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SUPERFUND: AN ASSESSMENT OF SUPERFUND SITE REMEDY SELECTIOIN AND IMPLEMENTATION

Final Report – ESD.10 Environment Team

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An Assessment of Superfund Site Remedy Selection and Implementation

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Preface

The following report was written for a term project by a team of graduate students in the Technology and Policy Program at the Massachusetts Institute of Technology. This report is intended to imitate the style of a National Research Council (NRC) report. Please note that the authors of the report are unaffiliated with the NRC. The NRC did not endorse or sponsor the generation of this report or its conclusions.

This report consists of six chapters. Chapter 1 introduces the Superfund program and the documented procedures for Superfund site remediation. Chapter 2 provides an overview of the methodology that the committee used to complete its charge. Chapter 3 describes three Superfund sites that the committee chose for a case study. Chapter 4 presents an analysis of the remedy selection process at these sites, and proposes several recommendations for changes to the Superfund program. Chapter 5 presents an analysis of remedy implementation at these sites and proposes additional recommendations for changes. Chapter 6 details our conclusions and includes suggestions for further inquiry.

Acknowledgement of Review Participants

The Executive Summary of this report has been reviewed in draft form by individuals chosen for their experience related to the Superfund program. The purpose of this review was to provide our team with further insight into the Superfund program and enlighten the team to program progress and efforts that we may have missed in our study. We wish to thank Ms. Katherine N. Probst of Resources for the Future for reviewing a preliminary draft of our full report. We also wish to thank the following individuals for their review of our Executive Summary: Dr. Karl E. Gustavson, Board on Environmental Studies and Toxicology; Prof. David H. Marks, Massachusetts Institute of Technology.

Although the reviewers above provided constructive suggestions, they were not asked to endorse the conclusions of this report and they did not review the report in its final form. The authoring committee bears full responsibility for the final content of this report.

Table of Contents

List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRBCA	Charles River Business Center Associates
EPA	Environmental Protection Agency
ESD	Explanation of Significant Difference
FS	Feasibility Study
FYR	Five Year Review
MDEP	Massachusetts Department of Environmental Protection
MOM	Management of Migration
MTL	Materials Technology Laboratory
NASA	National Aeronautics and Space Administration
OTA	Office of Technology Assessment
OU	Operable Unit
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyls
PRP	Potentially Responsible Party
RA	Remedial Action
RAO	Remedial Action Objective
RD	Remedial Design
RFF	Resources for the Future
RIFS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
VOC	Volatile Organic Compounds

List of Figures

Executive Summary

Summary

Since its inception in 1980, the U.S. Environmental Protection Agency's (EPA) Superfund Program has served as the primary mechanism for coordinating the remediation of sites contaminated with hazardous substances. Although the program has successfully overseen cleanup at hundreds of sites, experts have identified a number of weaknesses in the remedy selection and implementation processes. Our study focuses on two weaknesses that have been identified at individual Superfund sites in the previous literature:

Remedy Selection:

- Selection of non-permanent remedies over permanent remedies[1]

Remedy Implementation:

- Inconsistency and non-transparency shown in the documentation of cleanup objectives, site cleanup progress, and problems during remedy implementation[2]

Although these weaknesses were well documented in previous literature, our group found little evidence that the underlying cause of these weaknesses had been addressed. Our study adds to the current understanding of these weaknesses by investigating their origins using established policy and engineering systems analysis techniques. We have based our analysis on three Superfund site case studies. We offer several recommendations that address the observed weaknesses in site remedy selection and implementation. Lastly, we include suggestions for areas in which further inquiry may be useful.

Remedy Selection: Balancing Stakeholder Interests and Superfund Goals

The process of selecting a remedy for a Superfund site involves balancing the interests of many stakeholders to identify a set of technologies and actions that will reduce site contamination. Our team selected three Superfund sites for their diversity in size and ownership type in eastern Massachusetts to understand how stakeholder interests influence the selection of a cleanup remedy. First, our team identified which of the aforementioned problems with remedy selection persisted at each of the sites. Second, we considered the goals of three major stakeholders—the EPA, potentially responsible party (PRP), and the community—in the remedy selection process. We developed a list of the most prominent stakeholder goals, which included eliminating contamination from the site, choosing a permanent remedy, choosing a low-risk cleanup technology, cleaning the site as quickly as possible, and minimizing the cleanup cost. Third, we developed a tool to compare the prioritization of these goals at each of the three sites with the preferences of the major stakeholders. We used this tool to determine how the stakeholder interests were reflected in the selected remedy. Since the prioritization of goals differs among stakeholders, the remedy selection process involves inherent tradeoffs among stakeholder interests.

Previous literature identified the failure to select permanent remedies as required by the 1986 Superfund Amendment and Reauthorization Act (SARA) as one major weakness of the Superfund program. Our inquiry focused specifically on how the selection of a permanent remedy was prioritized with respect to other important stakeholder goals. We observed that for the one site

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[1] U.S. Congress, Office of Technology Assessment. "Are We Cleaning Up? 10 Superfund Case Studies: Special Report." Washington, DC: U.S. Government Printing Office OTA-ITE-362, June 1988.

[2] Probst, Katherine N. *Superfund's Future: What Will it Cost?* Washington DC: Resources for the Future, 2001.

where a permanent remedy was selected, less emphasis was placed on minimizing the risk or the time required for site cleanup. At a second site, a non-permanent remedy was selected over a permanent one, reflecting a preference by the community for a quick and proven solution over a more risky long-term one. A third site classified the selected remedy as permanent when it was not. Presently, the EPA definition of "permanence" is quite vague, enabling site managers to broadly and often falsely interpret its meaning. We recommend a two-part strategy to address these problems:

Recommendation #1: Omit the current requirement for permanence from Superfund site remedy selection criteria.

Recommendation #2: Create cost incentives to encourage the selection of permanent treatment technologies.

The first recommendation to omit the current permanence requirement would ensure that site managers do not misrepresent non-permanent remedies as permanent. The second recommendation envisions a greater role for the EPA in encouraging the implementation of permanent remedies, by ensuring that more effective treatment technologies will be available to site managers at a reasonable cost. Together, these actions would promote remedies that are better suited to the level and nature of site contamination, and to the interests of all stakeholders.

Remedy Implementation: Improving Information Management

Our study also found weaknesses in the documentation of cleanup progress during remedy implementation at all three of our sites. These weaknesses included the lack of a clear and concise statement of cleanup goals, difficultly in assessing progress towards cleanup, and a failure to follow up on previously identified problems. While some of these weaknesses had been identified in previous literature and addressed through amendments to EPA guidance documents, we found little evidence that these changes had significantly reduced the problem. We applied an established approach from the engineering systems field to develop several recommendations for improving the management and communication of information during the remedy implementation process, and considered several options for enforcing them.

Recommendation #3: Use "comprehensive goal statements" to articulate a complete set of objectives and targets for each site.

This recommendation would provide a complete, concise description of the cleanup goals for each site that would be included in all relevant documentation throughout the remedy implementation process.

Recommendation #4: Use graphical metrics instead of tables to measure site cleanup progress.

Currently, assessing progress towards cleanup often requires scrutiny of all the site documentation, including multiple summaries and detailed tables of data. Graphical metrics would allow cleanup progress to be communicated succinctly to all stakeholders. Moreover, they would enable rapid identification of problems, such as failure of a remedy or incomplete monitoring. Together, recommendations #3 and #4 would provide clarity to each individual site document, consistency across all site documents, and transparency across the entire site remediation process.

> **Recommendation #5**: Create a formal system for reporting problems that arise during cleanup to ensure that problems do not go unresolved.

During the analysis of our sites, we noticed that several problems identified in the course of site cleanup were not addressed subsequently in the site documentation. As in the case of objective and progress reporting, effective problem management is critical to instill community confidence that a site cleanup is being properly managed. Other government organizations use formal reporting to ensure that problems do not go unresolved; we believe the Superfund program would greatly benefit from adoption of similar practices.

> **Recommendation #6**: Issue mandatory changes to documentation procedures and create an EPA-level position for reviewing all documentation to ensure compliance at current and future Superfund sites.

This approach would standardize reporting both within and across Superfund sites. Although fewer Superfund sites are being identified today than in Superfund's earlier years, many of the remaining sites are large, complex, and may take decades to fully address contamination. With the longer times required for cleanup at the remaining sites, improved site documentation is perhaps even more important to ensure that unforeseen challenges do not inhibit the realization of cleanup goals.

In summary, our report includes six recommendations intended to improve the availability and sound selection of effective remedies for Superfund sites and to increase the clarity and transparency of reporting progress toward remedy implementation. In remedy selection, our recommendations would reduce tradeoffs inherent in the requirement that permanent remedies be selected. In remedy implementation, our recommendations would strengthen communication of objectives, cleanup progress, and problem management, enabling Superfund to more effectively fulfill its mandate of reducing threats to human health and the environment.

I. Introduction

I.A Background on the Superfund Program

The U.S. Environmental Protection Agency (EPA) was established in 1970 to protect human health and the environment. The agency's mission includes enforcing and implementing environmental laws enacted by Congress, assessing environmental conditions, and solving current and anticipated future environmental issues. In the late 1970s, residents living near Love Canal in upstate New York became aware of toxic sludge seeping into their basements. The situation prompted widespread horror and public outcry as residents realized their neighborhood had once been a chemical dumping ground. The discovery of the Love Canal contamination generated considerable pressure for federal action to clean up hazardous waste sites. In 1980, the U.S. Congress passed and President Jimmy Carter signed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), better known as the Hazardous Substance Superfund (or simply Superfund), to assist the EPA in addressing risks associated with contaminated sites.[3] Administered by the EPA, the Superfund Program addresses short and long-term risks associated with hazardous substances, and supports the permanent cleanup and rehabilitation of contaminated sites.[4]

Figure 1: A Superfund Cleanup Worker Gathers a Soil Sample
Image ©1997 Cable News Network, Inc.

When Superfund was first established, a $1.6 billion trust fund was authorized over five years, supported by proceeds from a uniformly applied excise tax on petroleum and chemical feedstock. The trust was intended to fund program operations and site cleanups in cases where the responsible party was unknown, bankrupt, or not cooperative.[5] In response to the identification of a larger number of such sites than anticipated, the Superfund Amendments and Reauthorization Act (SARA) of 1986 increased the size of the trust fund to $8.5 billion. SARA authorized funding by a broad tax levied on corporate profits but not on polluters specifically. The trust was renewed again in the early 1990s, when another $5.1 billion was authorized for the subsequent five-year period. However, the Superfund tax lapsed in 1995, and funds in the trust were depleted by 2003.[6] Superfund's annual budget is determined through the congressional appropriations process, and Congress has kept annual Superfund appropriations relatively constant in the range of $1.1 to $1.4 billion over the past few years, which since the expiration of the trust has been supported by general taxpayer contributions.[7]

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[3] "About Superfund." 2006. U.S. Environmental Protection Agency, www.epa.gov.
[4] "Key Dates in Superfund." 2006. U.S. Environmental Protection Agency, www.epa.gov.
[5] Reisch Mark and Bearden, David Michael. 1997. *Superfund Fact Book*, CRS Report for Congress 97-312 ENR.
[6] Strickler, Annie E. 2004. "Sierra Club Marks One Year Anniversary of the Bankruptcy of the Superfund Trust Fund." Sierra Club Online.
[7] Marianne Horinko, June 2004. "Today's Superfund and the Future of Site Cleanups." *Environmental Management*, 16.

The process of site remediation begins with a preliminary assessment to determine the level and extent of contamination. The EPA and its state and tribal partners have performed these assessments at 45,000 sites since the program began.[8] Inspected sites are then assigned a Hazardous Ranking Score, which the EPA uses along with input from local stakeholders to determine whether a site qualifies for listing on the National Priorities List (NPL), a compilation of sites that have been targeted for remediation. In cases where contamination poses an urgent threat to a community, the EPA may issue an immediate removal action, regardless of whether a site is listed on the NPL.[9]

Since Superfund was established, 1,500 sites have been added to the NPL. Of these sites, nearly 900 have undergone successful remediation or been referred to another federal agency. The 650 remaining sites are nearly all in the preliminary stages of cleanup.[10] In most cases, the cleanup cost is shouldered by any responsible parties—usually the current owner or operator of a site, the owner or operator at the time of hazardous substance disposal, the party that arranged for

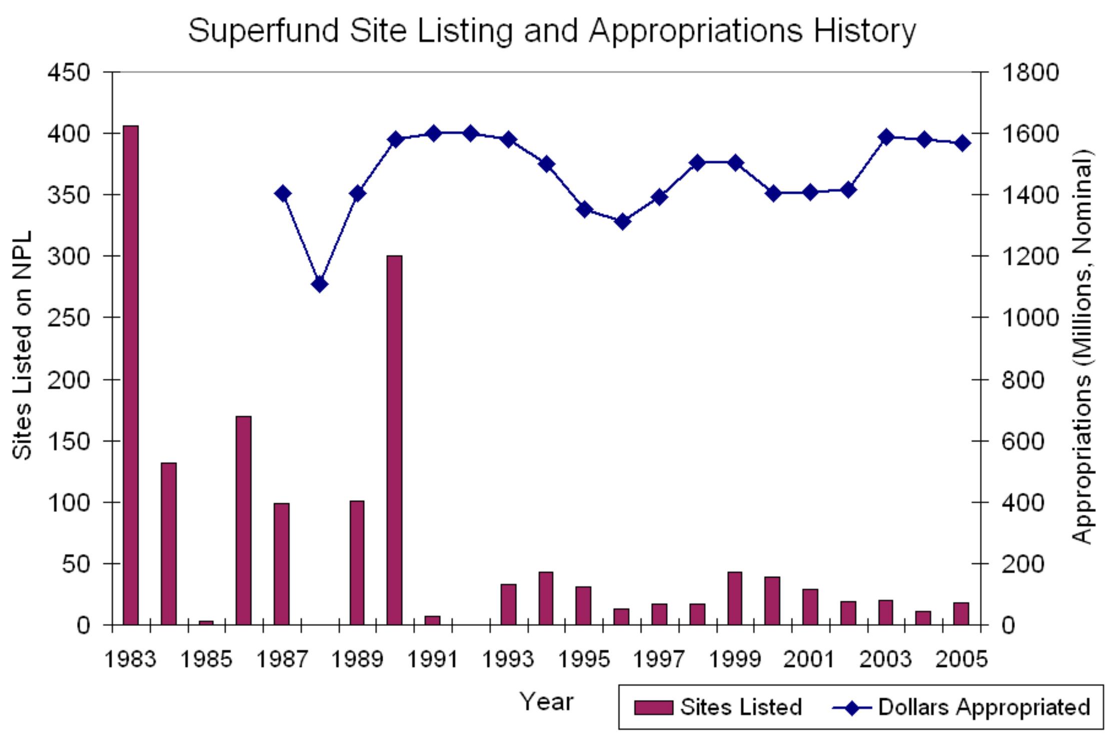

Figure 2: History of Superfund Site Listing and Financial Appropriations[11]

[8] Horinko, 13.

