maintaining safety and security at the site.

In addition to the cost of safeguarding and monitoring a site, forgoing remediation would have other drawbacks. The potential for accidentally exposing people and the environment to the contaminants would remain. In addition, it would permanently preclude other uses of the land and facilities.

The Surplus Reactors at Hanford: An Example of the Choices Facing DOE

The trade-offs involved in deciding which cleanup actions to undertake and when to do so are illustrated in DOE's analysis of decommissioning eight surplus reactors at Hanford. DOE examined several

The problem can be illustrated by considering the implications of the estimates. Focusing on health benefits, suppose first that the low end of the ranges turns out to be correct. If all cancer or noncancer health effects result in premature deaths, premature deaths would total 500. At a cost of $18.7 billion, the cost per life saved would come to $37.4 million.[4] If instead the midpoints of the ranges were correct, then the cost per life saved would be just over $3,000. The latter would be quite a bargain; however, the former would not be such a good deal when compared with other risk-reducing expenditures (see Table 3, but note that its estimates are lower because it discounted future benefits whereas the RIA did not).

These results leave policymakers little basis for understanding whether the proposed rule would make wise use of environmental cleanup dollars, but the RIA offers a modest amount of additional information. For example, it indicates that many of the potential benefits are concentrated at a relatively small number of facilities. Focusing on those facilities might be a way to make a large problem more tractable.

The RIA suggests another intriguing option. Noting that the primary benefits of the proposed rule involve reducing contamination in drinking water, the RIA indicates that the health effects of the hazardous waste sites in the sample could be mitigated largely by treating water that was destined for use by humans (for drinking, washing, and so on) or by providing water from alternative sources rather than by rooting out all contamination at the source. Ensuring the safety of water to be used by humans would cost only $4.8 million, according to the RIA.

4. This estimate is calculated as if all the benefits occur immediately. In reality, it would be many years before corrective actions would avert premature deaths. The estimate also ignores potential ecological benefits.

As far as protecting human health is concerned, then, the choice would appear to be between spending $4.8 million and spending $18.7 billion. Moreover, providing clean water from alternative sources could probably be achieved much more quickly than cleaning up contaminated groundwater, thereby giving health protection sooner. Each choice would provide essentially the same reduction in risk to human health. The difference is that the $18.7 billion would also buy clean groundwater and soil--or at least an attempt at cleanliness. As the RIA notes, some substances in the groundwater cannot be fully cleaned up using existing technologies: pumping and treating is relatively ineffective in removing dense nonaqueous-phase liquids, for example. If those are the choices, then adopting the more expensive approach would imply placing a very high value on nonhealth benefits.[5]

To summarize, the RIA proposes a methodology for evaluating benefits and costs associated with cleaning up hazardous wastes, identifies the kinds of benefits and costs, and provides some estimates of their magnitude. It suggests that knowing how contamination at hazardous waste sites is likely to affect people's health is essential to making sound decisions about remediation. And it points out that at least in some cases, there may be less expensive ways to reduce risks to human health than undertaking massive cleanup efforts. Such alternatives may meet only the objective of reducing risks to people; they may not meet the other objective of making sites available for other uses. The choice of objective is ultimately a political one, but it can be informed by knowledge of the trade-offs.

5. Choosing the option of providing clean water from alternative sources does not foreclose the option of cleaning up the contaminated groundwater. Using alternative sources could be considered an interim action, pending development of technology that would offer cheaper or more effective treatment of groundwater.

alternatives: immediate removal of the reactors to a disposal site, delayed removal, and permanent isolation with no remedial action.[31] As criteria for comparison, DOE considered the cost of each alternative over the next 100 years and the number of excess cancer deaths during the next 10,000 years caused by contaminants in the reactors.

31. Department of Energy, *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington*, Addendum (Final Environmental Impact Statement), DOE/EIS-0119F (December 1992). DOE considered dismantling the reactor cores as well as one-piece removal, but the latter is most relevant to the current discussion.

Immediate Remediation. DOE considered the option of immediately removing the reactor cores to their final resting place and dismantling the rest of the reactor buildings. DOE estimated that this action, which would take about 12 years for all eight reactors, would cost about $190 million (in 1990 dollars) and that the annual cost to monitor groundwater at the disposal site would be about $400,000. The total cost of this option over the next 100 years, therefore, would be about $230 million (see Table 4). DOE did not take account of the effects of time in its cost estimates, however. At a discount rate of 2 percent, the cost of immediate reme-

Table 4.
Costs and Cancer Fatalities Under Three Alternatives for Decommissioning Reactors at Hanford

Alternative	Cost Over 100 Years (Millions of dollars): In 1990 Dollars	Cost Over 100 Years (Millions of dollars): Discounted[a]	Occupational Dose (Person-rem)[b]	Cancer Fatalities: Occupational[c]	Cancer Fatalities: Population[d]
Immediate Remediation	230	180	159	0	1
Delayed Remediation	190	60	51	0	1
Permanent Isolation with No Remediation	40	20	24	0	20

SOURCE: Congressional Budget Office using data from Department of Energy, *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington*, Addendum (Final Environmental Impact Statement), DOE/EIS-0119F (December 1992).

NOTE: Remediation includes one-piece removal and disposal of reactor core.

a. Assumes a real annual rate of 2 percent.

b. rem = roentgen equivalent man, a measure of exposure to radiation.

c. Over a period of 100 years.

d. Over a period of 10,000 years.

diation would be $180 million over the next 100 years.[32]

DOE concluded that the public would not be exposed to radiation during the transportation of the reactor cores or dismantlement of the buildings. Nor would the workers be sufficiently exposed to cause cancer fatalities, according to DOE's analysis. Finally, the land on which the reactors are currently sited would be available for unrestricted use at the end of the 12-year remediation process.

Delayed Remediation. Another alternative DOE examined was to wait 75 years before removing the reactor cores from their present locations and transporting them to the disposal area. By allowing time for some of the radionuclides to decay, DOE estimates that this option would reduce the exposure of workers by more than two-thirds. Although DOE concluded that exposure rates would not result in any cancer-related deaths of workers even if remediation was undertaken immediately, it asserted that this delay would further reduce the risks.

DOE also determined that a 75-year delay in remediation would not increase risks to the public from the contaminants in the reactors. By continuing security and maintenance of the reactors, DOE is confident that those risks would not significantly increase.

Finally, the cost to DOE to remediate 75 years from now and provide security and maintenance of the reactors in the meantime would be less than the cost to remediate immediately, when the time value of money is considered. According to DOE, the cost to guard and maintain the eight facilities before remediation would be about $400,000 per year (in 1990 dollars). DOE estimates that remediation would cost about $190 million in 1990 dollars whether it takes place now or in 75 years. At a

32. At a discount rate of 4 percent, the cost would be $160 million; at the 7 percent discount rate favored by the Office of Management and Budget, the cost would be $140 million.

discount rate of 2 percent, however, the cost of this option would be $60 million--roughly one-third of the cost of immediate remediation.[33]

Postponing remediation for 75 years would have one major disadvantage: it would preclude for a significant period of time any alternative uses of the land on which the reactors are situated. The reactors are located on or near the banks of the Columbia River--a popular recreation area and prime agricultural land--and that land would be unavailable for public use for at least 75 years.

Permanent Isolation of the Reactors. DOE also evaluated the option of leaving the reactors, with their cores and associated other nuclear waste, in place permanently rather than removing them to a disposal site. Given that DOE estimated an annual cost of about $400,000 to guard and maintain the eight facilities, total undiscounted costs over the next 100 years would amount to approximately $40 million. At a discount rate of 2 percent, the cost of this approach would be about $20 million, significantly less than either immediate or delayed remediation.[34]

Some important disadvantages, however, are associated with this option. The first is the potential for increased exposure of the public to the reactors and their contents if the reactor buildings were ever allowed to deteriorate. DOE illustrates this risk by assuming that the reactors are abandoned after 100 years. Without routine maintenance, the reactor buildings would deteriorate, leading to the potential release of radionuclides to the environment and the potential exposure of humans to radioactivity and other safety hazards if people entered the site. As a consequence, DOE estimates that maintaining the reactors for 100 years and then abandoning them could result in 20 excess cancer fatalities over the next 10,000 years.[35]

The potential for exposure leading to fatalities exists even after 100 years because some of the radionuclides that are present in significant quantities will be radioactive for a very long time. Carbon 14, an element commonly found in nuclear reactors, has a half-life of 5,730 years. Thus, at the end of 100 years, almost 99 percent of the carbon 14 would remain. In addition, lesser amounts of even longer-lived radionuclides, such as uranium 238 and chlorine 36, would remain.

Finally, this option would preclude using the land or structures for any other purpose, such as recreation or agriculture. DOE did not include an estimate of the value people place on these uses, but it should be factored in to any decision about ultimate land use.

Choosing Among the Alternatives. Choosing one of these alternatives requires weighing the costs and benefits. The least costly alternative is permanent isolation with no remediation. The costs in discounted dollars at a rate of 2 percent would be equal to $180 million, $60 million, and $20 million for immediate remediation, delayed remediation, and no remediation, respectively. On the benefit side, DOE's analysis suggests that no cancer fatalities (among either the public or workers) should result from exposure to contaminants in the reactors during a period of 100 years. That is, no lives would be saved over the next 100 years by DOE's investment in remedial action, arguing for the cheapest alternative of no remediation.

Performing no remediation appears less attractive, however, if one believes that DOE might someday stop maintaining the reactors. In that case,

33. At a discount rate of 4 percent, the cost of delayed remediation would be about $20 million; at 7 percent, it would be about $7 million. DOE's undiscounted cost estimates for the two options involving remediation are very similar because the annual costs to monitor the quality of groundwater at the disposal site, which are incurred after immediate remediation, are approximately equal to the annual costs to guard and maintain the facilities before delayed remediation.

34. At a rate of 4 percent, the discounted cost would be about $10 million; at 7 percent, about $6 million.

35. The estimated dose from exposure to contaminants in reactors is much lower than the dose that would result from natural radiation. In fact, DOE estimates that the same population would receive a dose 200 times higher from natural radiation over the 10,000-year period than from contaminants in the reactors during the same period.

some fatalities might occur. Based on DOE's analysis, which assumes the reactors are abandoned after 100 years, 20 fatalities might result over 10,000 years without remediation, compared with one if remedial action was taken, either immediately or after 75 years (see Table 4).

Based in part on this reasoning, DOE has decided to undertake remedial action within 75 years.[36] DOE is currently working on the conceptual design and has not determined when removal of the reactors will begin.

Setting Priorities

Because DOE is responsible for cleaning up thousands of sites and because available resources will be constrained, the department, with guidance from the Congress and other interested parties, will have to make decisions about which cleanup tasks to tackle first and which to defer. To make the best use of limited budgetary resources, DOE must weigh the benefits and costs of various cleanup projects when establishing priorities among them. In other words, DOE should focus its attention on projects that would yield the greatest benefit--in terms of deaths averted or land and facilities returned to the public domain--per dollar invested.

But as noted throughout this chapter, the detailed information necessary to make such choices is often not available. In many cases, DOE does not know the nature or extent of contamination at its facilities, nor the health risks posed.

Additional Information Needed for Rational Decisionmaking

Thus, before DOE can make choices about how to clean up its complex, it will need additional information and tools. First, DOE must know the extent of the task it faces. To gain this knowledge, it must determine the type and extent of contaminants within its complex. DOE is in the process of characterizing its sites and will continue to do so for the next few years.

Second, once the extent of the contamination has been determined, DOE, in order to decide whether the problem requires remediation, must know what risk it poses to human health and the environment. Expanding the body of knowledge concerning health risks posed by pollutants is essential not only to DOE's cleanup program but also to environmental policy in general.

Next, DOE must have efficient and effective techniques to accomplish cleanup. As discussed in Chapter 4, this area might deserve added emphasis.

Finally, DOE needs standards for acceptable levels of contaminants, to indicate when cleanup tasks are complete. Such standards would be tied in part to the risks posed to human health, a question discussed above. An additional criterion for determining cleanup standards, however, is the ultimate use to which the facility or land will be put. If the land is going to be used for a park, it will have to be cleaned to pristine standards. But if it will be used as a national nuclear waste dump, then it will not have to be cleaned up at all. Thus, before DOE can make choices concerning how to conduct various cleanup projects, it will have to determine, in conjunction with the public and its representatives, the ultimate use of its surplus facilities.

Models for Setting Priorities

DOE has made a number of attempts to develop a process for setting priorities for its environmental activities. In consultation with state and local officials and other interested groups, DOE developed a model for setting priorities in the Environmental Restoration program that incorporated risks to human health, uncertainty, environmental impact, socioeconomic impact, regulatory commitments, and future costs. The Waste Management program has been working on a similar model.[37]

36. Department of Energy, "Record of Decision: Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington," *Federal Register*, vol. 58, no. 178 (September 16, 1993), pp. 48509-48513.

37. For a thorough discussion of setting priorities, see Congressional Research Service, *Setting Priorities for Department of Energy Environmental Activities*, Report 91-150 ENR (February 6, 1991).

In the wake of substantial criticism, however, DOE seems to have abandoned these modeling efforts. For example, the environmental restoration model was used in developing the fiscal year 1992 budget request but was set aside during preparation of the 1993 budget. Critics have complained of a number of shortcomings, especially inadequate consultation with affected parties and the use of subjective weights on which there was considerable disagreement.[38] In reality, moreover, regulatory requirements have preempted the results of the model, since DOE has had to devote essentially all of its near-term resources to specific actions set forth in its agreements with the Environmental Protection Agency and state regulatory authorities.

Public Involvement in Setting Objectives and Priorities

DOE's experience with trying to develop a model to set priorities has underscored the importance of involving the public in the process. Consequently, DOE has stepped up efforts to increase public participation in establishing cleanup policies. The department is participating in an effort led by the Environmental Protection Agency and aimed at finding ways of improving communications between federal agencies responsible for cleaning up waste sites and interested individuals and groups. The Federal Facilities Environmental Restoration Dialogue Committee, also known as the Keystone group after its facilitators, the Keystone Center, includes representatives of federal agencies, tribal and state governments, and environmental, community, and labor organizations. The committee has recommended that federal agencies keep citizens informed about environmental cleanup plans and solicit their views about objectives and priorities.[39] DOE has indicated a willingness to adopt the Keystone group's recommendations to improve the lines of communication.[40]

The Keystone process is based at the facility level, not the national level, which has several advantages. First, people living near a facility are the ones who would most directly experience the effects of cleanup policies--effects such as reductions in risk, availability of facilities and land for other uses, changes in employment, and effects on transportation (especially if wastes are transported off-site). They also may bring valuable knowledge of the needs and preferences of the local community--its values and heritage as well as socioeconomic factors--which may vary from facility to facility.

In some communities in which DOE has been a major employer, residents largely support the decontamination of facilities to make them available for other government, industrial, or commercial use. Some people may consider keeping jobs and preserving the economic base of the community to be more important than removing every trace of contamination--at least in the near term. Others may consider it a moral obligation to future generations to restore expeditiously all lands to their pristine state. In particular, some DOE facilities are on lands considered sacred by Native Americans.

The Keystone group recognized that federal funding might fall short of the amount needed to meet legal requirements at federal facilities. It proposed that budget shortfalls be allocated on an equal percentage basis among all facilities. This approach points up a disadvantage of focusing on individual facilities in that national priorities may differ from local priorities. If one facility was found to pose much more serious risks than others,

38. For a detailed critique, see James D. Werner, "Comments on Behalf of the Natural Resources Defense Council and the Environmental Defense Fund Regarding the Proposed Department of Energy Priority System for Environmental Restoration" (Natural Resources Defense Council, Washington, D.C., November 21, 1991).

39. Federal Facilities Environmental Restoration Dialogue Committee, *Interim Report: Recommendations for Improving the Federal Facility Environmental Restoration Decision-Making Process and Setting Priorities in the Event of Funding Shortfalls* (February 1993).