[9] "What is the difference between a removal action and a remedial action?" Superfund: Frequently Asked Questions. U.S. Environmental Protection Agency, www.epa.gov.

[10] *Ibid.*

[11] "Hazardous Waste Programs: Information on Appropriations and Expenditures for Superfund, Brownfields, and Related Programs." GAO-05-746R (Washington, DC: June 30, 2005). Expenditure data unavailable prior to 1987.

hazardous substance disposal, or the party involved in transporting the hazardous substance.[12] The EPA has succeeded in identifying many of the parties responsible for the contaminated sites and in exacting payment for cleanup measures totaling $21 billion.[13] The US government has paid for the remaining 30 percent of site cleanups. Figure 2 shows the historical number of sites listed on the NPL and annual appropriations to the Superfund program by Congress.

Over the lifetime of the program, Superfund has changed in character and scope. During the first two decades, most of the sites added to the NPL were small and owned by nonfederal entities. The EPA initially attempted to engage responsible parties in the early stages of site remediation. However, many responsible parties were unwilling to cooperate and little progress was made. This prompted the agency to change to a "fund first" approach, in which the EPA led the site remediation and collected from the responsible parties later in the process. This approach allowed many sites to be cleaned up quicker. Cooperation from responsible parties grew as the Superfund program became more established.[14]

The largest sites added to the NPL are distinguished as "mega-sites", meaning the EPA expects them to cost more than $50 million to clean. While smaller sites added to the NPL may be quickly cleaned, mega-sites can remain on the list upwards of ten years. Many of the sites currently listed are mega-sites still undergoing remediation. This added burden helps account for the fact that on average, fewer sites are undergoing remediation each year. The creation of other state- and federal-level programs that primarily target the removal of hazardous substances in smaller, less complex sites has reinforced this trend, leaving Superfund with the toughest cases.[15]

I.B The Site Remediation Process

Although the choice and implementation of remedies occur in a highly decentralized fashion, all sites share several milestones during the remediation process. These milestones are visually represented in the flowchart in Figure 3. Once a site is assigned to the NPL, the site is subject to a Remedial Investigation and Feasibility Study (RIFS), which defines the type of contamination and details any human health or environmental threats. It also evaluates potential cleanup alternatives. After completion of the RIFS, the EPA recommends a preferred remediation strategy, and subjects both the RIFS and the recommended remediation strategy to public scrutiny.

The chosen remediation strategy and timetable is outlined in a Record of Decision (ROD). A ROD represents the EPA's official decision document, involving the national or state government, responsible parties, and the neighboring community. The ROD specifies the remedial actions that will be implemented to clean up the site. The process of developing a ROD is overseen by the EPA project manager for a particular site, and RODs often differ substantially in their organization, technical depth, and consideration of alternatives.16 According to EPA guidelines, a ROD should be substantiated by technical considerations, cost, deadlines for achieving cleanup goals, and other relevant considerations. Sometimes the decision may be that cleanup is unnecessary because there is no serious threat to human health or the environment. For other sites, several RODs may be issued for different areas of focus, termed "operable units" (OUs).

[12] "How do I know if I am a Potentially Responsible Party (PRP)?" Superfund: Frequently Asked Questions. U.S. Environmental Protection Agency. (Accessed 6 Dec. 2006).
[13] *Ibid.*
[14] Barnett, Harold C. 1993. "Crimes Against the Environment: Superfund Enforcement at Last." *Annals of the American Academy of Political and Social Science* 525, 119.
[15] Horinko, 15.
[16] Ten Case Studies, 1988.

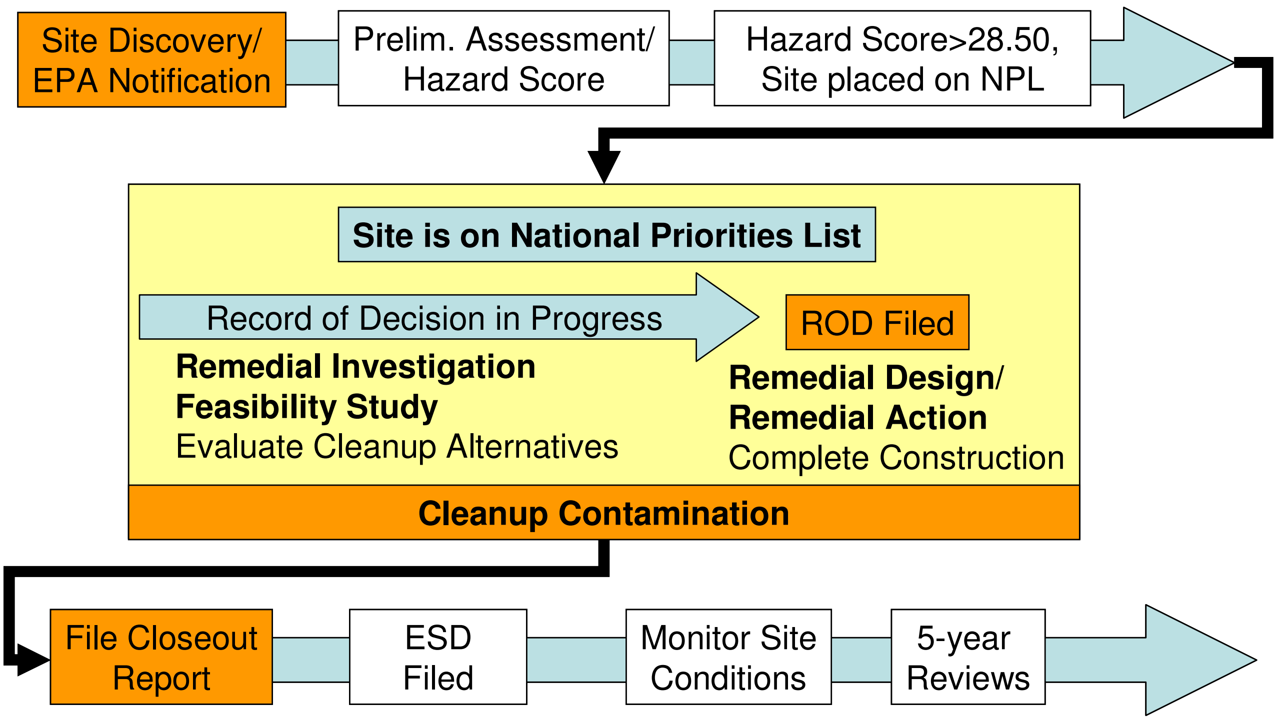

Figure 3: Flowchart of the Typical Site Remediation Process[17]

The ROD is followed by a remedial design (RD) study that determines how to engineer and construct the selected remedies at a site. Finally, the RD involves the technical specification of activities that will carry out the remedial action (RA), which progresses according to a set of remedial action objectives (RAOs). Any challenges that arise in the RD or RA phases may require revisions to the original ROD, which can be made by either an amendment or an Explanation of Significant Differences (ESD). Often, the RA may include provisions for long term monitoring to ensure that the remedial design is still effective. Five Year Reviews (FYRs) are conducted for sites with ongoing remediation or sites where hazardous substances may still pose a threat.[18] Sites are deleted from the NPL once the EPA has determined that a site no longer poses a threat to human health or the environment. The EPA expects that this determination will be based on technical evidence that contaminant levels have been reduced to acceptable levels.

[17] Created with information from U.S. Environmental Protection Agency. 2006. "NPL Site Listing Process."
[18] "Five Year Review Process in the Superfund Program." 2003. Summary of the U.S. Environmental Protection Agency Comprehensive Five-Year Review Guidance (EPA 540-R-01-007). Environmental Protection Agency, 1.

II. Methodology

II.A Superfund Remedy Selection and Implementation in Historical Perspective

Performance evaluation of the Superfund Program is essential for achieving optimal impact in reducing threats to human health and the environment. However, during the early years of the Superfund Program, the question of how to evaluate the soundness and effectiveness of chosen remedies fell secondary to addressing the most serious and immediate crises. Initially, it was expected that the Superfund program would last only long enough to clean up the major known sites—perhaps five to ten years. As a result, policymakers did not develop methods for monitoring and evaluating cleanup performance.[19] Only after the number of known and potential Superfund sites had expanded considerably did the program's directors seriously consider advocating for the expansion of its institutional role.

Since the program's inception, the processes of selecting a cleanup remedy and monitoring its implementation have been determined in a largely decentralized, site-specific manner. The rationale for this decentralized process is that sites differ widely in the extent and nature of contamination, and therefore remedies or narrow documentation requirements at the national level may ignore important site-specific factors. As a result, there is no single framework for tracking progress towards cleanup objectives.[20] Originally, remedy selection and implementation benchmarks were to be based on existing standards or criteria for particular chemicals involved, but there is no single, comprehensive list of standards that covers damages at all sites. In practice, remedies and documentation procedures are determined in a highly site dependent manner.[21]

Although remedies are selected on a site-by-site basis, the EPA specifies that relevant statutory requirements derived from CERCLA and SARA should guide the choice of remedial action at all Superfund sites. These statutory requirements include threshold criteria, which must be met for a remedy to be selected; balancing criteria, which are used to select among remedies that meet the threshold criteria; and modifying criteria, which are fully considered after a remedy has been proposed. These criteria are:[22]

Threshold criteria:

- Protect human health and the environment
- Meet Applicable or Relevant and Appropriate Requirements (ARARs), i.e., all federal and state laws that might apply to achieving cleanups

Balancing criteria:

- Select permanent over non-permanent remedies to reduce the "toxicity, mobility, or volume" of hazardous substances
- Consider both current and future potential health threats
- Find and negotiate with potential responsible parties (PRPs)
- Consider cost-effectiveness, which may favor early cleanup before contamination spreads

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[19] "Superfund Strategy." Washington, DC: U.S. Congress, Office of Technology Assessment OTA-ITE-252, April 1985, 7.
[20] *Ibid.*, 17.
[21] *Ibid.*, 18.
[22] "EPA Superfund Actions and ATSDR Public Health Data." Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-BP-ENV-156, July 1995, 2-3.

- Give strong consideration to each of these factors for a specific site as summarized in the ROD

Modifying criteria:

- Consider State concerns and priorities (in some cases concurrence is required)
- Consider community concerns

II.B Prior Work

A limited number of studies over the past two decades have investigated the extent to which these statutory requirements informed remedy selection and implementation. Many of these studies were performed by the Office of Technology Assessment (OTA), a congressional office appointed to provide input on policy issues with a significant science or technology component. Prior to its elimination in 1995, the OTA completed a number of reviews of the Superfund program. Several of the studies conducted in the 1980s evaluated the extent to which the chosen courses of remedial action incorporated the EPA's statutory requirements.

These studies presented several major critiques. In a report describing ten case studies of Superfund sites located nationwide, the reviewers often found that technical evidence was insufficient to support a particular remedy selection.[23] For example, the RODs often failed to weigh evidence of prior experience with a technology against other factors such as cost, community preferences, or potential effectiveness.[24] In a few cases, this omission led to the failure of a particular remedy before the completion of construction, incurring high costs and bad publicity.

The same report also pointed out that, contrary to EPA statutory requirements, impermanent remedies were often selected over permanent ones. This conclusion echoes an earlier study that found that conventional treatment technologies that would permanently reduce contamination remain underutilized.[25] The study identified several reasons why an impermanent remedy had been selected over a permanent one. First, a community may be eager to reduce any human health hazards as quickly as possible, an interest better served by moving contaminated materials elsewhere without permanently treating them. Second, an impermanent solution may be chosen primarily based on cost. However, while many impermanent solutions may cost less in the short run, in the long run they may incur unforeseen costs far higher compared to permanent solutions due to the need for additional remediation. Cost modeling conducted by the OTA showed that this "impermanence factor," which corresponds to the additional cost of choosing an impermanent solution, was considerable and if recognized, could heavily favor the selection of permanent remedies.[26] In reality, however, technology decisions are often based on short-run cost estimates.

A final problem identified was in the definition of cleanup targets in the RODs themselves. Remedial Action Objectives often incorporated the EPA statutory requirements into broadly defined aims for cleanup, such as the restoration of the site for commercial use, but did not specify what level of residual contamination would be acceptable to support it (or at least did not make these targets obvious). The lack of clear targets complicated later evaluation of a selected remedy's

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[23] "The Role of Cost in the Superfund Remedy Selection Process." 1996. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. 540/F-96/018.
[24] *Ibid*, 3.
[25] *Ibid.*, 1 / Superfund Strategy, 18.
[26] Superfund Strategy, 13.

performance, and failed to send clear signals to technology developers about emerging needs upon which they could focus their research and development efforts.[27] Although not mentioned specifically in any of the OTA evaluations (which were written before most of the initial Superfund projects had been completed), several experts and studies conducted by the Resources for the Future (RFF) drew our attention to the fact that site close-out reports and Five Year Reviews showed patterns of poor or superficially documented verification that cleanup objectives had been met according to initial ROD specifications.[28]

II.C Rationale for Our Study

Our report re-opens and expands on earlier inquiries by OTA, NRC, Resources for the Future and others to investigate the soundness of current procedures used at three Superfund sites 1) for selecting an appropriate cleanup remedy, and 2) monitoring the implementation of a remediation strategy. While the OTA reports provide insight on the first point, they had little to say about the second, given that remedy implementation was in process at only a few sites when the earlier OTA studies were undertaken. A 2001 study by Resources for the Future discusses in greater depth the weaknesses in follow-up documentation such as Five-Year Reviews.

The distinguishing feature of our report is that it goes beyond identification of problems in remedy selection to examine why these problems occur in the first place, and makes recommendations to address these underlying causes. Our hypothesis is that some of these problems may result from tradeoffs implicit in the goals of various stakeholders (of which the EPA is one). These tradeoffs may explain any failure to meet certain EPA requirements, such as the selection of a permanent cleanup remedy.

Our report also highlights that problems with information management during cleanup implementation may reflect underlying effects of document preparation by different parties, and perhaps most importantly, the absence of standardized reporting procedures for all Superfund sites. We apply several tools from the emerging engineering systems field that enable us to examine a potential method for classifying cleanup objectives more systematically and more clearly documenting any problems that may occur in the implementation process.

Today, just over 25 years since Superfund was founded, a wealth of completed cases offers us the opportunity to make a rich—if preliminary—appraisal of the "real" problems that underlie the remedy selection and implementation process in the Superfund Program. Our analysis aims to provide a theoretical basis for assessing these problems, and incorporating these new insights in ways that would improve the Superfund program. These lessons could be applied in other similar programs, such as programs for "brownfields" rehabilitation or other environmental cleanup efforts.

II.D Focus of Our Study

Our findings and analysis are divided into two broad sections, one that concerns remedy selection and the other that addresses the process of implementing the chosen remedy. First, our analysis will consider the final remedy selection for cleanup, paying particular attention to how the final choice was evaluated relative to other alternatives as described in the Remedial Investigation and Feasibility Study (RIFS). For each site, we will note the role that cost, permanence, time,

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[27] Ten Case Studies, 3.

[28] Probst, Katherine N. and Diane Sherman. "Success for Superfund: A New Approach for Keeping Score." Washington, DC: Resources for the Future, 2004.

technological risk, and potential to reduce contamination play in final selection. We then determine the extent to which site performance on these metrics reflects the goals of the three major stakeholder groups—communities, the EPA, and the potentially responsible parties. This comparative analysis will enable us to identify how potential trade-offs among stakeholder goals may have constrained remedy selection at the individual sites.

Second, we will evaluate current methods for monitoring the implementation of a Superfund site cleanup strategy, with a focus on the process of documenting milestones and problems that arise in the course of the cleanup process. For each site, we will ask whether cleanup targets were explicitly identified in the ROD, and if goal statements for achieving those targets were clearly defined. We will then ask how the authors of the ROD anticipated progress toward cleanup objectives would be measured, and look for evidence that confirms whether or not the monitoring actually took place. We will further identify any problems that arose in the course of cleanup and track them in subsequent documentation to assess whether or not they were effectively addressed. We will also compare the documentation methods to an established information management technique from the engineering systems field that has been developed for the purpose of improving project documentation and, as a result, performance. Finally, we examine whether or not such a method might help to improve cleanup implementation in the Superfund program, and what these changes would look like in practice.

II.E Site Selection

We decided to focus our inquiry on three Superfund sites, all of which had proceeded at least through the construction complete phase for the remedies we focused on. The sites were chosen on the basis of diversity in ownership type and size. To ensure that we would have access to the full range of relevant information, we selected sites located in Middlesex County, Massachusetts (all within EPA Region 1). One site, Wells G&H in Woburn, Massachusetts covers a large land area, and several privately owned manufacturing plants were held responsible for cleanup. Another site, the Materials Technology Laboratory (MTL), covers a small stretch of land along the Charles River in Watertown, MA. The U.S. Army was deemed the source of contamination, and the federal government was held responsible for carrying out the site cleanup. The Charles-George Reclamation Trust Landfill is located in Tyngsborough, MA and the Superfund program funded its cleanup. The following sections provide descriptions of site remediation at all three sites, followed by an analysis that parallels the outline of inquiry detailed above.

III. Site Assessments

III.A Materials Technology Laboratory

Figure 4: Satellite Map of Army MTL Superfund Site, Divided into Three Operable Units[29]

Location and Background

The Materials Technology Laboratory (MTL), located five miles west of Boston, occupies approximately 47 acres. The facility was established during the early 1800s and was used for arms manufacturing and research activities until it was deactivated in 1970. The US Army initiated investigations into site contamination in 1987. The site is divided into three operable units (see map). Our study focuses on the largest two units, OU1 and OU2. OU1 consists of most of the soil and underlying groundwater, with the exception of a small area northeast of the former building 131 which was designated as OU3. OU1 was divided into five unit areas: Zones 1 through 4 and the 11-acre River Park. OU2 consists of the two-mile-long stretch of the Charles River adjacent to the Army's MTL in Watertown, MA.

Nature of Contamination

Soil investigation in OU1 revealed concentrations of various research waste; volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), polyclorinated biphenyls (PCBs), metal concentrations (primarily lead); and pesticides in surface soil samples. The only significant risk to humans posed by OU1 was through soil, either through incidental ingestion, inhalation, and skin contact.[30] OU2 contained some industrial contaminants in riverbed sediment.

Remedial Action Objectives

The remedial action objective identified for OU1 was to "mitigate the risks to human health and the environment posed by direct contact with and incidental ingestion of contaminated soil."[31] Because the Remedial Investigation could not link contaminants in the riverbed to the MTL site, the EPA and US Army decided that no remedial action was necessary at the Charles River OU2. No further steps were taken for OU2 because no remedial action objectives were formed.

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[29] Satellite photo: ©Google– Imagery ©MassGIS, Commonwealth of Massachusetts EOEA, Sanborn, DigitalGlobe, Map Data ©2006 NAVTEQ™

[30] U.S. Environmental Protection Agency. *Record of Decision: Materials Technology Laboratory (OU 1)*. Watertown, MA. 26 Sept. 1996. 12-14.

[31] *Ibid*, 24.

Remedy Selection

Record of Decision

Site managers considered six remedial alternatives. The chosen remedy was to excavate contaminated soil and transport it off-site to a landfill. The site would then be back-filled with clean soil.[32]

The ROD states that the selected action did not satisfy the statutory preference for alternatives that "permanently and significantly reduce the volume, toxicity, or mobility of the hazardous substances." However, this alternative was selected despite this statute because "there were not other equally cost-effective and easily implemented alternatives that could achieve maximum extent of overall protection of human health and environment."[33] In-situ volatilization, which would have better satisfied the permanence requirement, was also evaluated as an alternative. However, the community expressed a strong preference for the chosen option, because it could be implemented 12 to 18 months sooner than in-situ volatilization.[34]

Remedy Implementation

Explanation of Significant Differences

Two ESDs were implemented for OU1 to provide appropriate protection for construction and utility workers. After initiating remedial action, the EPA realized that the soil risk assessment in non-residential zones did not allow for safe exposure of workers to soils more than one-foot below ground surface.[35] Because sub-surface utility maintenance would be required at this depth, a new risk assessment was performed. It was determined that additional excavation and disposal of soil at these depths would be required to ensure worker safety. The first ESD, written in January 1998, implemented these cleanup goals for Zones 1, 2 and 3 (which was sold in December 1998 to Charles River Business Center Associates). The second ESD, written in June, 2001, implemented these cleanup goals for the Charles River Park Area.[36]

Site closeout document

The final close-out document confirms that clean-up goals were achieved and more explicitly details the protocol for long-term monitoring of the site. The document states that confirmation sampling revealed that remedial objectives for soil cleanup were met, and that no long-term soil monitoring is planned. The Massachusetts Department of Environmental Protection (MDEP) was given a Grant of Environmental Restriction and Easement as the legal mechanism for overseeing the implementation of institutional controls. In addition, an Institutional Controls Memorandum of Agreement (IC MOA) required annual inspections of institutional controls and provided a checklist for the inspector to follow. Statutory Five Year Reviews were to be conducted, as hazardous materials in excess of levels allowing for unlimited use and unrestricted exposure would remain on the site.[37]

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[32] *Ibid*, 24.
[33] *Ibid*, 40.
[34] *Ibid*, 143-144.
[35] U.S. Environmental Protection Agency. *Explanation of Significant Differences: Materials Technology Laboratory (OU 1)*. Patricia L. Meaney. Watertown, MA. 7 June 2001, 4.
[36] U.S. Environmental Protection Agency. *Final Closeout Report: Materials Technology Laboratory*. Watertown, MA. 29 Sept. 2005. 6.
[37] *Ibid*, 14, 15.

Five Year Reviews

The first Five Year Review (FYR), conducted in January 2002, stated that "OU1, with the exception of Area E, has been determined to be protective of human health and the environment."[38] Soil samples from Area E showed benzo(a)pyrene concentrations in excess of ROD cleanup goals in the top three inches of soil. Charles River Business Center Associates (CRBCA), the owners and developers of that land, were held responsible for excavating and disposing of the contaminated soil. In a follow-up to the FYR, the EPA addressed a letter to the Army stating that CRBCA had not yet informed MDEP in writing that this process had been completed. The EPA requested that the Army submit this documentation once it had been received. No such documentation or notification of its receipt appears in the review.

The second FYR for OU1 was conducted in March 2006. The remedies were again deemed to be protective of human health and the environment.[39] However, some concern was expressed that erosion was occurring along the Charles River Bank, which could allow contaminated soil to be released into the river. Bank stabilization was deemed necessary to ensure "long-term protectiveness" of the site.

III.B Wells G&H Operational Unit 1 (OU1)

Location and Background

Wells G & H were two municipal wells developed in 1964 and 1967 as additions to the water supply of Woburn, MA. Woburn is a small industrial city of approximately 36,000 people located approximately 15 miles from Boston. The Aberjona River flows through the site and partially supplies the aquifer from which Wells G & H drew water. Ground water from the areas surrounding the wells also replenished this aquifer. Wells G & H supplied almost 30 percent of the city's water supply. After several drums of industrial waste were found near the wells in 1979, the wells were tested and found to be contaminated, and as a result, both wells were shut down. The EPA designated Wells G & H a Superfund site in September of 1983.

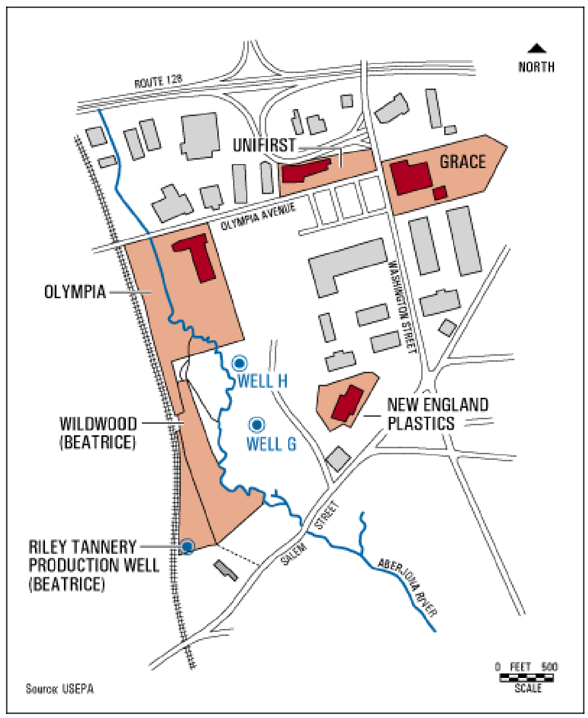

Figure 5: Map of Wells G&H Site
Source: Beyond A Civil Action, 1999.

The Wells G&H site is a mixed-use area that includes residential, commercial, and light industrial zones. The EPA found that five properties were the source of contamination at the site. The EPA identified five companies responsible for the contamination at the site: Beatrice Foods, Grace Company, New England Plastics, Olympia, and Unifirst. Figure 5 shows a map of the site with the

[38] U.S. Environmental Protection Agency. *Five-Year Review Report*. Patricia L. Meaney. Watertown, MA. 7 Mar. 2002.
[39] U.S. Environmental Protection Agency. *Second Five-Year Review Report*. Thomas E. Lederle. Watertown, MA. 2 Mar. 2006.

location of the industrial properties relative to the two wells.[40]

During the Feasibility Study, the EPA determined that the site would be addressed as three operable units: OU1 included the five source areas of contamination surrounding the wells, OU2 included the Central Area containing the wells and the Aberjona River, and OU3 included the Aberjona River Sediments. Our investigation focuses on OU1.

Nature of Contamination

Contamination from industrial waste impacted water, soil, and sludge. The groundwater was contaminated with VOCs, the Aberjona River was contaminated with PAHs and heavy metals, and the soil was contaminated with PAHs, PCBs, VOCs, and pesticides.[41]

The greatest potential risks identified at the site were attributed to future ingestion of contaminated groundwater, the inhalation of volatiles while showering, and exposure to surface soils through dermal contact and incidental ingestion. Other potential exposures included the inhalation of dust generated by site activities, the inhalation of volatiles released from the groundwater during industrial processes, and exposure to surface water and sediments from the Aberjona River through ingestion, inhalation, or skin contact.[42]

Remedial Action Objectives

The overall response objective for the site was to restore the entire aquifer to drinking water standards. In particular, the ROD aimed to limit both groundwater and soil contamination according to the seven RAOs listed below.

Soil Contamination:

- Prevent public contact with contaminated soil above the cleanup levels
- Stop the leaching of soil contaminants to the ground water
- Protect the natural resource at that site from further degradation

Groundwater Contamination:

- Prevent the further introduction of contaminated ground water from the source areas to the central area
- Limit the further migration of contaminated ground water off-site from the source areas
- Restore the bedrock and overburden aquifers in the vicinity of the source areas to drinking water quality
- Prevent public contact with contaminated groundwater above cleanup levels[43]

Remedy Selection

Record of Decision

Site managers considered eight remedial alternatives for soil treatment and four alternatives for water treatment. The chosen remedy was to treat the majority of the soil with in-situ volatilization, and treat the remaining soil with on-site incineration. The soil would be backfilled on site. The

[40] "Map of Woburn Wells G & H Area." Beyond a Civil Action, www.civil-action.com.
[41] " Wells G & H." Waste Site Cleanup and Reuse in New England. U.S. Environmental Projection Agency.
[42] *Ibid*, 10-11.
[43] *Ibid,* 29-30.

groundwater from the five source areas would be treated at individual treatment plants using air stripping or ultraviolet/chemical oxidation methods.

While there was a potential for short term public health threats to workers and area residents during excavation, incineration, and in-situ volatilization, the ROD stated that the risks would be minimized by the use of adequate preventive measures. In-situ volatilization was chosen because it had been successfully used at a number of Superfund sites for VOC removal, and incineration technologies had been demonstrated to be reliable. However, these technologies were not without risk, and pilot scale testing would be required for in-situ volatilization for full-scale design and optimization.

The EPA estimated the design, bidding, construction, and operation of the soil treatment remedy to take four years. It estimated the design, bidding, construction, and operation of the groundwater treatment remedy to take 22 years for the central areas near the actual wells, and 20-50 years for the source areas.

Remedy Implementation

Explanation of Significant Differences

On April 25, 1991 the EPA issued an ESD for OU1.[44] The ESD changed the remediation methods for soils on the Wildwood, New England Plastics, and Olympia properties. On-site incineration was changed to off-site incineration, nothing that off-site incineration was considered an "equally effective and protective of human health and the environment as on-site incineration" although it is more costly.[45] According to the ESD, many of the responsible parties felt that on-site incineration would require more coordination, making off-site incineration more cost-effective for them.

The remediation method of the UniFirst property was changed from incineration to in-situ volatilization because vapors from groundwater were re-contaminating the soil such that repeated incinerations would be required to achieve cleanup. According to the ESD, repeated incineration of soils would be more costly than originally estimated by EPA in the ROD. In-situ volatilization was the chosen alternative because the apparatus could remain on-site and be operated as necessary.[46]

Five Year Reviews

The Five Year Review was conducted on August 4, 1999 because cleanup had not yet been completed. The remediation of groundwater at W.R. Grace and UniFirst began on September 30, 1992, and the review claimed that the groundwater recovery systems had been operating for 5 years. According to the review, at the UniFirst property only, "low level VOC-contamination remains present in the soil…beneath the building and paved parking lot."[47] Most of the contaminated soil at the Wildwood Property had been removed, and only low level VOCs remained. Also, most of the contaminated soil and the groundwater at the New England Property had been removed, and only low level VOCs remained. Treatment systems had started for all sites, except Olympia. At the time of the review, EPA and Olympia had not reached an agreement

[44] U.S. Environmental Protection Agency. *Explanation of Significant Differences: Wells G&H*. 25 April 1991.
[45] *Ibid*, 3.
[46] *Ibid*, 4.
[47] *Ibid*, 5.

regarding cleanup of the Olympia property. The review stated that a settlement was expected by the summer of 1999.