40. Statement of Paul D. Grimm, then Acting Assistant Secretary of Energy for Environmental Restoration and Waste Management, before the Subcommittee on Energy and Water Development of the House Committee on Appropriations, April 26, 1993.

a broader perspective would probably favor shifting resources to it.[41]

Conclusion

Some people might argue that setting priorities beyond simply complying with regulations and agreements is unnecessary, or at least not productive, since compliance will take most of the resources DOE has available for the foreseeable future. Others worry that if DOE targets its efforts toward cleaning up the most severe problems first, it may lose the will or the resources to take care of smaller problems later. But any cleanup project uses resources that could be spent on some other activity, and society as a whole can gain the most by devoting those resources to activities that produce the most benefits.

Cleaning up all areas to pristine standards may be the ultimate goal desired by the public. But attaining that objective will be very expensive. Selectively reconsidering cleanup standards, and accepting some level of risk greater than zero, could substantially lower total costs. That could free public funds for other programs, such as environmental cleanup efforts deemed to be of higher priority than some of DOE's cleanup problems.

41. The additional resources could come from sources other than the DOE cleanup budget. But raising taxes or reducing federal spending on other services to pay for it would be more difficult, given the framework of the budget process.

Chapter Four

Issues Related to DOE's Cleanup Program

Although appreciable uncertainty surrounds the total cost of the Department of Energy's cleanup effort, the department can make choices as it proceeds with the cleanup that may reduce the cost of the program. This chapter explores four areas of DOE's current programs that have been the subject of Congressional, departmental, or public concern--DOE's efforts to develop new cleanup technologies, the schedule for cleanup activities dictated by interagency agreements, DOE's high overhead costs, and its large number of surplus facilities.

Investing to Develop Better Technologies

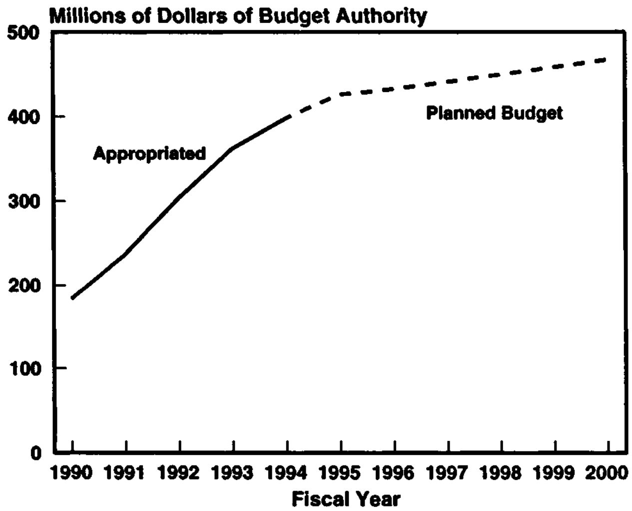
Cleaning up the Department of Energy's nuclear weapons complex could, by some estimates, take 30 years or more and cost hundreds of billions of dollars. To reduce both the cost and duration of the cleanup effort, DOE has initiated several programs to develop new technologies and processes for characterizing and cleaning up its sites. Based on research and analyses that have been completed, DOE feels that it can save potentially large amounts of money in the course of its cleanup by using new technologies. Yet the share of its budget that DOE devotes to developing new technologies is low compared with its own target and may be insufficient to fund development of some new cleanup techniques that could reduce costs.

DOE's Funding for Technology Development

DOE has already invested considerable amounts of money to develop new techniques for characterizing and cleaning up contaminated sites. Since fiscal year 1990, when it created a separate Office of Technology Development within the Environmental Restoration and Waste Management program, DOE has allotted about $1.5 billion to research in environmental technologies, including nearly $400 million in funds for fiscal year 1994.

Annual funding for DOE's Technology Development (TD) program will probably increase above the level appropriated for fiscal year 1994, though the growth may be slower than envisioned in previous five-year plans. DOE has asked for $426 million for fiscal year 1995 to fund technology development and plans to increase funding to $467 million by 2000 (see Figure 3). Previous budget plans, however, had included higher levels of funding for technology development through the end of this decade. The five-year plan submitted in August 1991 included two budget levels that would have increased that funding to about $500 million and about $540 million, respectively, by 1997. Indeed, the Administration's plans as of June 1993 also included levels of funding for technology development that were higher for the years after 1996 than those currently planned, reaching $500 million by 1999.

Figure 3.
Funding for Technology Development Within the Office of Environmental Restoration and Waste Management



SOURCE: Congressional Budget Office based on data from the Department of Energy.

Research and Development Projects. Within the budget for technology development, the research, development, demonstration, testing, and evaluation (RDDT&E) account commanded slightly more than half of TD funding in 1992 and 1993. This account includes funds for research on particular cleanup and assessment techniques in three broad areas--groundwater and soils cleanup, waste retrieval and processing, and pollution prevention. In each of these categories, DOE is conducting individual projects called integrated programs and integrated demonstrations to investigate specific techniques and methods (see Table 5).

Because detailed plans outlining how the funds for technology development will be spent for the next five years are not available, it is impossible to say specifically what the funding will buy. Based on previous spending and the request for funding for 1995, however, the two research and development areas most likely to receive the largest shares of the research funds are groundwater and soils cleanup, and waste retrieval and processing. Funding for these two categories accounts for more than two-thirds of the RDDT&E funding from 1992 through 1995 (see Table 6).

Other Activities in the Technology Development Program. Although more than half of the TD funds support activities in RDDT&E in the years from 1992 through 1995, the remaining funds--an average of 42 percent of total funding--go to other accounts that do not support research activities directly but that DOE feels are necessary to support other technical needs within the EM program (see Table 6).[1] One program provides laboratory and analytic support to characterize waste, water, and soil samples. Another program seeks to develop a scientific, technical, and educational system to ensure that an appropriately educated work force will be available in the future.

The Benefits of New Technologies

DOE feels that it has already benefited from its $1.5 billion investment in technology development. Indeed, it often points to two examples of the direct benefits of that effort. The first is a $15 million savings realized by capping the radioactive waste stored in a silo at the Fernald installation. (Capping involves covering the waste in the silo with bentonite to seal it and reduce the amount of radon released to the surrounding environment.) These savings were achieved by using a remotely controlled robot to measure accurately the three-dimensional contours of the solid waste in the silo. Using the three-dimensional map, DOE could then be very efficient in depositing the bentonite on top of the waste, resulting in minimum wastage and the most complete seal. The second example DOE often cites is the anticipated reduction in treatment time--from an estimated 200 years with old techniques to as little as six months--that could result from the introduction of new techniques for treating a gasoline spill at Lawrence Livermore National Laboratory.

1. The other accounts in the TD budget include Supporting Technologies and Infrastructure Programs, Technology Integration and Educational Development, Program Support, Program Direction, the Environmental and Molecular Sciences Laboratory, and the Hazardous Materials Training Center.

DOE expects to reap the bulk of the benefits of newly developed technologies in the future, however, when it begins to undertake remedial action in earnest. In some cases, new technologies may make possible the cleanup of contaminants for which technologies are not yet available. In addition, DOE has estimated that savings over the next 30 years, compared with the cost of using current technologies to complete the cleanup, could amount to almost $100 billion if technologies now under investigation can be applied successfully throughout the DOE complex.

The department's estimates of the savings that could result from introducing new technologies must be viewed with a certain amount of skepticism. First, DOE has not been able to show that it can estimate accurately the cost of cleaning up its facilities using today's technologies (see Chapter 2). That alone makes it difficult to calculate future savings. Second, many of those estimates are based on multiple assumptions. For example, to estimate the savings that might result from new remediation techniques that can be used with contaminants still in place, DOE calculates the cost to pump out con-

Table 5.
Individual Initiatives in DOE's Research, Development, Demonstration, Testing, and Evaluation Program, by Key Problem Area

Type of Initiative	Groundwater and Soils Cleanup	Waste Retrieval and Processing	Pollution Prevention
Integrated Demonstration	Volatile Organic Compounds in Nonarid Soils Volatile Organic Compounds in Arid Soils Plutonium in Soils Uranium in Soils Mixed Waste Landfill	Buried Waste Underground Storage Tank Decontamination and Decommissioning	Waste Component Recycling,Treatment, and Disposal Environmentally Conscious Manufacturing
Integrated Program	In Situ Remediation Technology Characterization, Monitoring, and Sensor Technology	Efficient Separations Mixed Waste	
Program	Dynamic Stripping Resource Recovery Minimum Additive Waste Stabilization	Supercritical Water Oxidation	DOE/U.S. Air Force Memorandum of Understanding

SOURCE: Congressional Budget Office using data from Clyde W. Frank, "Technology Development Is a Strategic Investment" (presentation by the Department of Energy to Congressional Budget Office staff, February 5, 1993).

taminated groundwater or dig up contaminated soil --costs that would not be incurred using new technologies. In order to arrive at savings that could be realized during the entire cleanup process, DOE must then apply the estimated savings per gallon of water or ton of soil to its estimate of the total number of gallons or tons that would need to be treated.

Calculations of savings based on these methods may represent upper bounds and should be viewed with caution. Rather than predictions of actual savings, these estimates might better be viewed as indications of the technologies that DOE sees as having the greatest potential. The following discussion examines some of DOE's technology development efforts, including both broadly applicable integrated programs and more narrowly focused integrated demonstrations.

Integrated Programs. Integrated programs (IPs) are DOE's technology development efforts with the broadest potential application. They are designed to explore basic technologies and techniques that can be applied to many cleanup projects throughout the

Table 6.
Summary of Funding for the Office of Technology Development, 1992-1995
(In millions of dollars of budget authority)

Activity	1992	1993	1994	1995[a]
Research, Development, Demonstration, Testing, and Evaluation				
Groundwater and soils cleanup	54	77	76	72
Waste retrieval and processing	54	69	104	99
Pollution prevention	6	3	1	1
Innovation and support	55	34	49	61
Other	0	8	23	20
Subtotal	169	191	253	253
Supporting Technologies and Infrastructure Programs[b]	30	45	57	75
Technology Integration and Educational Development[c]	37	38	36	29
Program Support	35	44	37	38
Program Direction	15	16	15	17
Environmental and Molecular Sciences Laboratory	17	28	0	0
Hazardous Materials Training Center	0	0	0	14
Total	303	362	398	426

SOURCE: Congressional Budget Office using data from Department of Energy, Office of Technology Development, *FY 1993 Program Summary* (February 1994); and Department of Energy, *FY 1995 Congressional Budget Request*, vol. 5, *Environmental Restoration and Waste Management* (February 1994).

a. Request.

b. Includes programs for liaison and communications, analytical laboratory management, robotics, decision support, and emergency management.

c. Includes programs for educational development, technology integration, and international technology exchange.

DOE complex and thus have the potential to generate large savings.[2]

One IP is investigating ways to separate waste efficiently from its surrounding medium, be it groundwater or soil. Since, according to DOE, only 0.5 percent of its more than 3 million cubic meters of cataloged waste actually consists of radionuclides, separating that portion from the noncontaminated portion will greatly reduce the volume of waste requiring disposal. DOE is investigating several processes that are available commercially and in use elsewhere to separate radioactive waste from its substrate. These processes include leaching and washing contaminated soil and incinerating combustibles in waste that contains both radioactive components and solvents.

Another IP is developing techniques for in situ remediation, a process that also can be used to treat waste in either water or soil. Methods being developed would eliminate the need to extract the contaminant from the soil or groundwater in order to treat it, thus avoiding the expense and effort associated with pumping out groundwater or digging up soil. Examples of in situ remediation include the introduction of microbes into the soil to break down contaminants and electrothermal means of turning contaminated soil into glass so that the contamination cannot spread.

DOE's estimates of potential savings from these two integrated programs are based on comparisons between the costs of operations using today's technology and costs that would result from doing things differently using new technologies. DOE estimates that in situ remediation could save $54 billion in cleanup costs throughout the complex compared with current methods. Similarly, the IP designed to develop efficient ways to separate radioactive waste from soil and mixed-waste solutions could save $40 billion according to DOE estimates; these savings would result from the reduction in projected volumes of soil and mixed waste requiring disposal. Thus, the technology developed in these two IPs together, if applied widely, could save more than $90 billion during the cleanup.

Of course, DOE has not yet proved that the technologies under investigation in its integrated programs can actually yield the results it anticipates or that the techniques can be applied at all sites. Nor is it possible to know precisely how much it will cost to develop the technologies envisioned in the IPs. Since 1990, DOE has allotted about $275 million to develop remediation techniques for contaminated soil and groundwater; its annual expenditures in this area have been on the order of $60 million to $80 million. Even if a 10-year investment at this level is required to develop appropriate technologies and even if DOE has overestimated its savings by an order of magnitude, savings would still greatly exceed the cost to develop the technology. DOE therefore is pursuing a number of technology projects that appear to show promise--that is, projects that will yield net savings when the present value of their cost is subtracted from the present value of the savings and other benefits that they make possible.

Integrated Demonstrations. Integrated demonstrations (IDs) are technology development efforts that are more narrowly focused than integrated programs. They are designed to apply and prove the feasibility of all technologies needed to conduct a cleanup from beginning to end--that is, from characterization to postclosure monitoring of a particular site.[3] DOE is currently conducting at least 10 demonstrations.

At the Fernald installation, for example, an ID is investigating the application of a technique for separating wastes, developed in the integrated program discussed above, to treat the contaminated soil. DOE estimates that this technique--referred to as leaching--would reduce by 80 percent the volume of waste requiring disposal. Including the costs of treatment, savings of 36 percent in the cost to clean

2. These programs are in some ways analogous to the basic technology programs within the Department of Defense, such as stealth research, that can, in theory, be applied to many weapons programs.

3. Again using an analogy with the Department of Defense's research programs, integrated demonstrations are similar to programs that develop specific weapons. Thus, if stealth research is analogous to an integrated program investigating in situ remediation, then the B-2 bomber development program would be an appropriate analogy for the integrated demonstration at Hanford using in situ bioremediation to clean up groundwater contaminated with nitrates and organic matter.

up Fernald would result. Using new excavation techniques rather than the current method of bulldozing could again, according to DOE estimates, reduce the amount of soil to be treated by almost two-thirds, yielding additional savings. Using both of these techniques could result in total estimated savings of 80 percent in the cost to clean up Fernald, compared with the current technology of excavation followed by disposal off-site.

Other integrated demonstrations also deal with cleaning up soils (for example, using a "rotomill" machine that monitors soil as it is excavated and removes less soil requiring subsequent treatment) or with cleaning up groundwater (for example, using an air-stripping method that pumps compressed air into an aquifer to flush out some of the contaminants). Still others deal with retrieving and processing waste: some seek better, cheaper means of identifying buried waste; others seek to reduce the cost of stabilizing and storing highly radioactive wastes. Appendix C discusses DOE's integrated demonstrations in more detail and presents the department's estimates of potential savings assuming the demonstrations are successful.

DOE estimates that the technologies under investigation in its integrated demonstrations could save a total of $12 billion, much less than the more than $90 billion in savings it ascribes to just two integrated programs. The savings associated with the integrated demonstrations are smaller than those of the integrated programs because IDs are more narrowly focused and their application is not so universal as technologies resulting from IPs. The estimates of savings associated with technologies being investigated in demonstrations might also be more realistic than those DOE associated with its integrated programs, because the demonstrations are tied to specific problems at specific sites and so have a closer association with actual experience than with predicted savings. Furthermore, DOE has conducted extensive cost-effectiveness analyses of some of the specific techniques under investigation in its demonstrations.[4] Thus, although these estimates also must be viewed with caution, they suggest a potential for savings with some basis in reality.