The second FYR for OU1 was conducted in September 2004. In contrast to the first FYR, this report included a technical assessment that was written following the 2001 protocol for five-year reviews.[48] This review addressed three questions regarding the current effectiveness of the cleanup remedy. These questions included:

> **Question A:** "Is the remedy function as intended by the decision documents?"
> **Question B:** "Are the exposure scenario assumptions, toxicity data, cleanup values and Remedial Action Objectives used at the time of remedy selection still valid?"
> **Question C:** "Has any other information come to light that could call into question the protectiveness of the remedy?"

In answer to Question A, the FYR states that with the addition of some institutional controls, the remedy would function as intended. For Question B, there were no clear answers presented in the FYR. Tables of data with little explanation were used to convey part of the answer to the question. Some unforeseen risks were identified that warranted further investigation. The RAOs were not specifically addressed. For Question C, the FYR states that the OU1 remedy is currently protective, but that conditions were identified that could affect the future protectiveness of the remedy and require further data collection, analysis, or remedial/corrective actions.[49]

III.C Charles George Reclamation Trust Landfill

Location and Background

The decommissioned Charles-George Reclamation Trust Landfill is located 35 km northwest of Boston and just a mile southwest of Tyngsborough, Massachusetts near the border with New Hampshire. It began operation in the late 1950s as a small municipal dump, and later expanded under new ownership to around 55 acres. From 1973 to 1976, the facility was licensed to accept hazardous substances, which included 1,000 pounds of mercury and 2,500 cubic yards of chemical wastes.[50] In the early 1980s, well sampling revealed trace amounts of toxic substances in the groundwater of wells that supply the Cannongate condominiums located nearby. The contaminated wells were shut down in 1982. The State of Massachusetts mandated site closure in

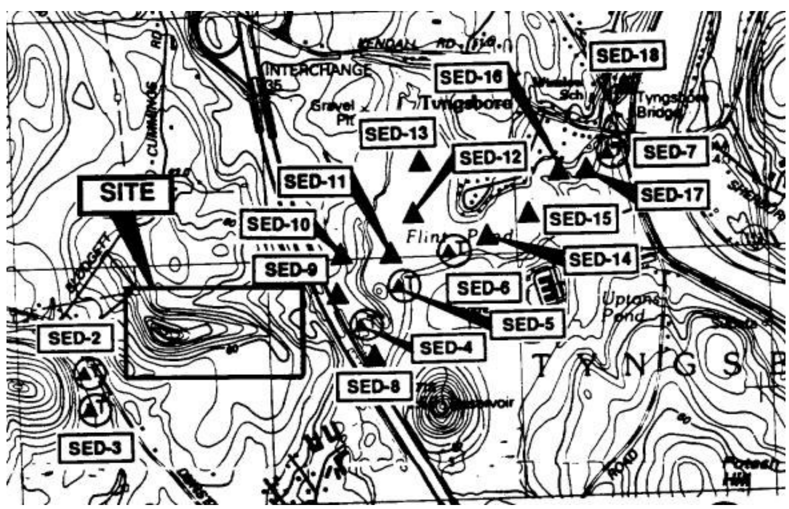

Figure 6: Charles George Sample Sediment Map
Source: Charles George Record of Decision Document

[48] U.S. Environmental Protection Agency, *Second Five-Year Review: Wells G&H*. Sept. 2004.
[49] *Ibid*.
[50] "Charles-George Reclamation Trust Landfill." 2005. Waste Site Cleanup and Reuse in New England, www.epa.gov.

1983, the same year in which the owners filed for bankruptcy and the site was entered into the National Priorities List.[51] Fifty-four potentially responsible parties, including the owners, were named. Due to difficulties in locating many of them and the fact that operators were bankrupt, most of the funds for cleanup were allocated from the Superfund Trust.

The contamination at the Charles George site was first addressed through several initial actions to provide a temporary water supply to the affected residents. In 1983, EPA reserved funds to develop a permanent water supply and contracted the Army Corps of Engineers to extend the water supply of the town of Lowell, Massachusetts to include the affected areas. This action was designated as Operable Unit 1 (OU1); three additional operable units were designated later and included capping the site, controlling contaminant migration, and collecting and discharging leachate and contaminated groundwater to a publicly owned treatment works. There were a total of three RODs for the site, the first for OU1, the second for OU2, and the third for OU3 and OU4. Unlike our other sites, the operable units at Charles George corresponded to the phases of remediation rather than geographically distinct areas. Our analysis considers only OU2, the control of the source of contamination in the landfill, as it provides an ample, but not overly complex, case for examining the prioritization of various goals in the selection of a remedial strategy and the effectiveness of implementation.

Nature of Contamination

Pollutants found at the site had contaminated groundwater, soils, and a nearby brook, marsh, and lake, threatening human health and affecting the ecological balance of natural lands in the area. Groundwater contaminants included benzene, tetrahydrofuran, arsenic, 1,4-dioxane, and 2-butanone, among others, while sediments were found to contain low levels of benzo(a)pyrene, which is known to cause immune suppression, developmental defects, and cancer.[52]

Remedial Action Objectives

This analysis will focus only on ROD2 (for OU2 only). No "Remedial Action Objectives" were explicitly specified.

Remedy Selection

The remedy selected included the following:[53]

- A full synthetic membrane cap
- Surface water diversion and collection system
- Vent network with off-gas collection system venting to the atmosphere
- Full peripheral leachate collection system
- Operation and maintenance requirements
- Annual mowing and maintenance of the vegetated surface
- Quarterly inspection of the pump station, leachate collection and disposal, and the cap surface

Language in the ROD suggested this option would provide a permanent remedy.[54] However, it was noted that the remedy would continue to require routine maintenance and did not remove or

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[51] *Ibid.*
[52] "Consumer Fact Sheet: Benzo(a)pyrene," 2006. U.S. Environmental Protection Agency.
[53] U.S. Environmental Protection Agency, *Record of Decision (OU2): Charles George Reclamation Trust Landfill.*

significantly reduce the total amount of contaminants. Later, the Five Year Reviews mention that if needed, a additional follow up feasibility study would be conducted to explore further remedial action if this option proved ineffective, recognizing that a cap is *de facto* a non-permanent solution.[55]

Remedy Implementation

Explanation of Significant Differences

One ESD was issued for the Charles George site, but only applied to the third ROD for OU3 and OU4. Therefore, we do not consider it here.

Five Year Reviews

The first Five Year Review, prepared by the company Metcalf and Eddy in 1995, considered the effectiveness of the cap remedy, among other aspects of the overall cleanup strategy. An inspection of the cap in the first FYR revealed signs of subsidence and significant gully erosion. Erosion was particularly evident in areas where vegetation was not yet well established, but was not extensive or cited as cause for alarm. Drainage channels and basins were generally in good repair. However, a few of the basins needed preventive maintenance. One area of the site exhibited potential leachate breakout.[56]

The first FYR also explicitly recalled the objectives of the RODS and looked at effectiveness of implementation, but this documentation was relatively brief. Some of the problems mentioned in earlier chapters were reiterated, and greater emphasis was placed on the numerous problems that had occurred with the leachate pumping system, which was a temporary solution included as part of the cap construction.[57] The leachate pumping system was later replaced with another temporary solution, and then later upgraded under the provisions of ROD 3.

The second FYR, also prepared by Metcalf and Eddy in 2000, had findings very similar to the first FYR, except that all findings were summarized more briefly. Two additional sections assessed compliance with ROD 2; these sections called for annual maintenance of the vegetated surface of the cap and quarterly maintenance of the leachate control system.[58] Although the FYR stated that quarterly maintenance was conducted frequently and rigorously, there was no explicit link to evidence that maintenance had taken place. In the previous FYR, this information had been contained in a separate chapter.

The third FYR, prepared by the EPA in 2005, cited problems that had occurred with the leachate management system in the past as documented in the first FYR.[59] The problem description was followed by a one-sentence statement that the problems were addressed through redesign of the leachate and groundwater collection and pumping system. The review also indicated that monitoring measures had been effective, and cited several figures and tables found elsewhere in the report to back up the assertion.

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[54] Ibid, 24.
[55] Metcalf and Eddy. Aug. 1995. *Charles George Reclamation Trust Landfill: Final Report Five Year Review*. 48.
[56] *Ibid.*
[57] Metcalf and Eddy. Mar. 2000. *Charles George Reclamation Trust Landfill: Final Second Five Year Review*. 29.
[58] Metcalf and Eddy 2000. 29-30.
[59] U.S. Environmental Protection Agency. June 2005. *Charles George Reclamation Trust Landfill: Third Five Year Review Report*. 4-1.

IV. Analysis: Remedy Selection

IV.A Site Findings

There were several notable trends evident in the remedy selection process at the sites studied in this report. First, across sites, cost seemed to be the most important factor in choosing a remedy. Site managers at all of the sites selected remedies that had low costs of design, implementation and maintenance relative to the alternative treatments considered.

Second, all three sites claimed to have selected a permanent remedy, but did not explicitly justify why these remedies were permanent. The only site where a truly permanent treatment technology was chosen was the Wells G&H site. The MTL site chose to excavate the contaminated soil and to transport it off-site to a hazardous waste landfill. This remedy was arguably non-permanent because the contamination in question was not destroyed; it was moved to another location that could potentially become another Superfund site in the future. At the Charles George site, the remedy chosen was a permeable membrane cap. This involved covering the hazardous landfill site with a synthetic cap, which prevents human or ecological contact with the contaminants. This solution was also arguably non-permanent because the contaminants were left on-site. The contaminants could become a problem in the future if the synthetic cap were to leak or crack. Since the landfill was established fairly recently, many of the containers holding the contaminants may yet erode further, and therefore the potential future effects may have been underestimated.

Based on the usage of the word “permanence” in the expert community, we define permanence as “a remedy that uses a treatment technology to destroy contaminants.” Using this definition, only one of our three sites chose a permanent remedy. Our findings across sites are consistent with the prior OTA study, which also asserted that non-permanent remedies were frequently selected over permanent remedies. Our analysis seeks to better understand why this problem is occurring through a detailed analysis of site goals and the interests of stakeholders involved in the remedy selection process. Following this analysis, our committee makes policy recommendations to improve this situation at future Superfund sites.

IV.B Site Analysis

Our study identified five goals that each of the site managers attempted to achieved to some degree. These goals included:

1) Minimizing the cost of the remedy,
2) Minimizing the time necessary to implement the remedy,
3) Minimizing the risk that the remedy would fail,
4) Minimizing residual contamination at the site, and
5) Maximizing the permanence of the remedy.

These goals are hereafter referred to as *cost, time, risk, contamination* and *permanence.*

Trade-offs existed among these goals at all three sites examined. That is, the fastest or lowest cost remedy was rarely the most permanent remedy or the remedy that most effectively minimized on-site contamination. Likewise, since most permanent treatments tended to be relatively unproven technologies, minimizing the risk of the chosen treatment often excluded permanent remedies from selection. The prioritization of goals, however, was not consistent between sites.

To better understand how the priority of each goal differed across sites, we developed a tool that allows us to visualize these tradeoffs. This tool is essentially a radar plot with the five main goals as the axes. Based on our site analysis and group consensus, we developed a radar plot for each site that depicts the extent to which each goal seemed to be considered in the remedy selection process, using the following scale:

4 – Strongly considered
3 – Moderately considered
2 – Weakly considered
1 – Not considered

We plotted the results for each site as shown below:

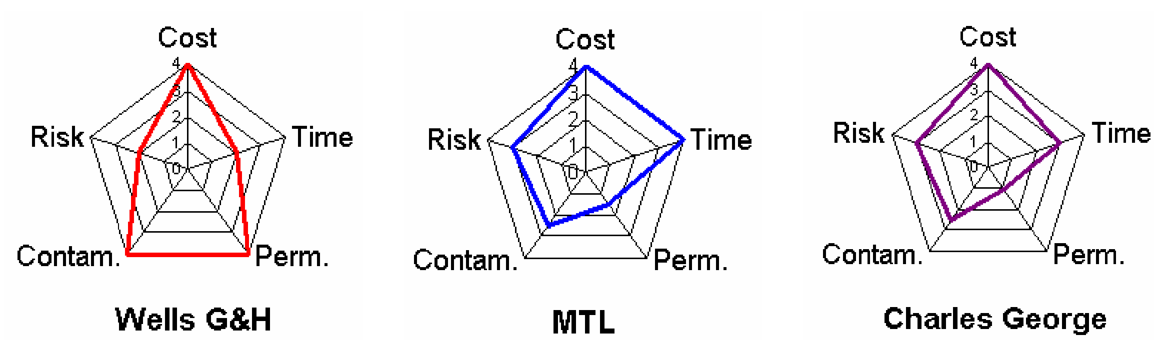

Figure 7: Importance of Goals in Site Remedy Selection

At the Wells G&H site, the selected remedy was in-situ volatilization. This remedy was a treatment technology, meaning that the contaminants in the soil were isolated and permanently destroyed. Selecting a permanent, low-cost remedy was the primary concern at this site. As a result, however, the selected remedy was not low-risk and could not be implemented quickly.

At the MTL site, the selected remedy was excavation and disposal, which we defined as a non-permanent remedy. The site manager also considered a permanent remedy with similar projected costs. However, the non-permanent remedy was chosen because it could be implemented more quickly and posed a smaller risk of failure. Cleanup of the contamination at MTL was compromised for cost reasons; some areas were only cleaned for commercial rather than residential use, despite community requests to have all areas zoned for residential use.

Charles George chose a permeable membrane cap as its remedy, which we also defined as a non-permanent remedy. This remedy was low cost, low risk and could be implemented quickly. It was also compatible with future planned remedies at the site. The Charles George site manager also considered a permanent remedy—excavation and off-site treatment—but this option was ruled out due to cost and safety concerns.

Thus, in two out of the three sites, permanent remedies were not chosen due to strong consideration of cost, risk and time, which tended to be a tradeoff with achieving permanence.