Possible Increases in Funding for Technology Development

The Department of Energy is spending a significant, but still relatively small, portion of its budget on the technology development programs designed to help the department realize these savings. The level of funding for technology development from 1990 through 1994 represented an average of 7 percent of the annual EM budget--roughly the same average share reflected in the Administration's latest plan, for 1995 through 2000.[5]

Compared with other major cleanup programs, DOE devotes a substantial share of its cleanup (EM) budget to technology development. For example, it exceeds the share of the Superfund budget that the Environmental Protection Agency spends to develop cleanup technologies. EPA administers Superfund, a federal program that provides funds for cleaning up pollution in the private sector and then attempts to recoup all or part of the cleanup cost from the responsible private parties. EPA allotted 4 percent of its total cleanup funds from 1988 through 1993 to research and development compared with 7 percent for DOE. In addition, DOE's absolute level of funding for technology development, which was almost $400 million in 1994, is appreciably larger than that of EPA's Superfund. In fact, DOE's 1992 allocation of $303 million is more than 4.5 times Superfund's investment of about $64 million in that year.

The share of funding that DOE allocates to technology development is, however, significantly below that of other government agencies engaged in complex technical projects. The Department of Defense invested an average of 13 percent of its total funding from 1988 through 1993 in research and development of new weapons. DOE itself, within

4. Joyce D. Schroeder, Steven R. Booth, and Linda K. Trocki, *Cost Effectiveness of the Site Characterization and Analysis Penetrometer System* (Los Alamos, N.M.: Los Alamos National Laboratory, December 1991).

5. In contrast to the discussions of the EM budget in Chapter 2, the total EM budget used as a basis for determining TD's share includes funding for the Uranium Enrichment Decontamination and Decommissioning program.

its weapons-related programs, invested an average of 24 percent of the funds in research, development, and testing during the same period. The weapons projects of both DoD and DOE are, of course, very different undertakings from the DOE cleanup program. Nonetheless, the difference in shares devoted to technology development is striking.

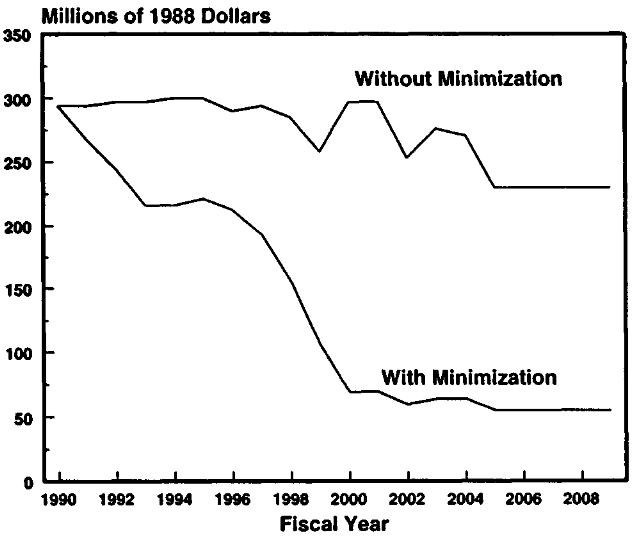
The planned 7 percent of DOE's cleanup funding earmarked for technology development is also well below DOE's own goal and the goal set by the Congress. DOE's first five-year plan, submitted in 1989, included a goal of devoting 10 percent of EM funding to developing new technologies for cleanup.[6] The Congress has also stipulated that at least 10 percent of EM funding for 1994 be devoted to that effort.[7] Achieving that goal would cost an additional $200 million to $250 million annually, from 1995 through 2000, based on the Administration's plan for spending levels in the out-years.

Availability of Suitable Projects. If the Congress is going to allocate additional funds for technology development, that money should be devoted only to projects that will ultimately result in significant net savings and other benefits. The Congressional Budget Office cannot evaluate candidate projects, but some evidence suggests that a number of projects would meet that test.

Various sources have identified several areas in which new technology could produce large savings. Representatives of DOE's Office of Technology Development have identified the contamination of soil by heavy metals as an area that is currently not being investigated for lack of funds.[8] The Department of Defense, which often works in partnership with DOE to develop cleanup technologies, has identified many projects it deems worthwhile but cannot fund at this time. The Office of Technology Assessment (OTA) and representatives of the Natural Resources Defense Council have pointed out the lack of technology for removing dense organic compounds that are not soluble in water from soil or groundwater.[9] DOE's latest detailed accounting of how it plans to spend its technology development funds does not specify any planned investment in technology to remediate such contaminants, but new approaches in this area may offer benefits that exceed the cost to develop them.

OTA identified waste minimization as another area deserving attention. Research in waste minimization or pollution prevention attempts to find ways to change manufacturing processes in DOE's plants so that they generate less waste requiring treatment or disposal. Reducing the volume of waste saves the cost of treating or disposing of it in the future, potentially saving billions of dollars (see Figure 4). During its deliberations on the fiscal year 1993 bud-

Figure 4.
Cost of Treating, Storing, and Disposing of Low-Level and Transuranic Waste, With and Without Minimization of Waste



SOURCE: Congressional Budget Office based on data from Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1992-1996* (June 1990).

6. Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan* (1989), p. 30.

7. House Committee on Armed Services, *National Defense Authorization Act for Fiscal Year 1993*, Report 102-527 (May 19, 1992), p. 342.

8. Personal communication from the Department of Energy, February 1993.

9. Office of Technology Assessment, *Complex Cleanup* (February 1991), p. 177; and statement of the Natural Resources Defense Council before the Western Governors Association Waste Task Force, Denver, Colo., October 7, 1992, p. 2.

get, the Congress also encouraged increased emphasis on research into ways to minimize waste.[10] DOE's funds to investigate such technologies, however, were reduced in 1993 by 50 percent from the previous year's level and have been further reduced to $1 million annually for 1994 and 1995.

Possible New Role for National Laboratories. Assuming that a number of projects are worthwhile, DOE would need to have enough trained personnel available to warrant an additional investment of $200 million to $250 million annually. That should not be a problem for two reasons. First, DOE's investment in developing weapons technology is decreasing from $1.7 billion in 1994 to $1.6 billion in 1995, and this reduction in effort might make personnel available for projects in other areas. Second, DOE has been discussing redirecting some of the more than 20,000 people employed at its labs from weapons research to research on environmental cleanup.[11] Thus, there should be sufficient personnel to perform the research.

Despite the availability of the labs and associated personnel for research in environmental cleanup, questions arise concerning the suitability of using the labs for this purpose. Transition from research in nuclear weapons design to research in cleanup technologies may not be all that easy. Nevertheless, the national labs are a potential source of scientists with experience in dealing with nuclear materials.

Possible Role for Other Agencies. Finally, DOE need not be the sole recipient of any additional funds made available for research into ways to deal more efficiently with cleanup problems. Many federal agencies are involved in remediation efforts, including the Environmental Protection Agency and the Department of Defense. Some cleanup tasks are unique to DOE, but many are common to all three agencies. Thus, a more productive approach might be to encourage collaboration among the three agencies, something the Congress promoted when it established the Strategic Environmental Research Development program in 1993 to coordinate environmental research and development efforts among federal agencies. Another approach would be to provide additional funds for technology development efforts at EPA or DoD rather than to DOE alone. A discussion of changes in budgets at EPA and DoD is, however, beyond the scope of this study.

Time Sensitivity of Investing in New Technology

If added investments are to be made in technology development, DOE argues that they should be made soon. The time available to develop promising new technologies that could reduce the cost of DOE's cleanup is relatively short if the department is to fulfill the terms of its agreements with the states and the Environmental Protection Agency. Recent statements by DOE indicate that if it is to realize significant returns on its investment in technology development and still meet its scheduled cleanup obligations, some new techniques must be ready for application by the late 1990s.[12]

This deadline is a consequence of DOE's agreements with various states and EPA that include timetables for initiating and completing cleanup tasks at various sites. An important milestone in the cleanup process is the filing of the records of decision for cleaning up specific sites. These documents outline how the cleanup will be accomplished and what technology will be used. The optimal time to develop and prove productive new technologies is therefore before the records of decision have been filed.

Based on the filing dates of records of decision stipulated in its agreements with the states and EPA, DOE has identified windows of opportunity for developing promising technologies in six areas in which it is conducting integrated demonstrations (see Table 7). Three windows--those associated

10. Senate Committee on Armed Services, *National Defense Authorization Act for Fiscal Year 1993*, Report 102-352 (July 31, 1992), p. 352.

11. "Environmental Cleanup Role Considered for A-Weapons Lab," *The Washington Post*, March 9, 1993, p. A10.

12. Statement of Paul D. Grimm, then Acting Assistant Secretary of Energy for Environmental Restoration and Waste Management, before the Subcommittee on Energy and Water Development of the House Committee on Appropriations, April 26, 1993, p. 47.

Table 7.
Schedule for Records of Decision in Selected Technology Areas

Activity	Records of Decision Completed: First	Half	Last	DOE Window[a]
Volatile Organic Compounds in Arid Soil	1990	1995	2005	1991
Buried Waste	1995	1999	2010	1992
Volatile Organic Compounds in Nonarid Soil	1991	1999	2010	1992
Uranium in Soil	1992	1999	2013	1997
Plutonium in Soil	1992	2000	2007	1998
Underground Storage Tanks	1990	2008	2025	1998

SOURCE: Congressional Budget Office based on Clyde W. Frank, "Technology Development Is a Strategic Investment" (presentation by the Department of Energy to Congressional Budget Office staff, February 5, 1993).

a. Optimum time by which introducing a new technology for cleanup will have the greatest impact in terms of reducing the costs of remediation.

with volatile organic compounds in arid soil and in nonarid soil, and with buried waste--were identified by DOE as opening in 1991 or 1992. Those dates have already passed, and DOE has stated that for every year that research is delayed, the benefits that can be reaped from the new technologies diminish. According to DOE, the best time to introduce improved technologies in the remaining three areas--uranium in soil, plutonium in soil, and underground storage tanks--is by 1997 or 1998.

Improving the Accountability and Management of DOE's Technology Development Program

If additional funds are to be appropriated for technology development, the Congress must have confidence that the funds will be spent wisely. But DOE's Technology Development program has been criticized for poor management. In an April 1992 report, the General Accounting Office (GAO) identified several shortcomings in that program that it felt hampered an efficient use of funds devoted to research.[13] In particular, GAO criticized DOE's lack of performance goals for its development programs. Furthermore, GAO pointed out that DOE has not estimated likely costs for its development projects or established schedules for program milestones or completion. In conclusion, GAO stated that the development of new technologies was important for DOE to accomplish its goals but felt that the department lacked the management tools to conduct an efficient program.

The General Accounting Office and others have made several recommendations for ways in which DOE could improve the management of its Technology Development program. To correct the problems of overall vagueness and lack of accountability, GAO suggested that DOE establish measurable performance goals, timetables, and key decision points for each technology development project. In its report, GAO noted that effective program management requires that estimates of the overall cost of each project be made early and updated and validated as the project matures. GAO felt that establishing a structure for each project, with cost and

13. General Accounting Office, *Cleanup Technology: Better Management for DOE's Technology Development Program*, GAO/RCED-92-145 (April 10, 1992).

performance goals and prescheduled evaluation points, would focus DOE's technology development efforts and help to identify both projects that succeed and those that fail.

Detailed Budget Reporting. As a first step toward making the Technology Development program more accountable, the Congress could reiterate its request that DOE provide more detailed information on how the department plans to spend its annual allocation of funds for research into new cleanup methods. The EM program has provided this information to the public and the Congress in the past--in its 1991 annual report to the Congress and its August 1991 five-year plan.[14]

The Congress, however, apparently has not been given detailed data on spending for individual research projects since 1991, and certainly not on a routine annual basis. DOE has failed to provide this information even though the Congress established the requirement for such a report in the National Defense Authorization Act for Fiscal Years 1990-1991. The report was to detail DOE's efforts to develop new techniques designed to reduce environmental hazards and contamination resulting from defense waste and to expedite environmental restoration efforts at inactive waste disposal sites. The Congress has obviously long recognized the need for additional information from DOE in order to perform its oversight function properly. Given the numerous concerns expressed by the Congress in reviewing DOE's cleanup budget, it may be time for the Congress to ask again for additional data to support DOE's request for research and development funds.

A New Management System. To provide structure, direction, and accountability for DOE's development programs, the Congress could also encourage or require the department to create an evaluation and reporting system for major projects that is similar to the one employed by the Department of Defense for its major weapon systems. Under the scheme used at DoD, all systems requiring more than $200 million to develop, or $1 billion to buy--both figures in 1980 dollars--are subject to internal review at four specific points in their maturation process: initiation, concept validation, initiation of full-scale development, and before entering production.[15] (See Appendix D for a detailed description of DoD's weapons acquisition process.) The status of each of these major systems is summarized annually in Selected Acquisition Reports, which DoD then submits to the Congress.

DOE and the Congress could establish a similar system for major projects in the cleanup arena, particularly those that require the development of new technologies to enable their completion. The system would cover an entire cleanup project--from definition of the site or operational unit, development of new technologies, and characterization and assessment, through completion of remedial action. This system would be particularly applicable to the narrowly focused integrated demonstrations, each of which would be only one part of an overall cleanup effort.

Including the development of technologies as part of a specific task to be completed, such as cleanup of the tanks at Hanford, would focus the research efforts and put them on rigorous schedules. Indeed, a report prepared for DOE in January 1993 on technology needs recommended that milestones in technology development projects be linked to schedule requirements of specific problems in environmental restoration.[16]

Possible Decision Scheme. To set up such a reporting and evaluation system, DOE would first need to establish milestones for the major decision points. For its cleanup activities, DOE could use four milestones:

1. establishing a cleanup project,

2. justifying the need for a new technology and initiating the applied research and development work,

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14. Department of Energy, Office of Environmental Restoration and Waste Management, Office of Technology Development, *Annual Report to Congress, Fiscal Year 1991*; and Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1993-1997* (August 1991).

15. These thresholds correspond to about $350 million in development funds and about $1.8 billion in procurement funds when converted to 1995 dollars.

16. Chem-Nuclear Geotech, Inc., *Technology Needs Crosswalk Report*, DOE/ID/12584-117, 1st ed. (prepared for the Department of Energy, January 1993), p. xv.

3. beginning assessment and characterization, and

4. filing a record of decision and beginning remedial action.

In justifying the need for new technologies at the second milestone, DOE would need to establish criteria against which to judge the new methods. In particular, new techniques should save money or time compared with current techniques. To focus resources on the most promising technologies, estimated savings in cost or time resulting from use of the new technology should exceed thresholds established by DOE. The department would also need to establish and approve preliminary schedules and cost estimates at the second milestone.

Reaching the third milestone--initiation of assessment and characterization--would depend on completing the research and development efforts for projects that require new techniques. For example, cleaning up the highly radioactive waste in the Hanford tanks requires new assessment techniques that should be developed and proved before characterization of the site begins. Furthermore, it is at the third milestone that DOE should establish final cost and schedule baselines, so most of the development work should be completed before these baselines are set.

The fourth and final milestone would involve filing the record of decision and selecting cleanup techniques. At this point, the characterization of the problem and development of cleanup techniques should be essentially completed.

DOE would need to establish a panel of senior managers within the EM program to approve transition of a project from one milestone to the next in the scheme outlined above. Projects making insufficient progress, demonstrating substantial cost overruns, or meeting unexpected technical problems would be restructured before proceeding. In this way, problems could be identified before they became too costly.

Reporting on major projects using a milestone format would also permit the Congress to judge their progress. For example, at some point (probably at the third milestone) estimates of the cost required to complete a project should be available. Once such baseline estimates are in place, the Congress can compare subsequent cost estimates with the baseline and focus on projects whose costs are growing.

The Congress has already mandated that parts of this management system be established. In its bill authorizing appropriations for national security functions for 1994, the Congress directed DOE to submit reports that provide schedules for and the estimated cost to complete many of the projects within the EM program. The initial reports--or baselines--for environmental restoration activities are due by March 1, 1995; similar reports for all activities for waste management, transition of operational facilities to safe shutdown status, and research and development activities are due by June 1, 1995.[17] The Congress also directed DOE to submit, following the initial report, annual status and variance reports that would inform the Congress of the amount of funds expended for any project during the prior fiscal year, as well as any growth in costs or schedule slippages with respect to the initial report.