IV.C Stakeholder Analysis

We believe that the influence of stakeholders would help to explain differences in the prioritization of goals at the individual sites. At least three major stakeholders participate in the selection of a remedial action: the EPA, the PRPs (when one or more can be identified), and the surrounding community members. While these stakeholders' preferences were generally consistent across all sites, each stakeholder had a unique prioritization of the five goals mentioned above. To better understand how the stakeholders affected the remedy selection process, we developed radar plots for each stakeholder by considering the emphasis that each tended to place on each of the five goals. Again, we assigned scores through group consensus based on our analysis of the site documents. The radar plots for the stakeholders are shown below, using the same 1-4 scale as above. The rationale for our stakeholder model follows.

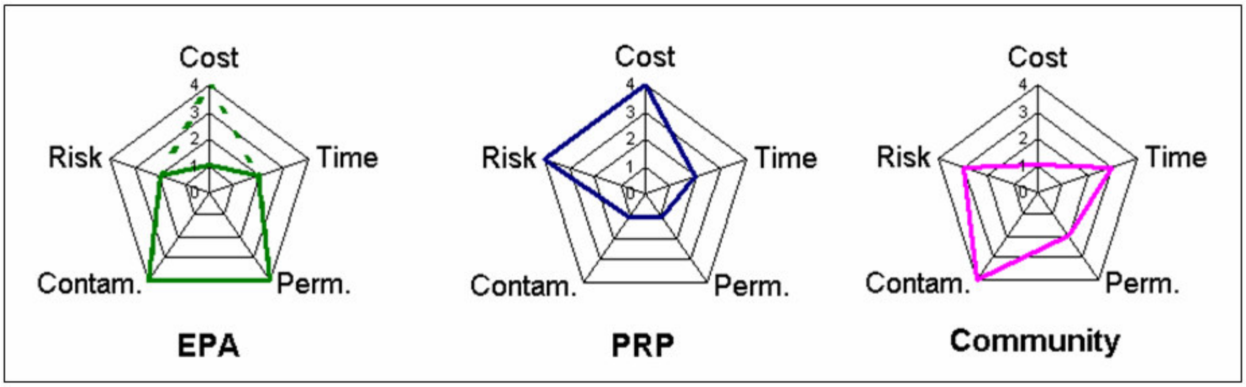

Figure 8: Importance of Remedy Selection Goals to Stakeholders

In our idealized model, the EPA always favors permanence and contamination reduction over all other goals, as stipulated by the CERCLA statutory requirements. If the EPA does not have to pay for the remedial action (i.e. if PRPs are identified and required to pay), cost is not a primary concern. However, if no PRP can be identified and the EPA assumes responsibility for financing the remedial action, cost becomes a high concern. Time is a moderate concern to the extent that it is necessary for the Superfund program to demonstrate efficiency. The EPA also prefers treatments that are low-risk but allows riskier treatments to be selected if they satisfy the goal of permanence.

PRPs strongly prefer to minimize cost, as they are responsible for paying for the remedy. They also prefer a low-risk remedy because if the selected remedy fails, the PRP is still liable for cleaning up the site. PRPs favor remedies that can be implemented quickly, but not at the expense of cost or risk. PRPs are generally not concerned with the reduction of contamination or the permanence of the remedy beyond the minimum extent required.

Community members are primarily concerned that contamination be reduced, given the potential health risks posed by residual contamination. Time and risk are also important factors; the community prefers that the cleanup be done as quickly and thoroughly as possible using proven methods. Permanence is a slight concern to the community given that non-permanent remedies could involve the removal and transport of contaminants, which poses additional risks. Cost is generally not as important to community members.

Comparison of the idealized stakeholder graphs to the three site graphs reveals that the EPA's goal of selecting a permanent remedy was given strong consideration at only one of three sites. The EPA's other main goal of reducing on-site contamination overlapped better with community concerns, and was thus was more explicitly addressed throughout the sites. Our model indicates that at the Wells G&H site, EPA goals, in addition to cost, played the largest part in the decision making process. At the MTL and Charles George sites, our model indicates that the PRPs and the community were substantially more influential than the EPA, resulting in a remedy that favored cost, risk, and time over permanence.

We found that the current CERCLA statute defining and requiring permanence, shown below, is largely responsible for allowing non-permanent remedies to be selected.

> The President shall conduct an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant. In making such assessment, the

Figure 9: CERCLA, Title 42, Ch.103 – I, § 9621, Part b(1)[60]

The policy specifies that permanent remedies should be "permanent," without specifying the scope of this permanence. That is, a remedy could be permanent for the site (as in MTL), by permanently moving the contaminants to another site. Alternatively, a remedy could be permanent in a broader sense (as in Wells G&H) by treating the chemicals so that they are physically destroyed.

IV.D Policy Options

In order to encourage more frequent selection of permanent remedies over non-permanent remedies, we evaluated two different policy options. The first policy option involves making the current CERCLA definition of permanence more explicit, so that permanence in the broader sense must be achieved. The second policy option involves omitting the current requirement for permanence and instead instituting cost incentives to encourage the selection of permanent over non-permanent remedies.

Option 1: Make CERCLA requirement for permanence more explicit

The EPA could ensure more frequent selection of permanent remedies by explicitly defining permanence as a treatment that removes and destroys all contaminants. Redefining permanence in this manner would make it unacceptable for a remedy to do anything short of detoxifying all of the contaminated material at a site, regardless of time, cost or risk considerations. Under this definition, transporting contaminated material to a hazardous landfill (as at MTL), or placing a cap over contaminants (as at Charles George) would not be acceptable remedies. The major problem with the policy, however, is that it is inflexible. Permanent remedies have varying degrees of feasibility across sites. Treatment of some contaminants, such as volatile organic compounds, is fairly routine, but more difficult for other contaminants, such as heavy metals. While separation processes do exist for the more difficult materials, they can be extremely expensive and time-consuming to implement for large volumes of material.[61] This additional challenge reveals why, in many cases, permanent remedies are not chosen to handle these contaminants. Requiring site managers to choose permanent remedies in spite of those concerns would not allow the site manager any discretion regarding whether the cost or time concerns are too exorbitant to warrant

[60] Comprehensive Environmental Response, Compensation, and Liability Act, Title 42, Ch.103 – I, § 9621, Part b(1).

[61] Burroughs, Chris. 10. March 2000. "Sandia scientists study 'natural' alternative to cleaning up uranium-contaminated sites: Natural attenuation may replace costly traditional remediation techniques." *Sandia National Lab News*. 52.

the environmental benefit. In some cases, it may be necessary to choose a non-permanent remedy to ensure that more sites can be cleaned up within a reasonable timeframe.

Option 2: Change CERCLA statute to omit requirement for permanence, and instead institute cost incentives to encourage the selection of permanent technologies.

The current requirement for permanence is so ambiguous that site managers can currently choose remedies based on the goals of cost, time, risk and contamination, and then claim that the chosen remedy is permanent. Thus, removing the current requirement for permanence would arguably have little effect on the extent to which permanent remedies are selected. Rather, removing this requirement could be beneficial in that site managers would not feel compelled to misrepresent non-permanent remedies as permanent. Site managers could instead depict the limitations of the chosen remedy more honestly, which would provide information about the shortcomings of the selected remedy to the EPA and the community.

One potential disadvantage to this approach is that omitting permanence as a requirement could encourage the selection of non-permanent remedies over permanent remedies in some instances. At Wells G&H, for example, it is unclear whether the CERCLA requirement for permanence was the reason the site manager considered only permanent remedy options during the remedy selection process. A permanent remedy was probably chosen at Wells G&H for technical reasons; permanent remedies existed for that particular site that were cost-effective and did not pose serious risk concerns or time lags.

In place of the current permanence requirement, cost incentives could be instituted that would encourage the selection of permanent treatments. Site managers most frequently select remedies on the basis of cost-effectiveness, so if the cost of permanent remedies decreased, project managers might choose them more often. Over time, more frequent use of these technologies would reduce the tradeoffs between permanence and cost, time, and risk. Increased demand would lead to R&D that would allow these technologies to be manufactured more cheaply, and at higher levels of performance. Site managers would have fewer concerns about the risk associated with a treatment technology after it has been field tested and proven at a number of sites.

One question regarding this type of cost-incentives program is how costly it would be for the EPA to establish. The determination of how large of a cost-incentive might be appropriate is outside the scope of this report. However, a relatively small cost incentive could inspire the choice of a permanent remedy at a site in which the cost difference between the two is relatively small. Such was the case at the MTL site, and the existence of such an incentive would have given the site manager good reason to choose the permanent treatment remedy over the non-permanent remedy. Providing cost incentives would therefore ensure that permanent remedies are chosen at the sites where they are relatively easy to implement. At sites where permanent remedies are extremely costly or risky to implement, site managers would still have the flexibility to choose a non-permanent remedy.

IV.E Recommendations

In conclusion, our study makes the following recommendations for the remedy selection process.

> **Recommendation #1**: Omit the current requirement for permanence from Superfund site remedy selection criteria.

Recommendation #2: Create incentives to encourage the selection of permanent treatment technologies

Recommendation #1 would eliminate the current need to misrepresent non-permanent remedies as permanent. Recommendation #2 would encourage more frequent selection of permanent treatment at the sites where it is reasonable to do so.

V. Analysis: Remedy Implementation

V.A Site Findings

After the ROD is published, the cleanup process enters the implementation phase. The progress during the implementation phase is documented in the Explanation of Significant Differences (ESD), Five Year Reviews (FYR), and site closeout documents. In examining and comparing the implementation phases of our three sites, we identified several common weaknesses:

1. A complete set of site goals—containing the remedial objectives, remedial actions, and target contamination levels—is not clearly articulated in any of the site documents. The information is partially summarized in the Summary Declaration of the ROD, but the remaining information is scattered throughout the many other reports.

2. Progress towards achieving the goals and objectives of the ROD is not conveyed in any sort of graphical format in the ESD, FYR, or closeout documents. Instead, progress is described through pages of text and often with accompanying tables of data. It is difficult to easily identify the original contamination levels, the target cleanup levels, and the progress made towards achieving those targets.

For example, the Wells G&H Five Year Review simply provided a summary of site progress, but lacked specific references to the follow-up measures outlined in the ROD for gauging site safety and progress. The progress towards achieving the specific RAOs was not addressed in the original FYR. However, in response to a study carried out by Resources for the Future in 2001,[62] an addendum was added to address whether and how the original RAOs were still valid. Both the FYR and the addendum neglected to answer whether the selected remedial actions were still appropriate to achieve the goals of the RAOs.

At Charles George, a similar pattern was noted, particularly in the FYRs. Information about progress toward site goals was scattered throughout the documentation, and tables showing progress toward achievement of the goals was difficult to interpret without specialized technical training.

3. During the implementation of the remedial actions, unforeseen problems sometimes occur which can delay the schedule, inflate the cost, or require a different remedial action to be selected. These problems should be reported in the ESD and FYRs, and changes to the original plan outlined in the ROD should be adequately justified. The status of these problems should also be reported in later FYRs. However, in several instances where problems arose, we observed that changes to the ROD were sometimes not adequately discussed or justified, and problems reported in the ESD or FYR were not mentioned in later FYRs, making it impossible to know if those problems had been satisfactorily resolved.

At the Wells G&H site, the RI/FS and ROD indicated that the remedial action for part of the soil decontamination would be incineration. However, this was changed to in-situ volatilization later in the implementation phase. We noticed an absence of explicit consideration of the advantages and disadvantages of switching the preferred remedy from incineration to in-situ volatilization.

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[62] U.S. Environmental Protection Agency, *Clarification of the August 1999 Five Year Review for the Wells G&H Superfund Site.* 26 December 2001.

There was no reference to the original discussion of options in the RI/FS, where the original decision in favor of incineration was made.

At the MTL site, one of the FYRs indicated that two feet of soil on the riverbank were shown to be eroding in a way that might increase future exposure to the buried chemicals in the soil. However, there seemed to be a low level of attention given to this problem, and a lack of discussion about the long-term efficacy of the chosen remedial action.

V.B Review of Alternate Reporting Styles

Before we were able to make recommendations on how to address the concerns outlined above, we reviewed some other examples of methods for articulating goals, communicating data, and documenting problems. We looked at material from other courses at MIT, literature from the engineering systems in field, and methods used by other government agencies.

One of the best ways we found to articulate complete, consistent goal statements is a method used in Engineering Systems Architecture.[63] This method uses "To / By / Using / While Also" statements to capture the complete set of goals and actions of a system. The "To" part of the statement identifies the primary objective of the goal; the "By" part identifies the solution-neutral process used to achieve the goal; the "Using" part identifies the specific object or process used to achieve the goal; and the "While Also" part identifies quantifiable performance metrics of the system. Additional qualifiers and attributes can be added to the goal statement as necessary. This type of goal statement can fully capture the intent of any system, the context within which the system operates, and specific metrics with which to measure the success of the system in meeting its goals.

Our committee searched for improved methods for communicating numeric data and progress towards reaching contamination targets at each site. In our search, we came across a well-known publication by Edward R. Tufte, entitled "Visual and Statistical Thinking: Displays of Evidence for Making Decisions."[64] In this publication, Tufte presents the data tables that were used to warn NASA managers of problems with the O-rings inside the Space Shuttle Challenger before its impending disaster. He points out how difficult it is for the reader to get the "right" message by looking at a table full of numbers. He then shows that a clever plot of the same data can instantly reveal how dangerous it was to launch the Challenger that day. Tufte's example illustrates that a "picture is worth a thousand words," and that using visual graphs or plots of data is a much better way to convey a particular message than a table of numbers.

Finally, we examined some of the techniques used by other government agencies to track and resolve problems that arise during the course of a program. Some agencies such as NASA and the Department of Defense use Non-Conformance Reports (NCRs) to track problems.[65] Any time a problem arises, an NCR is opened. The NCR documents the problem, identifies the suspected cause of the problem, outlines the steps that must be taken to solve the problem, and details a quantifiable method to confirm the resolution of the problem. Once the problem is solved, the solution is confirmed by the quantifiable tests and the NCR is closed out. In many cases, a

[63] MIT Course ESD.34 System Architecture, Fall 2006, Prof. Ed Crawley.
[64] E. Tufte, *Visual and Statistical Thinking: Displays of Evidence for Making Decisions,* Cheshire, CT: Graphics Press, 1997. 1-31.
[65] "Nonconformance Reporting and Corrective Action." National Aeronautics and Space Administration, satc.gsfc.nasa.gov.

program cannot pass through its next major milestone until all NCRs have been updated or closed out. This ensures that problems that arise are adequately addressed and do not go unresolved.

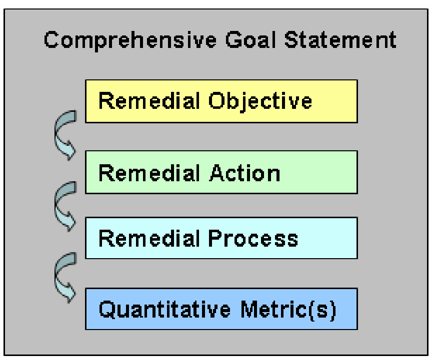
V.C Recommendations

After reviewing the issues above, we arrived at a number of recommendations to improve the implementation stage of the site remediation process. If enacted, these changes would help ensure that both the local site goals and overarching Superfund goals are achieved at each site. Our recommendations are presented below:

> **Recommendation #3:** Use comprehensive goal statements to articulate a complete set of objectives and targets for each site.