These Baseline Environmental Management Reports, as they are called in the authorization bill, would be similar to the reporting requirements envisioned in the decision scheme described above. They would not, however, require DOE to establish an internal review system, nor would they integrate research and development efforts with cleanup tasks. But they attempt to address the same problem as the postulated management scheme--that is, the lack of justification, continuity, and visibility within the EM program of individual projects designed to develop new and beneficial technologies for cleanup.

Not all projects in the EM program need to be subject to this management system. Some TD projects are not tied to a specific cleanup problem but instead represent efforts to develop techniques

17. The Department of Energy has made a partial response to the request in the authorization act with the information contained in its report *Environmental Management 1994* (February 1994). That report contains some data on funding, milestones, and performance by installation. The report does not, however, fulfill DOE's obligation to submit the Baseline Environmental Management Reports, as specified in the authorization act.

that are applicable to many environmental programs. The integrated programs, which represented about 10 percent of TD funds in 1991, fit this description and are more analogous to DoD's basic research programs that are not tied to specific weapons programs. Some or all of those programs might therefore be excluded from this management system, as might small projects.

DOE and the Congress will need to set thresholds for cleanup tasks so that only those of sufficient total or annual cost are subject to enhanced scrutiny. DoD's experience in this area might be used as an example. Acquisition programs that are subject to extensive reporting requirements represented historically about half of DoD's annual procurement funding and 15 percent of the research and development budget. By comparison, all of DOE's integrated demonstrations together received about 20 percent of EM's total funds for technology development in 1991.

A scheme similar to DoD's may not be the final answer for DOE's EM program. But it does represent a system for establishing goals, schedules, and specific decision points that is currently lacking in DOE's Technology Development program. By setting up a mechanism for keeping the Congress abreast of the progress and problems that arise in its cleanup program, DOE could help to answer charges of poor management and lack of accountability within that program. Addressing these concerns would be particularly important if the Congress decided to increase funding for technology development in an effort to reduce the total cost and duration of the cleanup.

Delaying Cleanup Until New Technologies Are Available

Even with additional funding, developing new technologies that expedite the cleanup effort or reduce its costs will not always be possible. Some research and evaluation efforts take a certain amount of time to come to fruition, and some techniques must be evaluated over fixed amounts of time and so cannot be hurried. Thus, in certain cases, no amount of added resources will yield earlier results.

In such cases, a weighing of costs and benefits--the method discussed in Chapter 3 as a means for setting priorities among cleanup tasks--may favor renegotiating the agreements DOE has with the states. Otherwise, these agreements will force DOE to undertake difficult projects on a stringent schedule rather than devote additional time and resources to accelerate research efforts. If all parties to an agreement concede that no promising technology is likely to be available before the deadline to commence cleanup, they could arrange an extension, assuming, of course, that the problem in question poses no immediate threat to human health or the environment. By renegotiating these agreements, DOE could avoid the expense of either additional research and development work or inefficient cleanup efforts.

Budgetary Effects of Delay

The Environmental Restoration (ER) program within the Office of Environmental Restoration and Waste Management is responsible for the actual cleanup of DOE's inactive sites. ER's activities include identifying and measuring contamination at DOE facilities, taking subsequent remedial action, and continuing to monitor a site after cleanup has been completed. In DOE's request for funds for 1995, ER's share was $1.8 billion, representing 29 percent of the total EM request. According to the Administration's plan, annual funding for the ER program would grow to $2 billion by 2000.

Delaying projects that are difficult to execute with today's technology would lessen the need for ER funds during the next six years. If delays of technically difficult projects were judged appropriate, how many projects might be affected? And how would such delays affect the budget?

Many of the projects that DOE is undertaking in its ER program are difficult or expensive to complete with today's technologies. According to the Office of Technology Assessment, cleaning up groundwater and soil may be extremely expensive or require a long time even if contaminants can be removed with current technology.[18] Almost all of

18. Office of Technology Assessment, *Complex Cleanup*.

DOE's major installations suffer from some sort of groundwater contamination. And cleaning up buildings contaminated with highly radioactive materials, referred to as decontamination and decommissioning, may present technical difficulties because current methods are costly, inefficient, and produce large quantities of waste material requiring disposal. Furthermore, DOE has already identified 500 surplus facilities that must be cleaned up before they can be demolished or released for other uses, and expects to add at least 1,000 more to its list. The challenge in decontamination and decommissioning is to develop methods that minimize the exposure of the workers to radiation and hold down costs.

To determine how many of DOE's projects would be difficult to perform with today's technology, the Congressional Budget Office (CBO) examined almost 1,000 activity data sheets in the Environmental Restoration program in the August 1991 five-year plan.[19] CBO designated the following types of projects in that plan as "technically difficult":

- characterizing very large land areas or highly radioactive waste in tanks,
- cleaning up contaminated groundwater or soil, and
- decontaminating and decommissioning buildings that contain radioactive waste.

That designation reflects the fact that DOE is conducting projects to develop new techniques in those areas. In the process, CBO also determined the portion of DOE funds that is slated for technically difficult projects.

Cost of Technically Difficult Projects. CBO's examination of DOE's August 1991 five-year plan identified 134 projects that were technically difficult. Results for the two budget levels included in that plan were similar; the share of ER funds devoted to technically difficult projects during the five-year period rose from about one-quarter in 1993 to about one-third by 1997. Total funding for these projects for the 1993-1997 period accounted in both budget levels for an average of nearly 30 percent of funding for the Environmental Restoration program. Such consistent results for both budget levels suggest that DOE would allocate the same proportion of ER funds planned for the 1995-2000 period to technically difficult cleanups. Based on the assumption that 30 percent of ER funding is allotted to such projects, DOE could spend up to $3.4 billion from 1995 through 2000 on characterizations and remediations that are difficult to conduct with today's technologies.

Illustrative Budgetary Effects. Delaying the execution of these projects until newer and better ways of carrying them out have been developed could reduce the funds needed for the Environmental Restoration program over the next six years. It is impossible for CBO to determine which of the 134 technically difficult projects should be pursued using today's technology and which should be delayed. To illustrate the budgetary effects, however, CBO assumed that half of these projects were delayed. In that case, funding for environmental restoration would be reduced by 15 percent over the next six years. Annual savings associated with such a slowdown would increase from almost $270 million in 1995 to almost $300 million in 2000. These savings would exceed the additional amount needed to increase funds for technology development from the current 7 percent of the Office of Environmental Restoration and Waste Management's total budget to 10 percent, should that be judged a desirable option.

Reduced Funding Would Affect Agreements

Any delay in the cleanup process would cause problems. DOE feels compelled to move ahead, even with technically difficult projects, because it has entered into agreements with various states and the Environmental Protection Agency that dictate the schedule for cleaning up sites within the complex. Some schedules call for beginning the cleanup process soon without regard to the availability of technologies that would facilitate its execution. Indeed,

19. None of DOE's five-year plans submitted since August 1991 include a detailed breakdown of ER funding planned for five years by individual cleanup project. Therefore, CBO had to rely on the five-year plan submitted in August 1991 for its analysis.

for projects involving many of the types of cleanup tasks for which DOE is attempting to develop new technologies, the first record of decision, which specifies how the cleanup is to be accomplished, has already been submitted (see Table 7). For projects involving the cleanup of volatile organic compounds in arid soils, for example, half of the records of decision are due by 1995. DOE therefore plans to proceed apace with many efforts in the next five years using current technologies to clean up some sites as specified in various agreements, even though that might not be the best or cheapest way to conduct the cleanup in the long run.

DOE is also required by law to request funding for its programs that is sufficient to meet the milestones included in the agreements to which it is a party. That would apply primarily to funding for the Environmental Restoration program, since most of the deadlines stipulated in agreements pertain to the beginning and completion of feasibility studies, assessments, and remedial actions. For this reason, officials at DOE feel that they have little discretion to delay or terminate ER projects. Failure to meet the terms of the agreements may result in the levy of fines by the states against DOE, something that the state of Ohio has already done.

Not only is DOE bound by many triparty agreements to timetables that dictate the start and finish of specific cleanup tasks, but it is also legally responsible for preventing the spread of contamination from its facilities to the surrounding environment. Thus, in some instances, DOE feels it must contain its waste and prevent it from entering water sources, either above or below ground, even though current techniques for containing such wastes are expensive.

Risks of Delay. A decision to delay some of its projects would mean that DOE would have to renegotiate its agreements with various states and EPA. If renegotiations were not successful and DOE breached existing agreements, it could face both financial and political costs. States could levy fines on the federal government that could, cumulatively, be substantial. Indeed, an Administration official testified in 1991 that subjecting federal facilities to the same environmental regulations as the private sector could create an atmosphere that would cause the federal government to commit its limited cleanup resources at the courthouse rather than in the field.[20] The state of Ohio levied a $750,000 fine against DOE in 1989, and DOE could face similar fines if it does not comply with state agreements or renegotiate them.

Benefits of Delay. Nevertheless, fines of this magnitude are small compared with the annual savings of approximately $300 million that DOE could realize by delaying some cleanup projects. Moreover, many of the concerned parties are becoming increasingly aware that some of the agreements are untenable. Many agreements were signed in the late 1980s and early 1990s before DOE knew much about the scope of its environmental problems. In the past few years, DOE and its contractors have conducted numerous exploratory samplings and investigations and now have a better idea of the magnitude of the problem facing them. In light of this new information, some of the goals and deadlines established in the agreements may be unrealistic.

Delaying some cleanup projects could also buy DOE time to gather the information needed to make informed decisions concerning the management and direction of its cleanup program. Recent statements by Administration officials indicate their awareness that DOE needs more information to manage its cleanup program efficiently.[21] The types of information needed include data concerning health hazards posed by the pollutants at its sites and the ultimate use of its surplus land and facilities.

Need to Reevaluate Priorities. Perhaps for these reasons, several parties, including Members of Congress and DOE officials, have suggested that DOE reevaluate its priorities, which could ultimately result in the need to renegotiate DOE's agreements.[22]

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20. Statement of Thomas E. Baca, Deputy Assistant Secretary of Defense for the Environment, before the Environmental Restoration Panel and Nuclear Facilities Panel of the House Committee on Armed Services, June 6, 1991.

21. "OMB Provides No Figures on Environmental Cleanup," *Congress Daily*, September 21, 1993, p. 4.

22. Senator J. Bennett Johnston raised this issue during a hearing held by the Senate Committee on Energy and Natural Resources on the Department of Energy's cleanup budget on July 29, 1993. It is also mentioned in U.S. House of Representatives, *Making Appro-*

The Assistant Secretary for EM, Thomas Grumbly, has testified that in some cases, the department has learned through site investigations that the problems uncovered are larger than anticipated or have no effective long-term technical solutions.[23] He asserted that in these cases, the best course of action may be to stabilize the site and invest in appropriate research to solve the problem more effectively in the long run. He emphasized that the department is committed to complying with its agreements. But he held open the door to conducting the cleanup in the most effective way possible through mutual renegotiation of those agreements.

Events at the Hanford installation provide an example of such a renegotiation. The Department of Energy, the Environmental Protection Agency, and the Washington State Department of Ecology recently updated and revised the original agreement they had signed in 1989. Under the renegotiated agreement, the date for beginning the cleanup of the highly radioactive waste has been delayed 10 years, and priorities for various cleanup tasks have been reordered. In particular, DOE has agreed to give higher priority to the treatment of low-level waste and to convert the waste into a form that is more durable and therefore poses less risk over the long run.

In their conference report on appropriations for 1994, the appropriations committees provided funds to implement the revised accord at Hanford and encouraged the department to review all of its compliance agreements.[24] The Congress acknowledged that DOE needs to develop a mechanism for establishing priorities among its cleanup tasks. To that end, the Congress directed DOE to submit to the appropriations committees a report evaluating the risks to public health and safety posed by conditions at the complex's sites that are addressed by requirements in the compliance agreements.

Problems Associated with Targeting Specific Cleanup Tasks for Delay

Both the Administration and Members of Congress have stated that the current regulatory environment, and particularly the large number of compliance agreements to which DOE is party, limit DOE's ability to carry out its cleanup program in the most effective way possible. The agreements create a set of priorities and demands that may be at odds with the limitations presented by technological and fiscal realities.

The Keystone process described earlier in this study was developed in recognition of these constraints and is intended to provide a framework for dealing with fiscal limitations. The Keystone report, which was prepared by a committee composed of representatives from the environmental community, recommended an approach for addressing funding shortfalls caused by Congressional appropriations that fell below DOE's request. If the approach recommended by the Keystone group is adopted--and it has been endorsed by DOE--then reducing funding for difficult projects may not have the desired effect of delaying them.

The Keystone group recommended that when the Congress appropriates less than what DOE requested for its environmental restoration activities, the funding shortfall be distributed equally among all sites. Thus, if the Congress reduced ER funding by 15 percent, as discussed in the section on illustrative budgetary effects, then each of DOE's 15 major installations would receive 15 percent less funding for ER activities. The committee further recommended that if DOE could absorb funding cuts without affecting the scope or schedule of established, legally binding agreements, then it could do so without consulting the regulators, affected tribes, and other stakeholders. But if DOE could not meet its obligations after absorbing a significant cut, the group strongly recommended that the states and EPA renegotiate DOE's obligations and milestones rather than take punitive actions.

priations for Energy and Water Development for the Fiscal Year Ending September 30, 1994, and for Other Purposes, Conference Report 103-305, to accompany H.R. 2445 (October 22, 1993); and Senate Committee on Armed Services, *National Defense Authorization Act for Fiscal Year 1994*, Report 103-112 (July 27, 1993), pp. 239-240.

23. Statement of Thomas P. Grumbly before the Subcommittee on Energy of the House Committee on Science, Space, and Technology, July 15, 1993.

24. See U.S. House of Representatives, *Making Appropriations for Energy and Water Development for the Fiscal Year Ending September 30, 1994*.

The process laid out by the Keystone group provides DOE and other federal agencies with a framework for accommodating fiscal limitations while minimizing confrontation with regulators and affected parties. But rigid adherence to a proportional sharing of budget shortfalls among all affected sites could hamper the Congress's and DOE's ability to set nationwide priorities for its cleanup program.

Under the process outlined above, a reduction in funding for the Environmental Restoration program would be shared equally by all of DOE's installations. But distributing the cuts equally could defeat the purpose of targeting reductions toward projects that are difficult to conduct with today's technologies, particularly if the more challenging tasks are concentrated at a small number of installations. Thus, if the Congress or DOE wishes to target specific projects for delay, it may have to repudiate the process that the Keystone group proposed and that DOE has subsequently endorsed.

Conclusion

Reducing funding for technically difficult projects during the next six years, thereby delaying them at least temporarily, could ultimately reduce the time and money that DOE needs to clean up its complex, particularly if the funds and time that would become available to DOE were used to develop productive new technologies. The resulting delays would require renegotiating some agreements with EPA and state regulators. But once the ultimate benefits of delay have been made clear, existing agreements may be easier to renegotiate.

Spending for Administration and Support

The Department of Energy's cleanup effort, as embodied in the EM program, is now five years old. Since its creation in 1989, the program has received a total of $23 billion, and more than $6 billion of that amount was appropriated for 1994 (including funding for the Uranium Enrichment Decontamination and Decommissioning program). Some critics have claimed that very little cleanup has actually resulted from this multibillion-dollar investment, however, and have questioned whether DOE is spending the taxpayer's money efficiently. In 1992, Leo Duffy, then Assistant Secretary for EM, stated publicly that waste and inefficiency chewed up 40 cents of every dollar in the cleanup program.[25] Several reviews of DOE's cleanup budget have highlighted concerns about the costs of administration and support.

Organization of the Nuclear Weapons Complex

Defining and estimating costs for administration and support require an understanding of how DOE operates the nuclear weapons complex. Management of and operations at DOE's 15 major installations have been the responsibility of contractors to DOE and its predecessors. At all sites still producing weapons or their components, the same contractor is responsible for both managing production and cleaning up the pollution that has resulted from past or current production.

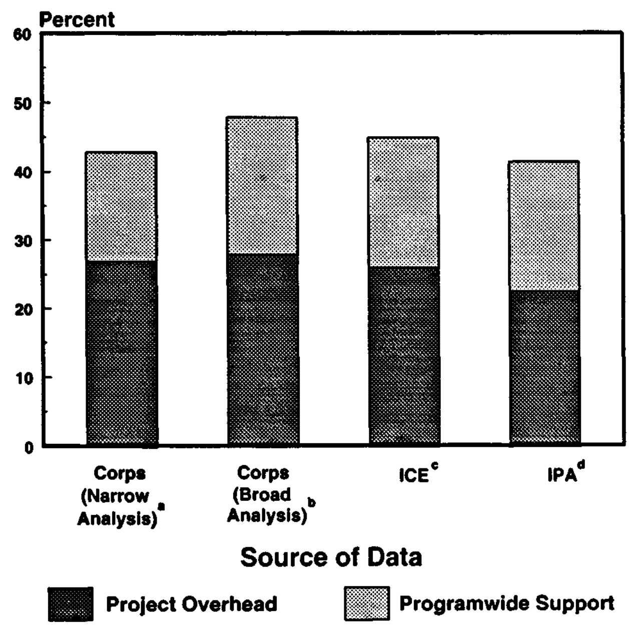
DOE oversees the performance of its contractors from its headquarters in Washington, D.C., and 10 operations offices (Rocky Flats and nine field offices). There are many more people employed by the contractors, however, than there are DOE personnel supervising their performance. In the EM area alone, more than 49,000 contractor personnel are engaged in cleanup, overseen by fewer than 1,800 DOE employees. Because most contractor personnel are located at various DOE sites, the ratio of contractors to DOE staff is particularly high in the field. For instance, only about 400 DOE employees work at the Richland field office, which oversees operations at the Hanford installation, in contrast to the approximately 12,000 contractor personnel employed at Hanford.

Because of the way it does business, DOE incurs administrative and support--or indirect--costs at

25. Douglas Pasternak, "A $200 Billion Scandal," *U.S. News and World Report*, December 14, 1992, p. 34.

two levels. The first occurs at the project level where the contractor charges for administrative costs. These indirect costs are generally referred to as overhead rates. The second layer occurs at the installation or program level and includes DOE's costs to direct and manage its programs as well as costs to provide services--such as security, road maintenance, utilities, and even laundry service--at some of its installations. These costs are referred to as programwide costs.

Figure 5.
Portion of Environmental Management Funds Devoted to Administrative and Support Activities



SOURCE: Congressional Budget Office based on data from various analyses.

a. Army Corps of Engineers, *Supplemental Report on Cost Estimates* (Report to the Associate Director for Natural Resources, Energy and Science, Office of Management and Budget, April 29, 1992). The narrow analysis focused on 55 projects at eight installations, representing about 20 percent of the total cleanup budget.

b. Army Corps of Engineers, *Supplemental Report on Cost Estimates.* The broad analysis expanded the narrow analysis by including all the projects at two additional installations--Fernald and Hanford.

c. The percentage devoted to project overhead was calculated by DOE's Independent Cost Estimating (ICE) team. See Gilbert/Commonwealth, Inc., *Independent Cost Estimate for the Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1993-1997* (Reading, Pa.: Gilbert/ Commonwealth, Inc., November 22, 1991). The percentage devoted to programwide support is a CBO estimate.

d. The percentage devoted to project overhead is from Independent Project Analysis, Inc., *Project Performance Study* (Reston, Va.: IPA, Inc., November 1993). The percentage devoted to programwide support is a CBO estimate.

Estimates of EM Spending on Administration and Support

Funds devoted to administration and support activities in the EM program--a combination of spending on overhead and programwide support--account for about 40 percent of EM's total budget. Several reviews have concluded that DOE spends at least one-fifth of the funds for each project for contractor overhead.[26] Analyses by CBO and the Army Corps of Engineers found that DOE devoted a similar share to programwide support. The combined spending on administrative and support functions within the EM budget--at both the project and program levels--ranges from 43 percent to 48 percent based on the Corps's analyses, and from 39 percent to 45 percent based on combining the overhead rates determined by DOE's Independent Cost Estimating team and Independent Project Analysis, Inc., with CBO's estimates of programwide spending (see Figure 5). These resulting estimates of total spending of about 40 percent or more on administration and support represent a proportion that is significantly higher than the share spent by some other government agencies that may be performing comparable tasks. Reductions in this category of spending may therefore represent one means of reducing EM budgets.

Overhead Costs at the Project Level. The Department of Energy has commissioned several studies of the overhead costs of its projects.[27] These studies

26. DOE's Independent Cost Estimating team estimated 26 percent, the Army Corps of Engineers estimated 27 percent to 28 percent, and Independent Project Analysis, Inc., estimated 20 percent to 23 percent.

27. Interagency Review Group, *Interagency Review of the Department of Energy Environmental Restoration and Waste Management Program* (April 29, 1992); Army Corps of Engineers, *Supplemental Report on Cost Estimates* (Report to the Associate Director for Natural Resources, Energy and Science, Office of Management and Budget, April 29, 1992); Independent Project Analysis, Inc., *Project Performance Study* (Reston, Va.: IPA, Inc., November 1993); Gilbert/Commonwealth, Inc., *Independent Cost Estimate for the Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1993-1997* (Reading, Pa.: Gilbert/ Commonwealth, Inc., November 22, 1991).

have found overhead rates charged by the contractor to be in the range of 20 percent to 28 percent.

DOE's Independent Cost Estimating team reviewed in detail the approximately 1,600 projects receiving funds in the EM program in the 1993-1997 five-year plan and evaluated actual overhead rates for subcontracts, labor, and material based on information provided by the department. Using this definition it found overhead rates of 26 percent, which it considered high.

The Army Corps of Engineers examined a more limited number of projects--55, representing slightly less than $1 billion, or about 20 percent, of the EM budget--in detail in order to evaluate the ability of field offices to estimate costs. In its analysis, the Corps defined overhead to include project management, supervision of construction at a site, the prorated cost of administrative functions, and the contractor's profit. The Corps found that 27 percent of the funds requested were earmarked for overhead. Compared with its overhead rate of 18 percent for similar projects, the Corps felt the overhead charged by DOE's contractors was high.

In its report, the Corps acknowledged that some factors might cause DOE's overhead rates to be higher than its own. Since DOE must deal with radioactive substances, certain activities that result from regulatory requirements unique to nuclear waste might lead to higher overhead costs. The Corps noted, however, that many activities in the planning, design, and construction phases of projects are common to the cleanup of both hazardous waste and radioactive waste. Since the Corps claims that it has extensive experience in construction and hazardous waste management, it felt that costs for most of the environmental activities undertaken by DOE and the Corps should be comparable.

A more recent study of DOE's cleanup program found that the EM office spent more than either the private sector or other government agencies for equivalent work. This study, conducted by Independent Project Analysis, Inc., for the Office of Environmental Restoration and Waste Management, was intended to assess the status of EM projects and provide a baseline from which to measure improvement. The study's authors compared key parameters of EM projects--such as management costs, cost growth, and schedule slippage--with comparable data from environmental remediation and waste management projects completed by the private sector and other government agencies.

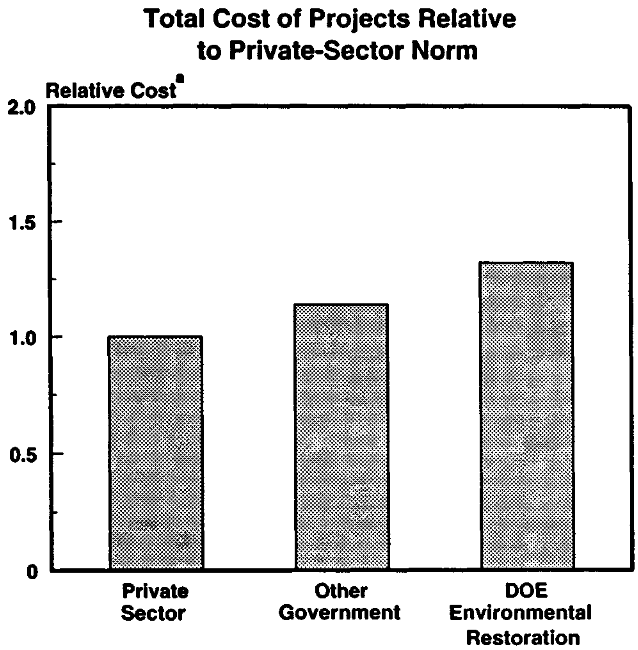
The authors of the study concluded that costs for work performed for DOE were significantly greater than the industry norm, in part because of high project management costs. The study's most striking conclusion was in the area of remediation projects; the total costs of DOE's environmental restoration projects were found to be 15 percent greater than those of other government agencies and 32 percent greater than those of the private sector (see Figure 6). The costs were higher, in part, because DOE's project management--or overhead--costs for its restoration projects, which consumed 23 percent of the costs of individual projects, were more than double those of other government agencies and nearly four times those of the private sector. These findings support those of the Corps and the ICE team and confirm that DOE is spending too much for project overhead.

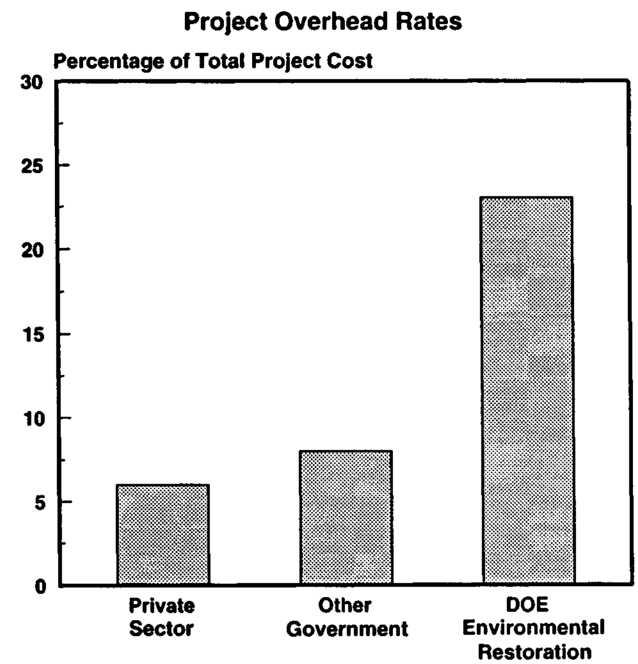
Administration and Support Costs at the Program Level. In addition to the indirect costs that DOE incurs as overhead on each project, it must also pay for the cost of managing and directing its overall cleanup program and for costs at each installation to support all the cleanup projects there. Programwide support activities would include oversight of compliance, preparation and review of documents, program support or direction, technical support, litigation, quality assurance, and liaison with local groups such as Native American tribes.

To estimate the total costs of these activities within the EM budget, the Congressional Budget Office reviewed the almost 2,000 projects included in the 1993-1997 five-year plan.[28] Based on the title of the activity data sheet that describes each of the projects funded by the EM budget, CBO identified projects that involved programwide administra-

28. In estimating the cost of administration and support within the EM budget, CBO used the lower of the two budgets included in the five-year plan submitted in August 1991. More recent five-year plans lack the detail needed to estimate these costs. As a consequence, the August 1991 five-year plan is the most recently submitted plan that presents the necessary detailed data.

Figure 6.
Comparison of DOE's Environmental Restoration Costs with Those of Other Sectors





SOURCE: Congressional Budget Office based on data from Independent Project Analysis, Inc., *Project Performance Study* (Reston, Va.: IPA, Inc., November 1993).

a. Normalized based on average performance of private-sector companies.

tion and support activities, as defined above. CBO included as programwide support those projects within the Technology Development program that did not contribute directly to research; that is, funds not in the RDDT&E account were considered to be programwide costs.

Using this definition, CBO found that more than 360, or 18 percent, of EM's projects were devoted solely to programwide support activities. Overall, funding for these projects represented 25 percent of the total EM budget for 1993. Based on the August 1991 five-year plan, that share would remain relatively constant, averaging 24 percent during the five-year period from 1993 through 1997. As in all other projects, a portion of the funds allotted to these projects performing programwide support activities would be spent on overhead. Assuming a project overhead rate of 20 percent, total EM funding devoted solely to programwide support--and not to project overhead--would be 19 percent.

The findings of a study by the Army Corps of Engineers support CBO's findings that a significant portion of DOE's cleanup budget pays for programwide management and support functions. The Corps, in its detailed analysis of one-fifth of the EM budget, found that 16 percent of the funds were devoted to such activities. These costs, according to the Corps, fall mainly into the categories of program management and program direction. The Corps also reviewed an additional third of the EM budget in less detail and found that 22 percent of it was devoted to programwide support activities. When this additional spending is taken into account, about one-fifth of the EM budget examined by the Corps appears to be devoted to administration and support activities. This level of spending--20 percent--is more than twice the 8 percent that the Corps says it spends for programwide support.

Illustrative Savings Realized from Reducing Spending on Administration and Support

Based on the analysis by CBO and others, the roughly 40 percent of EM funds spent on administrative and support functions is high compared with spending by other agencies--both government and private--engaged in cleanup activities and could be reduced. If DOE could reduce spending on administrative and support activities by roughly 25 percent, for example, it could save $630 million in 1995 based on the Administration's request. Annual savings would increase to $710 million by 2000, based on the levels outlined in the Administration's out-year targets. An illustrative 25 percent cut in overhead would result in a 10 percent overall reduction in total EM spending, which would fall within the range of cuts proposed by DOE's Independent Cost Estimating team and the Army Corps of Engineers.

Because the two reviews used different definitions of overhead, the cuts in total EM spending that would result from the reductions in overhead recommended by the ICE team and the Corps are not proportional to the reductions in overhead. The ICE team recommended a 25 percent cut in contractors' overhead only, which would result in a 7 percent reduction in total spending. The Corps suggested a decrease of roughly 60 percent in total administrative and support spending--both overhead and programwide--which would yield a 25 percent overall reduction. Compared with the reductions recommended in these two reviews, the 10 percent cut in the overall budget contemplated in this illustration is well below that recommended by the Corps and is somewhat higher than the reduction proposed by the ICE team.

How would savings in administration and support costs be realized? Although identifying management changes is not the focus of this study, other organizations have suggested ways in which DOE could better manage its EM program and thereby reduce administrative and support costs. They include increasing the program's oversight of contractors and reforming the process by which it makes contracts.

Increase Oversight of Contractors. Both internal and external reviews of DOE's operations have highlighted the lack of government oversight of contractors' performance. The interagency review of the EM budget found that the program, which is increasing rapidly in scope and funding, had insufficient staff both to budget effectively and to oversee the programs for which it was responsible.[29] At many field offices, for example, it is the contractors, not government personnel, who prepare and review technical documents and cost estimates.

The Corps recommended that DOE add personnel in order to provide better oversight of contractors' performance. Assistant Secretary Grumbly, in his statement of July 15, 1993, before the Subcommittee on Energy of the House Committee on Science, Space, and Technology, outlined his intention to respond to this recommendation by shifting essential project management responsibilities at each site to DOE personnel. For example, Grumbly would like DOE personnel to prepare internal cost estimates rather than rely on contractors to prepare them.

Greater reliance on DOE personnel would require an increase in the number of DOE employees. In a period when the federal government is committed to reducing the size of its work force, such an increase could be difficult to achieve and could increase the cost of the EM program in the short run. It might be possible, however, to shift some personnel within the national defense function. That budget function includes both the Department of Defense (with about 900,000 federal civilian employees) and the weapons and associated cleanup activities of the Department of Energy (about 6,000 federal civilian employees). A shift of personnel from DoD to DOE could benefit DOE's cleanup effort by providing personnel who have extensive management experience.