These comprehensive goal statements should be referenced in site documents, should contain the following elements, and could be organized as shown below:

(a)



(b)

[To] Objective – states the remedial objective

[By] Action – states the general action chosen to meet the objective

[Using] Process – states the specific remedial process chosen to meet the objective

[To attain] Metric – states the quantifiable targets needed to verify the remedial objective has been met

Figure 10: (a) Structure of Comprehensive Goal Statement, (b) Explanation of Comprehensive Goal Statement

An example of a comprehensive goal statement for soil remediation at the Wells G&H site would be:

GOAL # 1:

To stop the introduction of contaminated groundwater from the source areas to the rest of the aquifer
By treating 7400 cubic yards of contaminated soil from the Wildwood property
Using in-situ volatilization for soil and carbon adsorption for vapors
To attain target soil concentrations of

- 62.5 ug/kg for Chloroform
- 36.7 ug/kg for Tetrachloroethene
- 12.7 ug/kg Trichloroethane

Figure 11: of Comprehensive Goal Statement for Soil Remediation

Each site would have as many goal statements as necessary to completely capture the goals of the site. These goal statements provide a concise way to understand the goals of each site and to track the progress towards these goals. For a given site, these goal statements would appear in the ROD and would be explicitly referenced in each follow-on document (ESD, FYRs, and closeout document). These goal statements should also appear in the introductory summaries of each document, so that the reader can quickly find all the relevant information without having to read the entire document.

Recommendation #4: Use graphical charts instead of tables to measure site cleanup progress.

In many of the RODs and FYRs, progress towards achieving the site target goals is often shown by including tables of data. We believe that using a graphical chart is a better way to convey the relevant information to the reader. Using graphical data representation would enable the reader to make a quick, intuitive assessment of the beginning contamination levels, the target contamination levels, and the progress made towards achieving the target levels. An example of this type of graphic (using fictional data) is shown here:

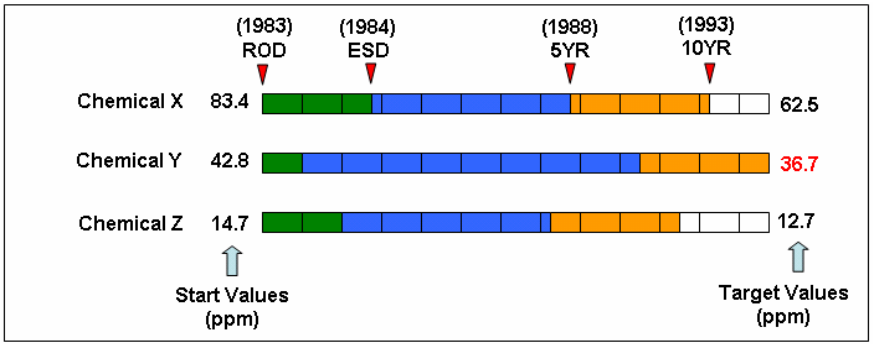


Figure 12: Example of Graphical Representation of Site Progress (Fictional Data)

This type of graphic could be presented with the comprehensive goal statements. Together, they would allow the reader to glance at any of the administrative documents and immediately know the full set of site goals and the progress made towards achieving those goals. These recommendations would add clarity to the individual documents, consistency across all site documents, and transparency throughout the whole site remediation process. The reader should note that this recommendation does not propose replacing any explanatory text contained in the ROD or the supporting documentation. Rather, the goal statements and graphics would supplement and summarize the text of the document.

Recommendation #5: Create a formal system for reporting problems that arise during cleanup to ensure that problems do not go unresolved.

When problems arise during the site remediation process, it is important to document the problem and the steps taken to alleviate the problem. This is necessary in order to have confidence that the site remediation goals were achieved as planned. Such a documentation system is also particularly important for consistency at sites involving multiple parties, or that cover long time spans during which EPA staff are likely to change positions.

We recommend developing a formal documentation system similar to the Non-Conformance Reports mentioned above. Using this type of documentation system would ensure that problems are adequately addressed and do not go unresolved, since site close-out would depend on closing out all unresolved reports.

V.D Implementation Options

Our group identified three possible options for how to implement the above recommendations: "Status Quo," "New EPA Office," and "State Environmental Agencies." Our list of options is by no means comprehensive, but our goal was to present some potentially new ideas and discuss the feasibility of each. These options are discussed below with an analysis of the advantages and disadvantages of each.

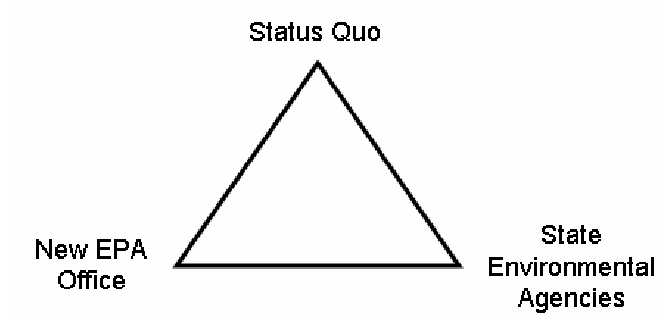


Figure 13: Options for Enforcing Implementation Recommendations

Option 1: "Status Quo": The EPA issues new mandatory guidelines for site managers, PRPs, and third-party contractors for site documentation and progress reporting.

Currently, the Superfund program provides guidelines for how to structure the content of the ROD. However, these guidelines indicate *what* to include but do not show *how* to include the relevant information. Under the "Status Quo" option, the EPA would issue new guidelines to specify the methods and approaches to use for conveying information, such as comprehensive goal statements and graphical bar charts. These guidelines would apply to the ROD, ESD, FYRs, and closeout documents.

This recommendation is similar to a previous recommendation made by Probst and Sherman.[66] Their report recommended using a site Scorecard that is essentially a fill-in-the-blank form containing all the relevant information about each site. Using the form would create standardization between sites, and would also provide a brief, comprehensive summary of the status of each site. Our suggestion for standardizing the goal statements and using graphical charts is complementary to and compatible with the site Scorecard suggestion.

To implement this recommendation, some amount of planning would be required to establish the preferred reporting standards. The EPA could consult with site managers, community groups, and experts in the field to review the proposed new standards. Once the standards are established, site managers, PRPs, and third-party contractors would require training to learn the new requirements and understand how to incorporate them into future site documents.

One benefit to this recommendation is that the proposed changes are internal to the EPA, meaning that no Congressional action would be necessary to authorize the changes. The EPA would benefit by having all site documents reported in the same format, which would facilitate comparisons across sites, and could help identify trends throughout the entire Superfund program. The EPA would also be better assured that Superfund goals are being satisfied, since information would be more visible and problems would be formally tracked. The community would also benefit, since

[66] Probst et al. 2004. 1-39.

the relevant information contained within the reports would be more transparent and easier to understand.

Perhaps the largest burden of this implementation option would be the requirement to formally document and track any problems or changes to the remediation plan. This would result in an increase in paperwork, and would require a certain level of training for the individuals preparing the documents. It would also require more administrative overhead to track the documents and manage the close-out process for each problem that arises. This recommendation might also pose a small burden on the PRPs, since many PRPs have their own methods for writing documents and reporting data. Another potential burden would fall on Superfund sites with unusual circumstances or rare types of contamination that may be difficult to report using the standardized document guidelines.

Option 2: "New EPA Office": Establish a centralized office within the EPA to oversee and publish all site documents.

To alleviate the problem of having to train many site managers, PRPs, and third-party contractors to use new documentation standards, we considered an option to create a new office within the EPA to oversee and publish all site documentation. Under this plan, site managers, PRPs, and contractors would periodically submit progress data to the new EPA office. The office would then compile this data and publish the site document using our recommended standardized formats.

The same benefits of standardizing the documents would be realized with this option. Rather than retrain everyone to use the new formats, training would only be required for the staff of the new EPA office, since they would be responsible for writing the site documents. These EPA staff would become experts at writing site documents, and they would write more efficiently and consistently than a diffuse group of managers, PRPs, and contractors.

One of the disadvantages of this approach would be the increased overhead costs for the EPA. This could be especially troublesome given the relatively constant amount of funding from Congress coupled with increasing costs for complex site cleanups. Another disadvantage is that it could be difficult for the site managers, PRPs, and contractors to transfer all their information to the EPA office for report publishing. Information could be lost during the transfer, or the EPA office could misinterpret some of the information. Perhaps one of the biggest disadvantages is that the EPA staff writing the site documents would have no local knowledge of the sites, which is likely to be useful in writing site reports.

This led us to consider a final option:

Option 3: "State Environmental Agencies": Employ State environmental agencies to oversee and publish all site documents.

This option is similar to option 2 except that state agencies, rather than the EPA, would be placed in charge of compiling site documentation. This option has the advantage that local knowledge of the sites would be retained since the local State agencies would be responsible for producing all the site documentation. Involving the state environmental agencies in the process would also help encourage state interest in the site remediation process. This could lead to states providing additional resources or incentives for site cleanup, since they would be more closely involved in the entire process.

One big question with this option is whether the EPA or federal government has the power to require state governments to participate in the site remediation process. Some states, such as Massachusetts, already play an active role in Superfund site remediation and may be willing to take on more responsibility; however, other states may be less willing to participate. Additionally, by requiring state participation, there is a question of who would pay for the states' involvement. The federal government could reimburse the states for their work, or the states could provide their own funding. Finally, this option would introduce another stakeholder in an already crowded process that includes the EPA, site managers, PRPs, and community interests. Including another major stakeholder would complicate the tradeoffs already taking place.

V.E Recommendation

Our recommendation is a combination of Option 1 and Option 2 and includes the following:

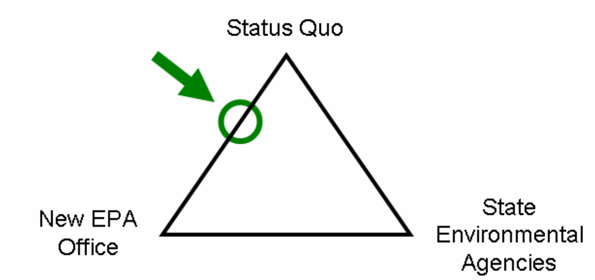


Figure 14: Implementation Recommendation

Recommendation #6: Issue mandatory changes to documentation procedures and create an EPA-level position for reviewing all documentation to ensure compliance at current and future Superfund sites.

We believe our recommendation offers the right balance of power between the EPA and local authorities. It ensures that local knowledge is retained and incorporated into the implementation process by keeping the site managers and PRPs responsible for writing the site documents. By instituting an EPA review of site documentation, the Superfund program could make certain that site documents are standardized and accurate. Finally, we believe that these recommendations could be implemented at a reasonable cost to the Superfund program.

VI. Conclusion

VI.A Summary of Recommendations

This section summarizes the recommendations of this report and suggests several areas for further inquiry. Though the problems addressed in this report were previously identified in studies of the Superfund program, it is important to note that our recommendations are based on case studies of only three Superfund sites. Although sites were chosen for their diversity of size and ownership, they shared several features that limit the broader applicability of our recommendations. Specifically, the three sites studied were all in EPA's Region 1 and were all added to the NPL prior to 1992. The committee recommends that the EPA consider the relevance of these recommendations in the context of more recent and geographically diverse Superfund site experiences.

The committee has offered six recommendations. The first two recommendations focus on the issues of permanence in the remedy selection process. At present, permanence comes at the cost of time and certainty that a remedy will work. Also, requiring permanence motivates project managers to misrepresent non-permanent remedies as permanent ones. These recommendations, listed below, remove this motive while stepping up efforts to develop the portfolio of proven technologies available for remediation.

Recommendation #1: Omit the current requirement for permanence from Superfund site remedy selection criteria.

Recommendation #2: Create incentives to encourage the selection of permanent treatment technologies.

The remaining set of four recommendations focuses on clarifying the procedures for documenting goals, progress, and problems in the implementation process. Currently, assessing cleanup goals and progress towards cleanup often requires scrutiny of all the site documentation, including multiple summaries and detailed tables of data. Comprehensive goal statements would bring clarity, consistency, and transparency to the remedy implementation process. Graphical metrics would allow cleanup progress to be communicated succinctly to all stakeholders. Moreover, they would enable rapid identification of problems, such as failure of a remedy or incomplete monitoring. A problem reporting system would ensure that problems are communicated clearly and do not get lost in the process. Our committee recommends these changes be implemented through modifications to documentation requirements and that a new EPA-level position be created to oversee compliance. The committee felt this option combined the advantages of local knowledge about a site with the consistency offered by national oversight.

Recommendation #3: Use "comprehensive goal statements" to articulate a complete set of objectives and targets for each site.

Recommendation #4: Use graphical metrics instead of tables to measure site cleanup progress.

Recommendation #5: Create a formal system for reporting problems that arise during cleanup to ensure that problems do not go unresolved.

Recommendation #6: Issue mandatory changes to documentation procedures and create an EPA-level position for reviewing all documentation to ensure compliance at current and future Superfund sites.

VI.B Topics for Further Inquiry

In the course of this study, the committee identified several topics which merit further investigation. These topics are summarized below:

Topic #1: Investigate how to create economic incentives for increased use of innovative cleanup technologies

Newer cleanup technologies are being developed at Superfund sites, but they may be viewed as unreliable because the technologies lack field testing or have not been proven under specific site conditions. For this reason, site managers are reluctant to select newer technologies. The EPA could offer economic incentives to site managers to encourage them to use new technologies, thus providing the field testing that would assess their reliability. The organization of such an incentive program, including the amount of the incentive and the range of technologies to be supported, could be an area of future study.

Topic #2: Further explore liability concerns related to Superfund site remedy selection

Currently, when PRPs select a cleanup strategy for use at a Superfund site, they must attain the EPA's approval before implementing the cleanup strategy. However, if the approved cleanup remedy proves unsuccessful, the PRPs are still held liable for cleaning any remaining hazardous materials at the site. As a result, PRPs are reluctant to select innovative technologies, which could provide more permanent remedies but have a lower rate of success. The EPA has recognized this issue and in 1998 instituted a pilot liability-sharing initiative. Through this initiative, the EPA agrees to reimburse up to 50 percent of the cost of an innovative remedy if the remedy fails and subsequent action is required.[67] The potential for this initiative remains unclear, however, as it has only been utilized at five sites since its inception. Further investigation into the role of liability in remedy selection could be useful in designing a more widespread liability assumption program.