Enlisting more government staff, either from DOE or DoD, to perform more of the managerial, planning, and budgeting functions that contractors now perform, though possibly costing more in the short run, could save money in the long run. For example, increased oversight might result in less duplication of effort among contractors or in lower overhead rates. Indeed, Grumbly predicted that adding 400 federal workers to do jobs now handled by contractors would save $360 million in 1995 and more in later years. He also predicted that in-

29. Interagency Review Group, *Interagency Review of the Department of Energy Environmental Restoration and Waste Management Program.*

creased oversight, in conjunction with contract reform, could result in a 10 percent to 20 percent increase in contractors' cost efficiency over the next four years.

Reform the Contracting Process. DOE has traditionally contracted with a single entity (referred to as a management and operations, or M&O, contractor) to manage operations at an installation. The M&O contractor may then hire subcontractors to perform specific functions, such as drilling wells or providing security.

Both GAO and Assistant Secretary Grumbly have endorsed the need to reform the contracts that DOE has with its M&O contractors. The agencies that preceded DOE used special incentives in their contracts because they believed such incentives were needed to attract and retain contractors to conduct work and research on nuclear weapons. Since then, DOE's contractors have been reluctant to negotiate contracts with more stringent clauses. One example of a nonstandard contract is DOE's exclusion of the standard procurement clause from its contract with the University of California for operating the three national laboratories. As a consequence, one of the labs leased vehicles at commercial rather than government rates, costing DOE an additional $600,000.

Another example concerns nonstandard indemnification clauses in some of DOE's contracts that have grown out of DOE's historical practice of indemnifying, or reimbursing, almost all of a contractor's costs to compensate for the unique risks inherent in producing nuclear weapons. Such clauses have had unforeseen consequences, however. In one case, DOE could not prove that a contractor's costs had been caused by bad faith or corporate mismanagement and so was forced to reimburse the contractor's loss of $420,000 in money and materials that employees had stolen. GAO applauded DOE's attempt to avoid a recurrence of these types of expenses by moving to delete clauses from its contracts that do not reflect standard practice.

Both GAO and Grumbly have highlighted the need for DOE to establish requirements for the performance of its contractors that would specify the product to be delivered, cost targets, and schedules. Because some of DOE's contracts have no established criteria for determining management or award fees, contractors have no idea on what basis their performance is evaluated. Some contractors have been awarded significant fees--nearly $2 million at Rocky Flats--even though a DOE review board initially recommended no award at all; and some contractors receive substantial management fees, which increase automatically every year, to cover "indirect costs" and "complementary and beneficial activities" that were never specified.[30] To remedy this deficiency, both GAO and Grumbly recommended replacing the subjective or, in some cases, nonexistent award criteria with ones that can be measured.

In his testimony of July 15, 1993, Assistant Secretary Grumbly provided additional ideas on how to improve the performance of contractors. He suggested that fixed-price contracts that are solicited competitively for some tasks, such as remedial activities and landlord functions, could be appropriate at some installations. In this way, the single contract between DOE and the M&O contractor at each site and its attending subcontracts could be replaced by several smaller contracts made directly with the EM program. Such a system would engender more competition and, as a consequence, lower prices. Assuming that DOE hired more government personnel to monitor the contracts, this system would also give the EM program more control over the performance of its contractors. Grumbly also recommended that DOE make contractors more responsive to its needs by limiting the length of all contracts for services to no more than five years.

Separate contracts for weapons production and cleanup might also enhance efficiency. Even though many managers within the EM program acknowledge that the contracts they monitor carry high overhead rates, they point out that they do not always have direct control of those rates. At installations where both production and cleanup are still occurring--Savannah River and Oak Ridge, for example--the overall contract for M&O is not under

30. In a case cited by GAO, one M&O contractor's annual management fee started at $12 million and increased automatically every year by $250,000.

EM's control. Since the M&O contractor is responsible for both production and cleanup, as contracting practices now stand, the terms of the contract are controlled by whichever program is bigger, which is traditionally weapons production and not cleanup. To remedy this situation, Assistant Secretary Grumbly, along with other observers, has suggested that all environmental restoration work at installations with production activities be contracted separately. EM staff would then be directly responsible for overseeing the work and contracts for environmental restoration at all installations.

It is impossible to quantify with confidence the savings that could result from each of these initiatives. Assistant Secretary Grumbly, however, has predicted that the amount the EM program must pay contractors to perform tasks at DOE installations will drop 10 percent to 20 percent in four years. As a consequence, DOE is reducing its budgets in anticipation of these savings. In its authorization bill for 1994, the Senate Committee on Armed Services recommended a $40 million reduction in EM's budget to reflect management efficiencies. In the same vein, the renegotiated agreement at Hanford specified that a savings of $1 billion be achieved over the five years from 1994 through 1998, which would represent slightly more than a 10 percent reduction in the Administration's proposed funding of $8.4 billion for the same period.

Of course, some risk is associated with cutting budgets in anticipation of management efficiencies. If the efficiencies are not realized, then cleanup programs will be delayed.

Nevertheless, those risks may be worth taking. Budget cuts targeted toward management costs may increase DOE's incentives to reduce those costs expeditiously. And if administration and support costs can be reduced, then DOE could devote a larger share of its funding to cleanup activities.

Maintaining DOE's Surplus Facilities

The scope of DOE's mission has decreased drastically since the end of the Cold War. The nuclear weapons complex, designed to produce and maintain some 23,000 nuclear warheads, will shrink over the next decade along with the size of the U.S. nuclear arsenal. As a consequence, many facilities that have been producing nuclear weapons or the materials to build them, some for as long as 50 years, will no longer be needed. Accelerating the process of putting the surplus facilities in a state of low maintenance would require additional funding initially, but it could save money in the long run.

As facilities cease operations, responsibility for their security and maintenance will be transferred from the Defense Program in DOE to the Environmental Restoration and Waste Management program. In July 1992, DOE created a new office within the EM program--Facility Transition and Management (FT)--to monitor these facilities after they have been declared surplus and as they are made ready for final cleanup and disposition. The FT program eventually could be responsible for removing as many as 7,000 facilities from defense production in the next 30 years.

Some of the facilities that DOE decides it no longer needs for production may have to go through several steps to prepare for final disposition. The first step is a decision by DOE that the building is surplus. This decision results in a transfer of the facility from the control of the Defense Program to the FT program. The next step is to remove all hazards that need to be eliminated so that the facility can be maintained cheaply and safely until it can be turned over to the Environmental Restoration program for decontamination and decommissioning. After D&D, the building can be demolished or turned over to another government or private agency for other uses.

While the facilities are in transition from production to cleanup, a process that can take many years, they must be maintained and guarded so that no harm comes to either the public or the environment from the hazardous material inside. If most of the hazardous material and contaminated production equipment is removed from the building, then the requirements for inside utilities, such as ventilators and radiation detectors, and security measures can be minimized. This state--known as safe shutdown--means that the facility cannot be restarted for production but can be left in a state of low maintenance. Achieving safe shutdown requires an investment of time and money. But if many years elapse before the facility is cleaned up or disposed of--as in the case of the surplus reactors at Hanford discussed in Chapter 3--then placing it in a state that requires low annual investments for maintenance is worth the initial effort.

In a recent report, GAO concluded that the FT program faces problems concerning maintenance, safety, and costs.[31] In general, DOE's inactive facilities are deteriorating physically. GAO reported that the upkeep of inactive facilities is not a high priority among maintenance jobs and that such work is not generally required by environmental regulations or covered by interagency agreements. As a result, many projects for repairing surplus buildings are deferred in favor of higher-priority work elsewhere at the sites. As a consequence, conditions at those buildings are often in violation of regulations established by DOE and the Occupational Safety and Health Administration. These violations have resulted in accidents; in one such accident, a worker on the roof of a 48-year-old reactor building was killed when the roof panel collapsed.

GAO has concluded that the failure to properly maintain inactive facilities can increase the dangers and costs associated with cleaning them up. Slipshod or undocumented work performed while shutting down a facility can lead to unanticipated problems or accidents during subsequent decontamination and decommissioning. An explosion that occurred during the cleanup of a nuclear research facility at Hanford, for example, was the direct result of a contractor's decision to eliminate an interim work step earlier in the project.

Improper maintenance can also affect the cost of cleanup projects. When the plutonium fuel facility at Savannah River was put on standby in 1983, the equipment was not fully decontaminated, nor has it been cleaned up in the subsequent 11 years of inactivity. The internal equipment is now so badly deteriorated that it can no longer be used to remove the plutonium that remains in the facility. DOE estimated in January 1992 that an additional $115 million will therefore be needed to decontaminate and decommission the facility. Had the facility been adequately cleaned initially, DOE could have avoided the subsequent higher cleanup costs.

In general, the cost to maintain surplus facilities awaiting cleanup is substantial and could grow because of problems of the sort just noted. Increasing near-term funding designed to attain safe shutdown status at surplus facilities could produce long-term savings in the DOE budget by reducing annual security and maintenance costs in later years.

Hanford's N-reactor as an Example

The N-reactor at the Hanford installation in western Washington provides a good example of the types of costs that can be incurred and the potential for savings that exists. The reactor, which was used to produce plutonium for nuclear weapons, has been maintained since October 1990 on a "cold standby status," which means that no production is occurring and the reactor is not operating but could be restarted if necessary. Even though DOE has decided that the reactor will never be restarted, 130 full-time employees are needed to maintain the reactor at a cost of about $25 million annually in 1995 dollars.

Because large amounts of highly radioactive materials are still stored on the site, these personnel are needed primarily to maintain security and to meet safety standards. In particular, over 500 tons of radioactive debris such as fuel carts, fuel baskets, and process tubes are stored in a water-filled basin adjacent to the reactor building. In addition, three underground silos contain highly radioactive spacers that were placed inside the fuel rods. Before the facility can be decontaminated and decommissioned, all of these wastes must be removed and disposed of. In the meantime, DOE must guard and maintain buildings, monitor radiation levels, and complete routine upgrades to utilities on schedule. In fact, DOE contends that costs to maintain the facility will rise over time as it ages if steps are not taken to place it in safe shutdown.

31. General Accounting Office, *Cleaning Up Inactive Facilities Will Be Difficult,* GAO/RCED-93-149 (June 1993).

Placing the N-reactor in safe shutdown would involve removing superfluous materials from the site, including all the highly radioactive debris from the storage basin and the storage silos, as well as 7,000 cubic feet of documents. Because DOE has not made funds available for this purpose, however, current plans call for maintaining the N-reactor in cold standby status through 2000, at the cost of about $25 million a year, before beginning efforts to achieve safe shutdown. Once safe shutdown is attained, however, annual maintenance costs would drop by 90 percent, to about $2 million, based on estimates made by Westinghouse--the contractor responsible for most of the operations at Hanford (all costs are in 1995 dollars). The process of attaining safe shutdown of the N-reactor could take up to six years and require an investment of almost $290 million. Overall, attaining safe shutdown sooner rather than later--starting in 1995 rather than 2000--would reduce total costs, adjusted for the time value of money, by about 30 percent.[32]

Other Surplus Facilities

Detailed data on other DOE facilities are not available, but the situation represented by Hanford's N-reactor is probably not unique. The DOE complex contains many large facilities, some with high levels of radiation. More and more of these facilities are being idled as the need to produce nuclear weapons diminishes. Hanford alone, in addition to the N-reactor, contains several large plants that at some time in the past 50 years housed operations to separate plutonium from irradiated fuel cells. Other installations across the DOE complex contain surplus buildings with significant radioactive contamination, including plants designed to machine plutonium at Rocky Flats and the gaseous diffusion plant at Oak Ridge.

DOE will eventually have to make investments at many of these facilities to attain safe shutdown, with decommissioning to follow. Making these investments now could reduce maintenance costs, resulting in substantial annual savings. But determining how much might be saved at facilities throughout the complex is difficult for several reasons.

First, it is difficult to ascertain how much DOE is spending to maintain surplus facilities before safe shutdown. The 1995 request for surveillance and maintenance in the FT budget totals $319 million, although that figure is unlikely to include the entire cost of maintaining the facilities. In fact, a recent press article reported that DOE was spending $240 million annually at Hanford alone to maintain its idle facilities.[33] But if the figure of $319 million represents a conservative estimate of the cost of surveillance and maintenance throughout the complex, and if reductions in maintenance costs similar to those associated with the N-reactor could be realized generally, then investing to achieve safe shutdown of DOE facilities could yield savings in maintenance costs of hundreds of millions of dollars a year.

Second, accurate estimates of the investment required to achieve these savings are not currently available. In one sense, the size of the investment is irrelevant, since at most sites the investment will have to be made eventually because of the presence of long-lived radioactive debris. But the magnitude of the cost would provide some indication of the feasibility of making that investment sooner--given current budgetary constraints--in order to achieve savings in maintenance costs.

In its 1995 budget, the Office of Facility Transition and Management has requested a total of $109 million to place facilities in safe shutdown. As with surveillance and maintenance costs, however, it is impossible to know, without additional data, exactly what that request included and what activities are being funded elsewhere in the EM budget. Even if the $109 million represented an appropriate annual total for the investment required to achieve safe shutdown, it is not clear how long DOE would have to sustain that level of investment. Given the scope and schedule of other cleanup activities, DOE might

32. The reduction of 30 percent results from differences in discounted present values, an economic calculation that takes into account the time value of money. A savings of 30 percent is based on an annual real discount rate of 2 percent. Savings fall to 24 percent at a discount rate of 4 percent and rise to 35 percent without discounting.

33. Matthew L. Wald, "At an Old Atomic-Waste Site, the Only Sure Thing Is Peril," *New York Times*, June 21, 1993, p. A1.

have to continue investing that much for a substantial period.

Even though DOE realizes that these trade-offs exist, it does not have the budgetary data needed to evaluate the benefits or drawbacks of either deferring or accelerating the deactivation of surplus buildings. Part of this deficiency may stem from the fact that DOE's shift in mission--from production to cleanup, dismantlement, and storage--has been recent and abrupt. DOE is in the preliminary stages of planning and conducting cleanup work for all of its inactive facilities. It does not know the number of facilities that are inactive but not yet transferred to the EM program, the full extent of the dangers they pose, or the cost to maintain them safely until they can be turned over to the Environmental Restoration program for ultimate cleanup and disposal. Some facilities that were preparing for modernization or restart are now being closed permanently.

The newly created program for overseeing these transitions may facilitate the collection and standardization of budgetary data and may make the evaluation of the benefits of accelerating or deferring attainment of safe shutdown possible in the future. Once the necessary data are available, DOE should be able to determine where increases in funding to accelerate safe shutdown should be made.

Appendixes

Appendix A

Profile of Major Facilities and Remedial Action Programs

The Department of Energy's budget for the Office of Environmental Restoration and Waste Management supports a number of facilities and activities across the nation. This appendix briefly describes the budgets and environmental challenges for the department's major facilities and remedial action programs. Table A-1 presents their 1994 appropriations and 1995 budget requests; Table A-2 shows the growth in their budgets since 1990.[1]

Hanford Site

The Hanford Site occupies 560 square miles in southeastern Washington State, near Richland. One of the original facilities of the Manhattan Project, it was established in 1943 as the site of the first full-size reactor to produce plutonium. The historic B-reactor produced the plutonium used in "Fat Man," the nuclear bomb dropped on Nagasaki in August 1945. After World War II, Hanford continued to produce and process plutonium for nuclear weapons.

The activities at Hanford's nuclear reactors and chemical separation facilities have generated large quantities of dangerous wastes--radioactive materials, heavy metals, volatile organic compounds, and other hazardous chemicals. Over the years, wastes have been disposed of in large underground storage tanks. The oldest tanks, with only single shells, are of greatest concern because many are leaking or feared to be leaking. The reactors also present disposal problems because of their radioactivity.

Hanford's environmental cleanup budget for 1994 is nearly $1.5 billion, 24.1 percent of DOE's cleanup budget. DOE anticipates that Hanford will require approximately that share of the cleanup budget for the foreseeable future.

Savannah River Site

The Savannah River Site is located on approximately 325 square miles of land along the Savannah River in south-central South Carolina near Aiken. DOE considers it one of the department's greatest environmental challenges. Its five reactors, two chemical separation facilities, and reactor fuel manufacturing facility have produced tritium and plutonium. As a consequence of these activities, it has various kinds of radioactive and mixed wastes to dispose of. Savannah River's Defense Waste Processing Facility is intended to stabilize high-level radioactive waste.

Savannah River's environmental cleanup budget for 1994, $757.4 million (12.3 percent of the total), is about 3 percent lower than its peak of $779.0 million in 1993.

1. The budget totals for 1994 and 1995 differ from those given in Chapter 2 because they include the budget of the Uranium Enrichment Decontamination and Decommissioning program.

Oak Ridge Reservation

The Oak Ridge Reservation, located near Oak Ridge, Tennessee, contains several discrete facilities that together account for 10.6 percent of DOE's cleanup budget in 1994.

The K-25 site was one of the original Manhattan Project facilities, with a mission to enrich uranium by gaseous diffusion. Following shutdown of the uranium enrichment process in 1987, the K-25 site has been used for various environmental cleanup functions. Its cleanup budget in 1994 is $270.2 million.

Table A-1.
Environmental Cleanup Budgets for DOE's Facilities and Remedial Action Programs, 1994 and 1995

Facility or Program	1994 Appropriation: In Millions of Dollars	1994 Appropriation: As a Percentage of DOE's Cleanup Budget	1995 Budget Request (Millions of dollars)
Headquarters			
Washington, D.C.	726.7	11.8	995.0
Facilities			
Hanford	1,490.0	24.1	1,591.6
Savannah River	757.4	12.3	743.6
Oak Ridge	652.7	10.6	648.3
Rocky Flats	477.2	7.7	639.7
Idaho National Engineering Laboratory	408.7	6.6	392.4
Fernald	304.4	4.9	294.2
Waste Isolation Pilot Plant	185.3	3.0	184.6
Los Alamos National Laboratory	185.1	3.0	180.0
Lawrence Livermore National Laboratory	89.5	1.4	80.2
Sandia National Laboratory (Albuquerque)	73.0	1.2	51.9
Mound Plant	47.4	0.8	45.0
Pantex Plant	35.7	0.6	45.6
Nevada Test Site	18.0	0.3	23.1
Kansas City Plant	14.1	0.2	13.2
Pinellas Plant	11.1	0.2	9.0
Other	551.7	8.9	167.9
Remedial Action Programs			
Formerly Utilized Sites Remedial Action Program	42.7	0.7	74.1
Uranium Mill Tailings Remedial Action Project	104.1	1.7	100.9
Total[a]			
All Facilities and Programs	6,174.8	100.0	6,280.3

SOURCE: Congressional Budget Office based on data from Department of Energy, *Environmental Management 1994*, DOE/EM-0119 (February 1994).

a. Includes funds for the Uranium Enrichment Decontamination and Decommissioning program.

Table A-2.
Funding by Facility, 1990-1995 (In millions of dollars)

	Appropriations					1995
	1990	1991	1992	1993	1994[a]	Request[a,b]
Headquarters						
Washington, D.C.	60.5	196.3	416.5	447.2	726.7	995.0
Facilities						
Hanford	441.3	828.6	1,060.4	1,481.4	1,490.0	1,591.6
Savannah River	471.1	644.6	550.5	779.0	757.4	743.6
Oak Ridge	282.7	353.3	448.6	553.1	652.7	648.3
Rocky Flats	139.7	173.0	181.8	291.2	477.2	639.7
Idaho National Engineering Laboratory	185.6	323.2	248.4	372.9	408.7	392.4
Fernald	84.4	263.6	214.3	293.9	304.4	294.2
Waste Isolation Pilot Plant	104.6	164.0	141.0	150.7	185.3	184.6
Los Alamos National Laboratory	47.9	82.1	120.5	172.9	185.1	180.0
Lawrence Livermore National Laboratory	33.8	52.7	77.8	107.6	89.5	80.2
Sandia National Laboratory (Albuquerque)	16.3	37.7	58.5	73.7	73.0	51.9
Mound Plant	19.1	30.7	42.2	44.5	47.4	45.0
Pantex Plant	5.4	19.7	26.2	41.0	35.7	45.6
Nevada Test Site	13.0	n.a.	13.7	20.7	18.0	23.1
Kansas City Plant	12.0	17.4	27.5	16.9	14.1	13.2
Pinellas Plant	3.0	4.7	4.6	9.2	11.1	9.0
Other	353.7	260.6	463.5	484.2	551.7	167.9
Remedial Action Programs						
Formerly Utilized Sites Remedial Action Program	0	29.2	49.0	40.9	42.7	74.1
Uranium Mill Tailings Remedial Action Project	n.a.	119.6	141.9	139.3	104.1	100.9
Total						
All Facilities and Programs	2,274.1	3,601.0	4,286.9	5,520.3	6,174.8	6,280.3

SOURCE: Congressional Budget Office based on data from Department of Energy, *Environmental Management 1994*, DOE/EM-0119 (February 1994).

NOTE: n.a. = not available.

a. The 1994 and 1995 budgets include funding for the Uranium Enrichment Decontamination and Decommissioning program.

b. The 1995 budget request allocates all funding for technology development ($426.4 million) and transportation management ($20.7 million) to headquarters.

The Y-12 plant also was built during World War II. Its original mission was to separate uranium isotopes by an electromagnetic process. After the war, it was used for manufacturing and developmental engineering and for treatment, storage, and disposal of radioactive and hazardous wastes. Its environmental budget for 1994 is $97.8 million, a decline of about $10 million from 1993.

The Oak Ridge National Laboratory conducts research on fusion, fission, and many other energy technologies. Its site is contaminated with radioactive and hazardous wastes. The budget for environmental cleanup in 1994 is $163.1 million, a decline of $17 million from 1993.

A new responsibility of the Oak Ridge office in 1994 is the Uranium Enrichment Decontamination and Decommissioning program. This program, which is funded through taxes paid by utilities to support enrichment of uranium used at nuclear power plants, is not part of the weapons-related work described in the main body of this study. But its budget of $286.3 million in 1994 accounts for a large share of the budgetary growth at Oak Ridge ($199.1 million) and at the gaseous diffusion plants at Portsmouth ($47.8 million) and Paducah ($39.4 million).

Rocky Flats

The Rocky Flats Plant is located about 16 miles northwest of Denver, Colorado. The plant itself covers about 400 acres on an 11-square-mile site. From 1952 to 1992, Rocky Flats produced weapons components fabricated from plutonium and other metals. As Denver has grown, suburban development has pushed closer to Rocky Flats, and concerns about migration of contaminated groundwater as well as other environmental risks have increased.

The environmental cleanup budget for Rocky Flats in 1994 is $477.2 million, 7.7 percent of the total. The growth of its budget by $186 million (a rate of 63.9 percent) from 1993 to 1994 made it the fastest-growing part of the Environmental Restoration and Waste Management program.

Idaho National Engineering Laboratory

The Idaho National Engineering Laboratory (INEL) covers about 890 square miles in southern Idaho, about 40 miles northwest of Idaho Falls. Its research, development, and operations activities have generated radioactive, hazardous, and mixed wastes. The Idaho Chemical Processing Plant (ICPP), located at the same site, handles and stores spent fuel from naval reactors. It treats wastes to stabilize them and reduce their volume.

The environmental cleanup budget for INEL (including ICPP) in 1994 is $408.7 million, 6.6 percent of the total.

Fernald

The Fernald Environmental Management Project is located on 1,050 acres near Fernald, Ohio, about 17 miles northwest of Cincinnati. Formerly a producer of uranium metal ingots and uranium oxides, it became in 1991 the first DOE facility to be turned over entirely from production to environmental restoration. One of the major problems is groundwater contaminated by radionuclides, metals, inorganic compounds, and volatile organic compounds.

Fernald's environmental restoration budget for 1994 is $304.4 million, 4.9 percent of the total.

Waste Isolation Pilot Plant

The Waste Isolation Pilot Plant (WIPP), located about 25 miles east of Carlsbad, New Mexico, is intended to be the long-term disposal site for transuranic wastes from Hanford, Savannah River, INEL, Rocky Flats, and other DOE facilities. Development of the facility has been held up by regulatory hurdles. One major obstacle was overcome with passage in 1992 of the WIPP Land Withdrawal Act, which withdrew from public use lands surrounding WIPP, allowing DOE to proceed with testing once it obtains approval from regulators. DOE still faces the challenge of convincing regulators and the general public that it will ensure safe storage of wastes. WIPP's 1994 budget of $185.3 million is about 3 percent of DOE's cleanup total.

Los Alamos National Laboratory

The Los Alamos National Laboratory, located about 25 miles north of Santa Fe, New Mexico, is the site of nuclear weapons research and development dating back to World War II. Its activities have resulted in a variety of hazardous and radioactive wastes. Its environmental budget of $185.1 million in 1994 is about 3 percent of the total.

Lawrence Livermore National Laboratory

The Lawrence Livermore National Laboratory is in Livermore, California, 40 miles southeast of San Francisco. It has interim status under the Resource Conservation and Recovery Act for treatment, storage, and disposal of hazardous, mixed, and low-level radioactive waste. It also has nonnuclear explosive test facilities at a site about 15 miles southeast of the main site. Testing activities have resulted in contamination of both soil and groundwater. The 1994 environmental cleanup budget is $89.5 million, about 1.4 percent of the total.

Sandia National Laboratory

The Sandia National Laboratory performs research, development, and testing of nonnuclear components of nuclear weapons at sites near Albuquerque, New Mexico, and Livermore, California. This work has resulted in hazardous, radioactive, and mixed wastes. The environmental cleanup budgets are $73.0 million at Albuquerque and $5.7 million at Livermore in 1994. Together they account for 1.3 percent of the total.

Mound Plant

The Mound Plant in Miamisburg, Ohio, conducted research and development and produced nonnuclear and tritium-containing components for nuclear weapons. In 1993, its mission changed from production to environmental cleanup. Its environmental budget of $47.4 million is a little less than 1 percent of the total.

Pantex Plant

Nuclear weapons are assembled and disassembled at the Pantex Plant, near Amarillo, Texas. The environmental cleanup budget is $35.7 million, about 0.6 percent of the total cleanup budget.

Nevada Test Site

The Nevada Test Site covers about 1,350 square miles in Nevada, about 65 miles northwest of Las Vegas. Above-ground and underground tests of nuclear weapons have contaminated both surface and subsurface soils. In addition, transuranic waste and mixed waste are stored at the site. The cleanup budget for 1994 stands at $18 million.

Kansas City and Pinellas Plants

The Kansas City Plant manufactures nonnuclear weapons components. These operations result in hazardous and toxic wastes. The environmental cleanup budget in 1994 is $14.1 million.

The Pinellas Plant, near St. Petersburg, Florida, developed and produced special electronic and mechanical equipment. Production has ceased, having been consolidated at the Kansas City Plant. The environmental cleanup budget is about $11.1 million in 1994.

Remedial Action Programs

In addition to its facilities, DOE has two major programs for cleaning up contaminated sites.

The Formerly Utilized Sites Remedial Action Program is intended to clean up radioactive contamination at 33 sites in 13 states resulting from early activities of the atomic energy program. Its 1994 budget is about $42.7 million. The program is overseen by the Oak Ridge field office.

The Uranium Mill Tailings Remedial Action Project is intended to stabilize and control mill tailings at 24 sites and approximately 5,000 properties in 10 states and on two Indian tribal lands. Cleanup of surface contamination is nearly complete, but cleanup of groundwater is still at an early stage of assessment. Its 1994 budget of $104.1 million is overseen by the Albuquerque field office.

Appendix B

Estimating the Costs of Cleaning Up DOE Sites

Estimators of costs at the site or project level face many of the same problems as those working at the program level. Information yet to be acquired about the type, magnitude, location, and toxicity of contaminants and the likelihood of their migrating to populated areas will affect the estimates of remediation costs. But one advantage at the site level is that the project typically is well defined, as are the tasks required to accomplish it. Cost engineers break down the work needed to accomplish each task into its basic components, known as the work breakdown structure (WBS). The Department of Energy typically aggregates several tasks within a WBS into an activity data sheet (ADS), the basic building block of the department's five-year plan. The ADSs set forth the specific assessment or cleanup tasks that serve as the basis for cost estimates.

Estimating the costs of assessing and cleaning up a site typically begins by identifying all the basic components of work, such as drilling wells or digging up soil. Cost estimators determine the amount of labor of different types and the equipment and materials needed to complete the task. After multiplying the inputs by wage rates and other unit costs, estimators add in overhead and other allowances they deem necessary to arrive at a cost estimate. The job of estimating the costs of completing individual cleanup tasks throughout the nuclear complex typically falls on contractors at DOE's facilities, in consultation and coordination with DOE staff at the facilities. But headquarters staff also become involved, providing general guidance on preparing cost estimates and monitoring and coordinating the work done at the field offices.

Cost estimators use a variety of analytical tools. The choice of tools and the degree of confidence in the estimate depend on the stage and type of activity. DOE's environmental restoration work consists of two principal types of activities: assessment and remediation (cleanup). The costs of each are estimated separately.

Estimating the Costs of Assessing Sites

Assessing a site to determine the type and extent of contamination is perhaps the more challenging activity to estimate because so many factors are unknown. In this respect, assessment is akin to research and development: at the start of a project, researchers do not know exactly what they will encounter and therefore cannot confidently predict costs, schedules, or outcomes. For example, before beginning assessment, workers may not know how many monitoring wells will be needed to obtain an accurate picture of subsurface contamination.

DOE makes three types of estimates of assessment costs: planning estimates, preliminary estimates, and detailed estimates.[1] Planning estimates are made during the preliminary assessment/site investigation (PA/SI) stage of a cleanup project. At this stage, cost estimates are based on what little information is available about a site, such as location and history of use. DOE uses analogy, simple cost-estimating relationships, and statistical tools to

1. Department of Energy, Environmental Restoration and Waste Management Cost Assessment Team, *Cost Estimating Handbook for Environmental Restoration* (n.d.; updated periodically), p. 2-2.

make cost estimates.[2] Because of uncertainties, contingency factors must be built in to the cost estimates.

After the PA/SI is completed, DOE makes a preliminary estimate of costs as it develops a work plan for the remedial investigation/feasibility study (RI/FS). By this time, cost estimators have some idea about the kinds of assessment activities to be carried out--for example, drilling, sampling, laboratory analysis--and can make rough estimates based on past unit costs of such activities.

During the RI/FS stage, DOE makes detailed estimates of assessment costs as additional information becomes available. "Detailed" estimates can be based on engineering data and drawings, specifications, the contract schedule, and other factors specific to each project. By this point, cost estimates can be made with much greater confidence than before. From experience, cost estimators know roughly how much labor--and what skill levels--will be required to complete certain tasks. Applying hourly rates gives an estimate of labor costs. Similarly, they can estimate the amount of equipment and materials. The estimators add an overhead rate to take into account management resources devoted to the task. But none of these tasks is strictly mechanical. All require judgment and "guesstimates" about the amount of resources needed: the less well defined a task, the more subjective the cost estimates.

Estimating the Costs of Cleaning Up Sites

For long-range planning and budgeting purposes, DOE makes preliminary estimates of cleanup costs even before assessment has proceeded far enough to reduce uncertainty about what the eventual cleanup process will entail. These "planning estimates" are like those for assessment in that they come so early in the process that there is little solid information on which to base them and therefore considerable uncertainty in the estimate.