[67] "Superfund Reforms Round 2-9a: Risk Sharing—Implementing Innovative Technology," U.S. Environmental Protection Agency.

Topic #3: Quantify the effects of site re-use and examine its role in terms of stakeholder goals

Many Superfund sites are converted into shopping centers or residential units once the sites are deemed safe for use. More analysis should be conducted to quantify economic or social benefits of cleaning up a site to re-use standards. It is possible the structure of a re-use facility could be integrated into the selected remedy; for example, the foundation of a new shopping center might offer additional protection at a site. Also, new developers interested in purchasing a site for reuse purposes may affect the remedy selection process. For example, the remediation of OU1 of the Materials Technology Lab site was expedited to accommodate the interests of potential business developers. In our study, we applied a stakeholder goal analysis tool to three parties: the community, the potentially responsible parties, and the EPA. Future work could use these same tools to examine the role that business developers may play in site remedy selection.

Works Cited

Background

Barnett, Harold C. 1993. "Crimes Against the Environment: Superfund Enforcement at Last." ***Annals of the American Academy of Political and Social Science*** **525.**
We used this document to learn more about the history of the Superfund program. We had heard mixed reports about the earlier years of Superfund and how long it took the program to catch on. This report clarified that information and expounded some reasons for Superfund's "growing pains".

Biography of Karl Gustavson was based on information on the National Research Council website at www.nationalacademies.org, and the National Academies Press website, http://darwin.nap.edu/books.
We use the biographical information from the National Research Council's to fill out Dr. Gustavson's profile in Appendix B: Biography of Outside Experts.

"Hazardous Waste Programs: Information on Appropriations and Expenditures for Superfund, Brownfields, and Related Programs," GAO-05-746R (Washington, DC: June 30, 2005). Expenditure data unavailable prior to 1987.
We used this information to put together a graph plotting Superfund expenditures. This information demonstrates graphically how annual appropriations to the Superfund program have leveled off around $1.3bn/year since 1990. It would have been helpful, however, if appropriation data was available from the program's inception.

Horinko, Marianne. June 2004. "Today's Superfund and the Future of Site Cleanups." ***Environmental Management*****.**
This document provided information about the current state of the Superfund program from the former acting administrator of the EPA. While perhaps overly optimistic regarding the future of Superfund, this report was useful in understanding the degree to which future cleanups would differ from past cleanups.

MIT Course ESD.34 System Architecture, Fall 2006, Prof. Ed Crawley.
The course provided the systems architecture window through which we examined the Superfund remedy implementation. The "Comprehensive Goal Statements" in Recommendation #3 are an adaptation of a technique from this class.

Office of Solid Waste and Emergency Response, US. Environmental Protection Agency"The Role of Cost in the Superfund Remedy Selection Process." 1996. U.S. Environmental Protection Agency. 540/F-96/018. www.epa.gov/superfund/resources/cost_dir/cost_dir.pdf (Accessed 8 Dec. 2006).
This document discusses a way to condense the nine CERLCA criteria for Superfund site remedies into five less specific criteria. This is similar to the technique we used for our Goal Analysis Tool. Though we found the document after developing our own tool, it was reassuring to see that another office recommended reducing the number of criteria.

Probst, Katherine N. www.rff.org/Probst.cfm and personal communication with Ms. Probst. We used this profile of Ms. Probst to fill out her profile in Appendix B: Biography of Outside Experts.
We found some of the information to be out of date and we received corrections from our contact with Ms. Probst.

Probst, Katherine N. *Superfund's Future: What Will it Cost?* Washington DC: Resources for the Future, 2001.
This book contains some history on congressional appropriations and projects how much spending will be needed to support the program into the future. The specific chapter we used discussed Five Year Reviews and how inconsistencies exist in the reporting styles between Five Year Reviews at different sites.

Probst, Katherine N. and Diane Sherman. 2004. "Success for Superfund: A New Approach for Keeping Score." Washington, DC: Resources for the Future.
We found this document after we had done some brainstorming on recommendations. This document cites many of the same documentation issues that we list in our Findings sections. The document recommends some creating a "site scorecard" in Superfund documentation. It was helpful to see that our ideas were on the right track, and we decided that our recommendations provided more explicit instructions for how to implement document standardization.

Reisch, Mark and David Michael Bearden. 1997. *Superfund Fact Book*, CRS Report for Congress 97-312 ENR. www.ncseonline.org/NLE/CRSreports/Waste/waste-1print.cfm (Accessed 6 Dec. 2006).
This report is a Congressional Research Service report intended for congressmen with little knowledge of the Superfund program. It was helpful for us to gain background information on the program and to see how well-versed the average policy maker is with Superfund.

Satellite photo: ©Google– Imagery ©MassGIS, Commonwealth of Massachusetts EOEA, Sanborn, DigitalGlobe, Map Data ©2006 NAVTEQ™.
This satellite photo shows where the MTL site is located in Watertown, MA. We feel that it helps the reader to locate the site and to identify better with the report.

Strickler, Annie E. 2004. "Sierra Club Marks One Year Anniversary of the Bankruptcy of the Superfund Trust Fund." www.sierraclub.org/pressroom/releases/pr2004-09-30.asp (Accessed 6 Dec. 2006).
This site provided more historical information on the Superfund trust fund and how the fund was supported over its lifetime. The article was interesting, but only informed a small section of our report.

Tufte, E. 1997. *Visual and Statistical Thinking: Displays of Evidence for Making Decisions,* Cheshire, CT: Graphics Press.
This reference was not directly relevant to the Superfund program, but it provided guidance on the importance of visuals in communicating information. One of our team's recommendations is to include standardized graphics to report progress at Superfund sites. Tufte espouses the use of effective and efficient graphics in data communication.

U.S. Congress, Office of Technology Assessment. "Are We Cleaning Up? 10 Superfund Case Studies: Special Report." Washington, DC: U.S. Government Printing Office OTA-ITE-362, June 1988.
This report, written in 1988, provided a basis for our analysis on remedy selection. The OTA evaluated the RODs at ten Superfund sites and sited common problems among them, including the selection of non-permanent remedies over permanent remedies. This report, as an unbiased review of ROD documents, assisted us in understanding some of the potential shortcomings of these documents.

U.S. Congress, Office of Technology Assessment. "EPA Superfund Actions and ATSDR Public Health Data," Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-BP-ENV-156, July1995.
This document provided information on the nine criteria that are expected to guide the choice of remedial actions at Superfund sites. We found the nine criteria to be somewhat diffuse and decided to condense them to a smaller number of criteria for our \Goal Analysis Tool.

U.S. Congress, Office of Technology Assessment. "Superfund Strategy." Washington, DC: U.S. Congress, Office of Technology Assessment OTA-ITE-252, April 1985.
This OTA review was written prior to the approval of SARA, and detailed a vision for the future of Superfund. The review emphasized that Superfund should shift its focus towards permanent cleanups, given that more sites were being added to the NPL than had been expected at the program's inception. This document was provided unbiased review of the program in 1985, and guided our understanding of the importance of permanent versus non-permanent cleanups.

U.S. Environmental Protection Agency. "About Superfund." 2006. www.epa.gov/superfund/about.htm (Accessed 6 Dec. 2006).
This EPA website provides a broad overview of the Superfund program, and was one of the first documents that our committee reviewed to gain a better understanding of the nature and history of the Superfund program.

U.S. Environmental Protection Agency. "Five Year Review Process in the Superfund Program." 2003. Summary of the U.S. Environmental Protection Agency Comprehensive Five-Year Review Guidance (EPA 540-R-01-007).
This document provided a summary of the guidance documents issued by SARA in 2001 regarding five-year reviews. The summary helped us to understand the information that site managers are currently expected to include in a five-year review.

U.S. Environmental Protection Agency. "How do I know if I am a Potentially Responsible Party (PRP)?" Superfund: Frequently Asked Questions. U.S. Environmental Protection Agency. www.epa.custhelp.com (Accessed 6 Dec. 2006).
This FAQ provided information about the five possible types of responsible parties, specifically regarding their potential relationship with the hazardous waste site. Overall, this FAQ website provided concise background information useful to understanding the Superfund remediation process.

U.S. Environmental Protection Agency. "Key Dates in Superfund." 2006. U.S. Environmental Protection Agency, www.epa.gov/superfund/action/law/keydates.htm (Accessed 6 Dec. 2006).
This website was useful in constructing the Superfund timeline for our group presentation of this report. It gave us a sense of how old the Superfund program was when the sites we chose were added to the NPL. However, the dates on this page contradicted some of the dates on other EPA pages.

U.S. Environmental Protection Agency. "NPL Site Listing Process." 2006. U.S. Environmental Protection Agency. www.epa.gov/superfund/sites/npl/npl_hrs.htm (Accessed 2 Dec. 2006).
We used this section of the EPA website to learn how Superfund sites are added to and removed from the National Priorities List. This was useful for distinguishing between characteristics of our sites, since only some of the Operable Units we studied have been removed from the list.

U.S. Environmental Protection Agency. "Superfund Reforms Round 2-9a: Risk Sharing—Implementing Innovative Technology," U.S. Environmental Protection Agency, www.epa.gov/superfund/programs/reforms/reforms/2-9a.htm (Accessed 1 Dec. 2006).
This document described a risk sharing initiative in which the EPA would share liability with PRPs if the PRPs chose to select an innovative technology. However, this initiative had only been utilized by five sites since its inception in 1998, and was fairly sparse in evaluating its utility and widespread potential.

U.S. Environmental Protection Agency. "What is the difference between a removal action and a remedial action?" Superfund: Frequently Asked Questions. U.S. Environmental Protection Agency. www.epa.custhelp.com (Accessed 6 Dec. 2006).
This FAQ enhanced our understanding of the timing of the remediation process. Specifically, the difference between a removal action and remedial action is that a removal action can be completed before a site is placed on the National Priorities List. Overall, this FAQ website provided concise background information useful to understanding the Superfund remediation process.

Sites

Metcalf and Eddy. August1995. *Charles George Reclamation Trust Landfill: Final Report Five Year Review*, www.epa.gov/region01/superfund/sites/charlesgeorge/34778.pdf (Accessed 6 Dec. 2006).
We referenced information from the first five-year review for Charles-George, written in 1995. This report reviews or assesses all of the following: adherence to ARARs, present conditions and activities at the site, prior risk assessments, and evaluation of data. This review includes several recommendations for changes to the remediation process. Lastly, it includes specifications regarding the next review: a deadline, and information that should be included.

Metcalf and Eddy. March 2000. *Charles George Reclamation Trust Landfill: Final Second Five Year Review*, www.epa.gov/region01/superfund/sites/charlesgeorge/34797.pdf (Accessed 6 Dec. 2006).
We referenced information from the second five-year review for Charles-George, written in 1995. This report reviews or assesses all of the following: adherence to ARARs, present conditions and activities at the site, and compliance with Records of Decision. Lastly, we used this document because it specified if the site was currently protective.

U.S. Environmental Protection Agency. "Charles-George Reclamation Trust Landfill," 2005. Waste Site Cleanup and Reuse in New England. http://www.epa.gov/region1/superfund/sites/charlesgeorge. (Accessed 8 Dec. 2006).
We used this site for general information regarding the Charles-George site. This site was useful because it either directly included or linked to the following information concerning the site: a historical description, list of contaminants, the cleanup approach, the current status of cleanup, and all documents included in the Administrative Record.

U.S. Environmental Protection Agency. *Charles George Reclamation Trust Landfill: Third Five Year Review Report*, June 2005 www.epa.gov/region01/superfund/sites/charlesgeorge/34797.pdf (Accessed 6 Dec. 2006).
We referenced information from the third five-year review for Charles-George, written in 2005. We found it useful in that it reviews or assesses all of the following: adherence to ARARs, present conditions and activities at the site, and compliance with Records of Decision. It specified if the site was currently protective. Because this was the third review it allowed us to better support our recommendations, regarding problem tracking in the remedial implementation process.

U.S. Environmental Protection Agency. *Clarification of the August 1999 Five Year Review for the Wells G&H Superfund Site.* 26 December 2001.
This document was an addendum to the first five year review conducted at Wells G & H. It provided a statement, in response to criticism by Resources for the Future, ensuring that current remedies at Wells G & H were in fact protective.

U.S. Environmental Protection Agency. "Consumer Fact Sheet: Benzo(a)pyrene," 2006. Ground Water and Drinking Water. http://www.epa.gov/safewater/contaminants/dw_contamfs/benzopyr.html. (Accessed 7 Dec. 2006). U.S. Environmental Protection Agency.
We used this fact sheet to specify the type of contaminants found at the Charles-George site. It was useful for illustrating the different types of contaminants found in the groundwater and drinking water at the site.

U.S. Environmental Protection Agency. *Explanation of Significant Differences: Materials Technology Laboratory (OU 1).* Patricia L. Meaney. Watertown, MA. 7 June 2001. http://yosemite.epa.gov/r1/npl_pad.nsf/51dc4f173ceef51d85256adf004c7ec8/25001afe0850c69a8525691f0063f701!OpenDocument (Accessed 30 Dec. 2006).
This document was an Explanation of Significant Difference at the Materials Technology Laboratory, written in 2001. It included information relevant to our assessment of remedy selection and implementation, in that it essentially altered the decisions presented in the Record of Decision.

U.S. Environmental Protection Agency. *Explanation of Significant Differences: Wells G&H.* 25 April 1991.
This document was an Explanation of Significant Difference at Wells G & H, written in 1991. It included information relevant to our assessment of remedy selection and implementation, in that it essentially altered the decisions presented in the Record of Decision.

Appendix A: Team Member Biographies

Ms. Lisa M. Jakobovits, Massachusetts Institute of Technology

Lisa Jakobovits is a first year Masters student in the Technology and Policy Program. She holds a B.S. from Stanford University in Science, Technology and Policy, and thus has spent several years studying problems at the interface of technology and policy. Her current research focuses on analyzing the effects of reducing uncertainty on climate change policy. Lisa also spent two years teaching high school English in Japan.

Ms. Valerie J. Karplus, Massachusetts Institute of Technology

Valerie Karplus is first year student in the Technology and Policy Program at the Massachusetts Institute of Technology. Her research focuses on energy and environmental policy in China. After graduating from Yale University with a B.S. in Molecular Biophysics and Biochemistry and Political Science, Valerie spent several years in China writing about the development of China's biotechnology industry. She brings her experience in analyzing complex issues involving technology and policy to assess remedy selection and implementation in the Superfund Program.

Mr. Robert E. Love, Massachusetts Institute of Technology

Robert Love obtained a Bachelor of Science degree in Electrical Engineering from Tennessee State University in 2006. His area of concentration was Computer Science and Architecture. In addition, he completed a minor in Art and Design. During his time as an undergraduate, Mr. Love worked within the Department of Energy and the Central Intelligence Agency. During his time with the Department of Energy, he helped develop new techniques and products for portable office lighting. As an intern with the Central Intelligence Agency, he helped create new communication standards for small and large scale systems. Mr. Love is currently a Masters candidate in the Technology and Policy Program at MIT. He brings high technical competency and a history of strategic analysis to the benefit of the team.