2. Ibid.

As part of the RI/FS stage, the Comprehensive Environmental Response, Compensation, and Liability Act (which established Superfund) requires analysis of alternative remedies and their costs. The "feasibility estimates" of cost, schedule, and design that are prepared at this stage serve as a basis for selecting a remedy in the record of decision. In principle, DOE considers the estimates of cost and schedule made at this point as forming the first formal baseline for measuring and evaluating cleanup performance.[3] In practice, however, very few projects at major DOE facilities have reached the record-of-decision stage.[4]

As DOE progresses with cleanup, cost estimates can become more detailed, following the same pattern as estimates of assessment costs.

Tools for Estimating Costs

Estimating costs of environmental cleanup, if not still in its infancy, can hardly be called a mature science. The Superfund program is just 13 years old, and given the time required to identify and assess contaminated sites before proceeding to remedial action, the amount of cleanup experience on which to base estimates of new projects is limited. As cleanup efforts proceed around the nation--not only at DOE facilities but also at defense and other federal facilities and at private Superfund sites--professional cost estimators gain new information to add to their data bases that they can then use in estimating costs of new projects. The lessons learned from these experiences are shared through interagency task forces as well as professional journals and conferences.

DOE's Environmental Restoration and Waste Management Cost Assessment Team has prepared the *Cost Estimating Handbook for Environmental Restoration* to assist the DOE offices that estimate the cleanup costs at various sites. The handbook

3. Ibid., p. 2-5.

4. The DOE cleanup program that is farthest along is the Uranium Mill Tailings Remedial Action Project. The nature of cleanup work at these sites is so different from cleanup at the major weapons facilities, however, that it provides only limited guidance to cost estimators.

describes different types of cost estimates and provides guidance on how to develop them. It makes suggestions on how to deal with uncertainties, contingencies, cost escalation, and other factors, and it describes data bases, tools, and techniques that can be useful to cost estimators in the field offices.

Building the cost estimates from the bottom up--estimating the cost of each component of work required to complete a task--is just one approach to the problem of estimating the environmental cleanup costs facing DOE. Another approach is to develop parametric cost-estimating models that express cleanup costs as a function of such variables as the type, volume, and concentration of contaminants; the medium (soil, groundwater, air); and the required remedy. Both DOE and the Environmental Protection Agency have developed such models to help estimate Superfund and similar cleanup costs.

DOE's Models for Estimating Costs

Cost analysts from the firm Independent Project Analysis, Inc. (IPA), have prepared studies on estimating costs and schedules of assessment and cleanup projects for the Department of Energy.[5] These studies contribute to the understanding of assessment and cleanup costs by developing statistical relationships between costs and a number of variables and between growth in costs and a number of variables. They have found that about three-quarters of the variance in assessment costs can be explained by an equation with five independent variables: the number of borings and new wells, an index of site complexity, the threat posed to the surrounding community, the number of previous cleanup efforts at a site, and whether assessment tasks at a site are occurring in sequential phases or concurrently.[6] Growth in costs can largely be explained by variables describing the complexity of the site, the complexity of the media, and the stage of the project relative to other work at the site (referred to as project definition).[7]

IPA has developed similar models for the remediation of hazardous waste sites. It finds that cleanup costs can be expressed as a function of six key variables: the volume of waste excavated, technological complexity, whether the site is a landfill, whether there is mixed debris at the site, the complexity of the waste, and whether the primary threat is groundwater contamination.[8] Together, these variables explain 96 percent of the variance in cleanup costs. Sources of error in cost estimates are the lack of complete information about the project, the type and complexity of remedial technologies, the complexity of the media, and the complexity of wastes at the site.[9]

IPA's studies drew from experiences at a variety of hazardous waste sites--not only DOE sites but also EPA Superfund and private industrial sites. But since the DOE cleanup program is still relatively young, there is not much experience with sites containing radioactive wastes. As more DOE sites are assessed and cleaned up, IPA plans to enter them into its data base and reestimate the relationships between costs and other factors.

EPA's CORA Model

The EPA uses the Cost of Remedial Action (CORA) model to estimate the costs of cleanup at individual Superfund sites.[10] EPA also aggregates the estimates generated by the CORA model in developing the overall budget for its Superfund program. To use the CORA model, one enters data on site characteristics, the kinds and amounts of contaminants, the cleanup technologies, and other perti-

5. Brett R. Schroeder and others, *The HAZRISK Assessment Study*, prepared for the Department of Energy by Independent Project Analysis, Inc., WD-90-04-HAZ (December 21, 1990); and B. R. Schroeder and J.B. Hartung, *The HAZRISK Cleanup Report*, prepared for the Department of Energy by Independent Project Analysis, Inc. (Draft, February 1991).

6. Schroeder and others, *The HAZRISK Assessment Study*, p. 23.

7. Ibid., pp. 38-39.

8. Schroeder and Hartung, *The HAZRISK Cleanup Report*, pp. 24-25.

9. Ibid., pp. 45-46.

10. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *The Cost of Remedial Action Model, Quick Reference Fact Sheet*, Publication No. 9375.5-06a/FS (May 1991). In addition to estimating costs, CORA contains a module that suggests the kind of remedial action that should be taken at each site.

nent information; the model uses this information to estimate cleanup costs. Tests of the model suggest that actual costs run from 30 percent below to 50 percent above the cost estimate it generates. Although the CORA model deals with most types of hazardous contaminants, it does not estimate cleanup costs at mining sites or sites with radioactive waste, nor is it able to estimate costs associated with such emerging technologies as in situ vitrification. It could be expanded, however, to cover additional technologies or types of pollution.

Appendix C

Description of Specific Integrated Demonstrations and Estimates of Savings

Preliminary results from the Department of Energy's research efforts have identified two areas in which the department feels technology can yield an early payoff--groundwater and soils cleanup, and waste retrieval and processing. DOE is conducting several integrated demonstrations in these two areas; they represent the two biggest items in the portion of the budget for technology development that funds research and development (see Chapter 4). Furthermore, one of DOE's major technical challenges involves cleaning up contaminants in the soil or groundwater.

Cleaning Up Soils

New technologies could save significant sums of money by reducing the amount of contaminated soil requiring disposal. Conventional treatment of contaminated soil involves excavating all soil that might contain waste, treating it if appropriate, and then disposing of it at an approved site. Without the ability to precisely locate contaminants within the soil, current techniques using bulldozers often require excavating at least twice the estimated volume of contaminated soil in order to ensure that all contamination has been removed. DOE estimates that excavating and disposing of soil from the Nevada Test Site alone could cost $2.5 billion using current techniques.

DOE is investigating techniques that would reduce the amount of soil that must be excavated initially as well as methods of treating the contaminated soil to reduce the volume of waste ultimately requiring disposal. By monitoring soil as it is excavated using a special "rotomill" machine, DOE can remove less material requiring subsequent treatment. The department is also attempting to further concentrate plutonium in the soil using such techniques as magnetic separation and centrifugation. According to DOE estimates, rotomilling and then concentrating the plutonium could reduce the amount of soil to be disposed of by a factor of five; the savings at the Nevada Test Site would be $2 billion, or 80 percent of the cost of using current technology.

Cleaning Up Groundwater

Cleaning contaminated groundwater is another thorny and major problem facing DOE. First, groundwater contamination has been detected at almost all of the major installations in DOE's nuclear weapons complex, although the extent and types of contamination at individual sites have not yet been fully characterized. Second, cleaning up contaminated groundwater may be very difficult, expensive, and time consuming. The most common technique used for eliminating contaminants from groundwater is to extract the water from the aquifer and then treat it. This pump-and-treat process can take a very long time because contaminants can diffuse or be absorbed into the material in the aquifer and be slowly released back into the water as it is being treated. For all of these reasons, cleaning up the contaminated groundwater at DOE sites using current techniques could be a very difficult and costly, if not impossible, task.

To reduce the time and money needed to remediate the groundwater at its installations, DOE is looking at new methods for extracting contaminants from groundwater that are more efficient than simply pumping groundwater up to the surface to treat it. Again, DOE has identified significant potential savings in terms of cost, time (from years to months), or both, using various techniques under investigation. The department estimates that these new methods could save about $3 billion over the cleanup period.

One method, called air stripping, pumps compressed air down into the aquifer containing the groundwater to flush out some of the contaminants, which are then collected in a vacuum grid located above the water table. This method works particularly well for extracting volatile organic compounds from groundwater. The vaporized contaminants are then pumped from the vacuum grid up to the surface where they can be treated. DOE estimates that air stripping can reduce the cost of cleaning up groundwater contaminated with volatile organic compounds by 65 percent compared with conventional pump-and-treat methods. DOE is conducting an integrated demonstration at Savannah River using air stripping and feels that such a technique might be applicable to half of its sites and of those sites belonging to the Department of Defense (DoD) that have groundwater contaminated with volatile organic compounds.

As part of that demonstration, DOE is also investigating technologies that would destroy contaminants while still in the aquifer. Such methods, called in situ remediation, would obviate the need for any above-ground treatment of vapors or water. Techniques such as air stripping, by pumping gas into the aquifer, would also allow the introduction of beneficial microbes for bioremediation or chemicals to break down contaminants in the groundwater. DOE estimates that such techniques could reduce costs by 70 percent compared with conventional pump-and-treat methods and that bioremediation might be applicable to 15 percent of DOE and DoD sites with contaminated groundwater.

Waste Retrieval and Processing

The Department of Energy has large amounts of waste in various types of storage--more than 1 million 55-gallon drums, some of which are buried, and more than 300 underground tanks. Many of these drums and tanks are decades old and are, or could be, leaking. A major task facing DOE involves locating the waste and retrieving, characterizing, and disposing of it in a safe and stable manner. DOE is investigating several techniques to address these problems, including ways to identify and separate contaminated soil from clean soil and to stabilize extremely radioactive waste stored in underground tanks and provide for its ultimate disposal. Integrated demonstrations are being conducted at the Idaho National Engineering Laboratory on buried waste, and at five sites including Hanford on underground storage tanks.

Buried Waste

The integrated demonstration at the Idaho National Engineering Laboratory is exploring and developing ways to locate buried radioactive waste more precisely and to retrieve the contaminated soil and separate it from clean soil. By knowing where the waste is buried, the amount of soil to be excavated can be reduced by 20 percent, according to DOE estimates. New and better ways to retrieve the soil could eliminate the need for workers to wear protective clothing, which limits their work time to two or three hours per day. Improved methods would also increase efficiency by a factor of at least two. The cost of cleaning up waste buried in trenches using current technology ranges from $14,000 to $26,000 per cubic meter. New characterization and retrieval processes could reduce costs to an estimated $700 per cubic meter. DOE estimates that at least 59,000 cubic meters of transuranic waste and surrounding soil need to be cleaned up at the Idaho site. If the cost to retrieve and dispose of a cubic meter of buried waste can be reduced to the levels estimated by DOE, then savings at that site alone could reach $1.5 billion.

Underground Storage Tanks

The Department of Energy has more than 332 underground tanks at five installations that store waste in various forms with varying levels of radioactivity. Some tanks are now 50 years old; because they were intended originally only as temporary storage facilities, some have degraded over time and some of their contents have leaked into the surrounding soil.

DOE has chosen Hanford as one of the installations at which to investigate and demonstrate new technologies for dealing with the problem of underground storage tanks. Hanford alone has more than 170 underground storage tanks, 149 of which are of the obsolete, single-shell design most prone to leaks. The first task is to determine exactly what is in the tanks, since some were filled more than 40 years ago and no one knows precisely what chemicals they contain. Most of the material remaining in the tanks is a highly radioactive sludge or cake that is relatively hard and would require drilling by special tools to attain cores for sampling. Such a procedure, within the tank, would be difficult and costly. DOE estimates that it needs five samples from each tank to determine the contents using current techniques. DOE also predicts that two fewer samples would be needed using newer techniques such as laser range-finders deployed inside the tank on a remotely operated robotic arm to identify the best locations for taking samples. At $1 million per sample, reducing the number of samples needed by 40 percent could result in a savings of $300 million at Hanford alone, according to DOE.

Appendix D

The Acquisition Process for a Major Weapon System

Chapter 4 included a discussion of ways in which the Department of Energy's management of its projects to develop new technologies might be improved. One possibility would involve establishing a framework for periodic review and decision points during a project. The process used to monitor Department of Defense (DoD) programs was presented as a possible model for such a framework. This appendix provides a brief description of that process.

The Department of Defense has established a process to manage the development and production of major weapon systems. This process is laid out in Department of Defense Instruction 5000.2, which has been revised many times in the past 20 years. Nevertheless, the basic concept remains the same--to provide a basis for comprehensive management and decisionmaking associated with shepherding a weapon from its inception until it rolls off a production line.

The design and development of major systems such as aircraft, missiles, and ships is a long process, in many cases taking 12 to 15 years. A weapon system proceeds through a series of development stages, from identifying alternative concepts for the system to initial operational capability, deployment, and support. These stages are paralleled by a series of technical and management decisions, called milestones, made by the Under Secretary of Defense for Acquisition, the head of the relevant service (for example, the Secretary of the Air Force), or the service's delegated acquisition executive.

First, the military services, the Office of the Secretary of Defense, or the Joint Chiefs of Staff determine that a particular mission requires a new weapon system to add operational capabilities or improvements that will enhance the effectiveness of existing equipment. The originator prepares a mission need statement (MNS) that is then reviewed by the appropriate DoD component. Milestone 0 is the decision point at which the Defense Acquisition Board (DAB) validates the need for a new weapon to meet the threat and grants permission to proceed to the next phase.

Following favorable review at Milestone 0, the new weapon system proceeds into the concept exploration and definition phase. During this relatively short period--typically one to two years--activity focuses on selecting the best alternative to fulfill the mission needs stated in the MNS. At the next milestone, Milestone I, the service seeks approval to initiate a new program and enter the demonstration and validation phase. The DAB establishes baselines for cost, schedule, and performance characteristics to be met at the next milestone.

During the demonstration and validation phase, the program office responsible for the weapon system directs preliminary engineering and design work--typically performed by a defense contractor--with an emphasis on reducing the risk of incorporating new and emerging technologies into the final weapon system. The contractor may develop early prototypes to demonstrate the feasibility of systems, subsystems, and components. Also during this phase, which usually lasts two to three years but can extend for five or more years in the case of complicated systems, the contractor may conduct some preliminary tests to demonstrate that the system is ready to enter the next phase.

Milestone II marks the entry into engineering and manufacturing development. At this decision point, the review board must be convinced that the production of the weapon system, and its performance up to standards, are feasible. The program's cost, schedule, and performance characteristics, initially established at Milestone I, are updated. The new thresholds serve as development baselines for reports to the Congress. The DAB also reviews and updates the plans for testing, acquisition, and support and logistics.

Following favorable review at Milestone II, the weapon system enters the engineering and manufacturing development phase in which the final design for the system is established. Tests are conducted to determine that design and performance criteria are met and that the weapon system will perform as desired in an operational setting. Any final design and engineering changes needed to ready the system for production are made.

Milestone III marks approval for production. At this final major decision point, the review board examines results of tests conducted during the previous phase and establishes the acquisition strategy and production baseline. Before the system may enter full-rate production, the Secretary of Defense must certify to the Congress that all operational testing has been completed successfully. The review board may approve initial production (at Milestone IIIA) before testing has been completed, with a proviso for subsequent review and approval for full-rate production at Milestone IIIB following the completion of all tests.

Once the system has been produced and deployed to the field, management responsibility for the system is transferred to the service and the relevant subordinate command. The military personnel who use and maintain the weapon continue to monitor its performance so that problems can be identified and fixed. Some weapons, after being deployed for a number of years, require major modifications to address a different mission, correct an operational deficiency, or incorporate new technology. If the modification is sufficiently expensive, its execution may generate another milestone (IV) and be subject to reporting requirements similar to those associated with new weapons.

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