Mr. J. Decker Ringo, Massachusetts Institute of Technology

Decker Ringo received Bachelors of Science degrees in Chemical Engineering and Mechanical Engineer from the University of Michigan in 2002. After graduation, Mr. Ringo studied literature and art at the University of London for one year. He then worked as a materials research engineer for three years at Lexmark International. Mr. Ringo has experience with industrial safety requirements and materials manufacture and disposal. Mr. Ringo’s current research at MIT involves higher education in Portugal.

Mr. Timothy A. Sutherland, Massachusetts Institute of Technology

Timothy Sutherland holds a Bachelor of Science degree in Aerospace Engineering from MIT, 2003. In addition, he completed a minor in Earth, Atmospheric, and Planetary Sciences, as well as a concentration in Urban Studies and Planning. Mr. Sutherland has three years of work experience at Payload Systems Inc, an aerospace and biomedical contractor for the U.S. government. During his time at PSI, he helped develop innovative products and technologies for NASA and the Department of Defense. Mr. Sutherland is currently a dual-Masters candidate in the Technology and Policy Program as well as the Department of Aeronautics and Astronautics. He brings to the team a strong set of technical and analytical skills, as well as a broad educational background in engineering, environmental earth science, and community organization.

Appendix B: Biographies of Outside Experts[68]

Ms. Katherine N. Probst
Senior Fellow
Resources for the Future, Inc.

Katherine N. Probst is a Senior Fellow at Resources for the Future. Over the past 25 years, she has conducted numerous analyses of environmental programs, focusing mainly on improving the implementation of Superfund and other hazardous waste management programs. She was the lead author of the book *Superfund's Future: What Will it Cost?* requested by Congress, on the estimated cost of the Superfund program to the U.S. Environmental Protection Agency. She was a member of U.S. EPA's Superfund National Advisory Council for Environmental Policy and Technology Subcommittee and of the EPA Science Advisory Board Committee that reviewed analyses of the benefits of the Superfund program. Ms. Probst received an M.A. in city and regional planning from Harvard University.[69]

Ms. Probst will be our primary consultant on all issues related to the interpretation of Superfund site documents, including Records of Design and Five Year Reviews. She has already provided us with guidance on the scope of our research project. Her extensive writing on this subject makes her particularly well suited to advise us on the origins and evolution of Superfund and its documentation procedures.

Mr. Karl Gustavson
Study Director
Board on Environmental Studies and Toxicology, National Research Council

Karl Gustavson is currently a member of the National Research Council, where he has served as the Responsible Staff Officer on projects related to environmental remediation at Superfund sites. Most recently, he participated in the study "Sediment Dredging at Superfund Megasites," to be completed in the Fall of 2006. He also served on a panel that authored the study *Superfund and Mining Megasites: Lessons from the Coeur D'Alene Basin* (NRC Press, 2005).[70]

Mr. Gustavson has been involved with several in-depth studies carried out by the National Research Council related to Superfund site remediation. He would be able to provide insight on which sites we might select for our study, given that he is familiar with a diversity of sites and the various site-specific factors that inform the choice of cleanup measures and success of the cleanup process.

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[68] This section lists a fictitious "committee" which was not actually assembled. The experts listed herein were contacted for comments about the Superfund program. The experts listed were not asked to endorse our study or our recommendations.

[69] Biography based on information for the Resources for the Future website, www.rff.org/Probst.cfm and personal communication with Ms. Probst.

[70] Biography based on information on the National Research Council website, www.nationalacademies.org, and the National Academies Press website, http://darwin.nap.edu/books/.

Appendix C: Committee Charge

This project is concerned with the assessment of Remedial Action Objectives (RAO) within the Environmental Protection Agency's (EPA) Superfund Program. The Superfund Program is a federal effort to clean up sites polluted with hazardous waste nationwide. The RAOs are site-specific goals that aim to prevent or minimize the health and/or environmental risks associated with hazardous waste. An important goal of this project is to examine how RAOs are chosen, and how the success of implementing an RAO is measured. The report will evaluate the effectiveness of the EPA's process for developing and monitoring progress toward RAOs. Case studies will be conducted on three sites of different sizes in the Greater Boston area (to be decided by the committee).

The committee's assessment will address the following:

- Did the rationale for choosing certain RAOs differ by site? If so, why? If not, what principles or standards guided the choices?
- What metrics were chosen to gauge progress toward accomplishing the RAOs? If no metrics were chosen for a particular RAO, was progress measured in another way?
- Was the choice of metrics designed for site-specific concerns, or was the selection somewhat arbitrary?
- How are the results of ongoing measurements incorporated into future plans for remediation at that site?

This report will provide insight into whether chosen RAOs are well aligned with the EPA's overall goal of reducing risks to human and environmental health.

Appendix D: Additional Site Information

Charles George Reclamation Trust Landfill

Location: Tyngsborough and Dunstable, MA (approximately 35 km west of Boston)

Size: 69 acres

Potentially responsible parties: Dorothy and Charles George (owners); 54 other responsible parties entered into Consent Decrees in 1992. By 2003, the 54 PRPs paid the Georges U.S. $3.8 million to settle all claims against them.

Site divisions (task-oriented):
OU1 – Establish a permanent water supply
OU2 – Control source of contamination
OU3 – Management of source migration

Overview of site actions: Included initial actions and four long-term remedial phases focusing on providing a permanent water supply; capping the site; controlling the migration of contaminants, including collection and treatment of landfill gas; and collecting and off-site discharge of leachate and contaminated groundwater to a publicly owned treatment works (POTW).

Timeline:

1955	–	Landfill began accepting municipal waste (owner unknown)
1967	–	Mr. George purchases and begins operating landfill
1973	–	Landfill received license to accept hazardous wastes
1981-1982	–	Volatile organic compounds and heavy metals detected in drinking water supplied to Cannongate condominium complex; site proposed for NPL
1983	–	Site added to the EPA's National Priority List
1983	–	EPA provided alternate water supply to Cannongate residents
1983	–	Final remedy selected to provide residents with permanent water supply
1988	–	Remedy selected to restrict movement of contaminants
1990	–	Interim gas flare and one of two groundwater extraction remedies completed
1992	–	On- and off-site groundwater monitoring program begun and will continue until cleanup goals are met
1995	–	A four well groundwater extraction system installed with new pump station
1997	–	Enclosed (permanent) gas flare installed
Fall 1997	–	Municipal sewer line extended to the site to convey waste to the Lowell regional wastewater utility
1998/9	–	Final phase of cleanup completed with construction of an operations and maintenance building and upgrading pumping stations
1998	–	"Construction complete" status obtained

Charles George Reclamation Trust Landfill – Remedial Action Options:[71]

I. *No Action*
- Leave site in its present state
- Would not reduce contamination to acceptable levels

II. *Partial Soil Cap*
- Six-inch cover over local soils on the landfill
- Substantial precipitation could cause exposure of hazardous material

III. *Partial Clay Cap*
- Uses relatively impermeable capping material
- Surface erosion below cap may be a problem due to precipitation

IV. *Partial Synthetic Membrane Cap*
- Impacts similar to option III above

V. *Full Soil Cap*
- Technically feasible but would still permit significant leachate production

VI. *Full Clay Cap*
- Same as option V except uses different cover material
- Large amounts of clay required may be impossible to procure

VII. *Full Synthetic Membrane Cap*
- Material is more readily available
- Effectiveness would be less dependent on weather conditions

VIII. *Complete Off-Site Removal and Disposal*
- Would remove the source contamination
- Two orders of magnitude higher in cost than options II-VII

[71] Charles George, Record of Decision.

Wells G & H

Location: Woburn, MA **Size**: 330 Acres

Potentially responsible parties: Unifirst Corp., Beatrice, W. R. Grace & Co., New England Plastics, Olympia Nominee Trust, Southwest Properties,

Site divisions:
Operable Unit 1 (OU1): Source Control and Contaminant Migration
OU2: Central Area – Soil and aquifer are under risk investigation.
OU3: Aberjona River Study (merged with Industri-plex OU2)

Response objective (according to 1989 ROD): To restore entire aquifer to drinking water standards.

Timeline:

1964, 1967	–	Wells G&H developed by City of Woburn
1964-79	–	Wells G&H supplied 25% of Woburn's drinking water
1979/05	–	Woburn police discovered abandoned 55-gallon waste drums
1980-82	–	EPA began assessing several industries that may have affected Wells G&H
1982/12/30	–	Wells G&H added to EPA's National Priority List
1983/07	–	EPA issued 3 orders against potentially responsible parties
1986/04	–	EPA released Community Relations Plan to keep citizens informed of updates
1986/10/17	–	EPA completed remedial site investigation (part I) of Aberjona River Study (OU3)
1988/04/20	–	EPA notified 8 potentially responsible parties
1989/02/03	–	EPA notified 14 more potentially responsible parties
1989/02/09	–	EPA published proposed plan for remediation of the site
1989/09/14	–	Record of Decision (ROD) for OU1 filed
1991/04/25	–	EPA filed Explanation of Significant Differences (ESD), providing changes to soil and groundwater remedy
1999/08/04	–	First Five-year review report filed (OU1)
2003/05	–	EPA released Aberjona River Study Baseline Risk Assessment (OU3)
2004/03	–	Southwest Baseline Risk Assessment filed for OU2
2004/09/30	–	Second Five-year review report filed (OU1)
2006/01/31	–	ROD for Operable Unit 3 (merged with Industri-plex site) filed

Wells G&H – Remedial Action Options:[72]

Alternative SC1-Limited Action
- Monitoring every year
- Involves institutional Contols and Public Education

Alternative SC3-Excavation/On-Site Incineration/Backfill On-Site
- On-Site Treatment is with a mobile incinerator

Alternative SC4-Excavation/Off-Site Incineration/Backfill with Clean Offsite Soil
- Off-Site incineration is at a treatment facility

Alternative SC5-Excavation/On-Site High Temp Enhanced Volatilzation/Backfill On-Site

Alternative SC7-Excavation/On-Site Super Critical Fluid Extraction/Backfill On-Site

Alternative SC8-Excavation/On-Site Enhanced Volatilization/On-Site Incineration/Backfill
- Same as SC5, except soil contaminated with organic compounds will be excavated

Alternative SC10-In Situ Volatilization/On-Site Incineration/Backfill On-Site
- Same as SC3, but in-situ volatilization used to ensure VOCs are eliminated

Alternative SC11-In Situ Volatilization/Excavation/Off-Site Incineration/Backfill
- Same as SC4, but in-situ volatilization used to ensure VOCs are eliminated.

Alternative MOM1-Limited Action
- Monitoring every five years
- Involves institutional Contols and Public Education
- 100 years for natural attenuation

Alternative MOM2-Pump and Treat Source Areas
- Pre-treatment to remove suspended solids and metals
- Treatment by either air stripping or Ultraviolet/Chemical Oxidation
- Groundwater pumped and treated at all source areas, except Olympia
- Treated at either separate source area plants, or one centrally located plant

Alternative MOM3-Pump and Treat Central Areas
- Groundwater pumped from central area
- Pretreatment follows
- Either air stripping Ultraviolet/Chemical Oxidation, or Carbon Absorption follows

Alternative MOM4-Pump and Treat Source Areas of the Central Area
- Combination of MOM2 and MOM3

[72] Wells G&H, Record of Decision.

Materials Technology Laboratory (USARMY)

Location: Watertown, MA **Size**: 47 Acres

Potentially responsible parties: Presumably the Army Materials Technology Lab, though this is not explicitly stated.

Site divisions:
River Park Area, OU1
Charles River, OU2: The Charles River in area adjacent to facility. No further action required.
36.5 acre parcel, OU3: Parcel of the site that was remediated by 1998, removed from the NPL, and sold.

Response objective (according to 1996 ROD): Removal and off site disposal of contaminated soils.

Timeline:

1816	–	Facility established by Pres. James Madison
1960	–	Army's first materials research nuclear reactor completed on site
1960-1970	–	Reactor used in materials research
1967	–	Arms manufacturing facility phased down and army sold land to Watertown for apartment bldgs., mall, and playgrounds
1970	–	Nuclear reactor deactivated
1991	–	US Army initiated investigations into site contamination
1992	–	Nuclear reactor decommissioned under jurisdiction of Nuclear Regulatory Commission
1994	–	Nuclear research lab demolished
1996/06	–	ROD for "Area 1" signed, calling for removal and off-site disposal of contaminated soil
1996/08	–	Removal and disposal of contaminated soil from "Area 1" complete
1996/09	–	Second ROD signed indicates OU1 groundwater is okay; soil needs excavation/removal
1998/08	–	36.5 acre parcel (OU3) transferred from US Army to Town of Watertown
1999/11	–	36.5 acre parcel (OU3) deleted from National Priorities List
2001/09	–	Soil excavation in "River Park" area (OU1) complete
2004/08	–	Ecological risk assessment of "Charles River Area" (OU2) complete
2005/03	–	River Park Area transferred to the Commonwealth of Massachusetts
2005/09/29	–	ROD states no further action is needed in OU2
2006/08	–	US Army decided to undertake wetland restoration project on site

U.S. Army Materials Technology Laboratory – Remedial Action Options:[73]

Alternative S1-No Action
- No remedial actions implemented at the site.

Alternative S2 – Institutional Controls
- Access restrictions to prevent entry into contaminated areas.
- Deed restrictions to restrict site development.
- Five-year site reviews to assess conditions.

Alternative S3 – Capping of Soils
- Institutional controls.
- Five-year site reviews to assess conditions.
- Construction of asphalt cap over contaminated soils.
- Use of runon/runoff controls during cap placement.
- Continued monitoring of cap and repair of cap as necessary.

Alternative S4 – Soil Excavation and Thermal Treatment
- Excavation of soil contaminated at levels greater than action levels.
- Transportation of soil to:
  - Option A-On-site incinerator.
  - Option B-Off-site incinerator.
  - Option C-On-site low-temperature thermal desorber.
- Backfilling of site with uncontaminated soil (Option B) or treated soil (Options A, C)

Alternative S5 – Soil Excavation and On-Site Physical/Chemical Treatment
- Excavation of soil contaminated at levels greater than action levels.
- On-site treatment of contaminated soil by:
  - Option A-Chemical oxidation.
  - Option B-Solvent extraction.
- Treatment or disposal of treatment residues.
- Backfilling of site with treated soil.

Alternative S6 – Soil Excavation and Off-Site Disposal or Reuse
- Excavation of soil contaminated at levels greater than action levels.
- Transportation of soil for off-site recycling or to a landfill
- Backfilling of site with uncontaminated soil.

[73] U.S. Army MTL, Record of Decision.